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Full Length Research Paper

Effects of computer-based simulation module on secondary school students' achievement in understanding of magnetic effect of electric current

[1]John K. Thiong'o, [2]Mwangi Ndirangu and [2]Mark Okere

[1]Kanjuri High School, Kenya
[2]Curriculum, Instruction and Educational Management Department, Egerton University, Kenya
[2]Curriculum, Instruction and Educational Management Department, Egerton University, Kenya

Corresponding Author Email: karimitj@gmail.com, okeremark836@yahoo.com or mndirangu@egerton.ac.ke

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Developing countries have realized the importance of physics in their quest for scientific and technological development. Physics plays a dominant role in spearheading technological advancement, promoting national wealth, improving health and accelerating industrialization. In Kenya, the overall students' performance in physics at Kenya Certificate of Secondary Examination has been poor, with very low student enrollment. This situation has been aggravated by the expository approaches used by physics teachers, bringing the need for teachers to seek an alternative pedagogy. The computer is being used to assist in the teaching/learning process in many subject areas with promising results.This study aimed at finding out the effect of computer-based simulation module on students' achievement in magnetic effect of an electric current. The study adopted Solomon-Four Quasi-Experimental Design which involved comparisons between two experimental and two control groups. Purposive sampling technique was used to select four County boys' secondary schools in Nyeri County which had computers, and were accessible to the researcher. The four schools were randomly assigned to the experimental and control groups. Each school provided one Form Two class for study and a total of 170 students were involved. All the subjects were exposed to the same content of magnetic effect of an electric current. However, the experimental groups were taught using Computer-Based Simulation module while the control groups were taught through regular teaching methods. Experimental group I and control group II were pre-tested prior to the implementation of the Computer-Based Simulation module. After teaching for four weeks, all the four groups were post-tested using the Physics Achievement Test (PAT). This instrument, which was developed by the researcher, was validated by three experts and pilot tested before use. The reliability coefficient using K-R21 for PAT was 0.81. Data were analyzed using t-test, one way ANOVA and ANCOVA at significance level of alpha equal to 0.05. The result of the study showed that Computer-Based Simulation Module resulted into higher achievement mean scores in magnetic effect of an electric current on PAT, among the groups that received the treatment. The mean scores were statistically significantly different in favour of the experimental groups. These findings are valuable to curriculum developers and implementers in designing teaching strategies which are likely to enhance the teaching and learning of physics in Kenyan schools and anywhere else where this has been a challenge.

Keywords: Computer-based instruction; simulations; achievement.

INTRODUCTION

Physics plays a central role in scientific progress and development. Its fundamental role lies in its everyday applications that have improved the quality of life in society. The subject enables learners to acquire problem-solving and decision-making skills that provide ways of thinking and inquiry. This helps them to respond to the widespread and radical changes taking place in industry, health, climatic conditions, information techno-

Table 1: Performance in KCSE Physics Examination between 2006 and 2011, in Kenya

Year	2006	2007	2008	2009	2010	2011
% Mean score	40.32	41.32	36.71	31.33	35.13	36.64
Standard deviation	18.50	17.50	17.72	17.01	17.87	18.36

Source: Kenya National Examinations Council (KNEC) 2012

Table 2: KCSE Examination Candidature by Subject between 2006 and 2011

Year	Total No of students	No of students in Physics and %		No of students in Biology and %		No of students in Chemistry and %	
2006	243,453	72,299	29.69	217,675	89.41	236,831	97.28
2007	276,239	83,162	30.15	248,519	89.38	267,719	96.57
2008	305,015	92,648	30.37	271,735	89.09	296,360	97.16
2009	337,404	104,188	30.87	299,302	88.71	328,922	97.49
2010	354,951	109,072	30.73	315,063	88.76	347,378	97.87
2011	409,887	120,070	29.29	363,817	88.76	403,070	98.34

Source: Kenya National Examinations Council (KNEC) 2012

logy and economic environment (Wambugu and Changeiywo, 2008).

Kenya aims to create a globally competitive and adaptive human resource base to meet the requirements of Vision 2030 (Republic of Kenya, 2007). However, the poor performance in physics reflects the serious handicap the country is confronted with, in developing an adequate number of qualified students pursuing physics related courses at the universities and tertiary colleges. This may lead to insufficient number of workers in careers that require a physics background. The results of the Kenya Certificate of Secondary Examinations (KCSE) between 2006 and 2011 reflect a performance of below 50% in physics for secondary students as is indicated in Table 1.

While selecting subjects for KCSE, physics is clustered together with biology and chemistry. Candidates must select at least two science subjects (KNEC, 2012). Few students choose to pursue physics during the last two years of secondary school (Wambugu and Changeiywo, 2008). For instance as shown on Table 2, the number of students who sat for physics between year 2006 and 2011 KCSE was below 30% while the candidature of other science subjects were above 88%. Therefore, the concern is not only poor performance in physics but also how to make it popular among secondary school students. Many reasons have been promulgated for the observed low level of enrolment and poor performance of students in physics at KCSE. These include students' poor attitude towards physics, perceived abstract and difficult nature of physics, subject-matter and poor teaching methods being adopted by many physics teachers (Olatoye, 2007; Adegoke, 2011).

According to Tanel and Erol (2008), regular teaching methods hardly improve the teaching of physics principles and concepts. Most of the instructional methods used in Kenyan classrooms are usually teacher-centered thereby giving students fewer opportunities for active participation in classroom discourse (Kiboss, 2000; Tanui, 2003). Kiboss (2002), argued that expository approach is the dominant teaching method commonly used for science instruction in Kenyan schools. It is therefore necessary to use methods which utilize instructional activities in which students are involved in doing and thinking of the application of what they are learning. It was against this background that this study attempted to explore the use of the computers in instruction in a physics classroom. Computer-based instruction is a methodology that has been lauded as able to present concepts that are difficult or dangerous to teach more effectively (Wekesa, 2003). Some of the benefits of using computer-based instruction include emphasis on active learning, enrichment of collaborative learning, encouragement of greater students' independence and task-based teaching (Basturk, 2005).

There are many types of computer-based instructional programs namely; simulations, tutorials, drills and practice, educational games and hypermedia (Alessi and Trollip, 2001). In this study, computer-based simulation approach was adopted. According to Smetana and Bell (2012), simulations can be effective than regular instructional practices in promoting the learning of

Experimental Group (I)	0_1	X	0_2
Control Group (II)	0_3	-	0_4
Experimental Group (III)	-	X	0_5
Control Group (IV)	-	-	0_6

Figure 1: research design

science content knowledge, developing process skills and facilitating conceptual change. Computer-based simulation (CBS) with animated colour graphic images is capable of presenting the dynamic nature of "magnetic fields and electric current" that lacks in regular teaching methods. Teaching of "magnetic effect of an electric current" may therefore greatly benefit from the use of CBS because flow of electric current and magnetic fields do not manifest themselves visibly. Therefore, the study reported in this paper was set up to investigate the effects of CBS module on secondary school students' achievement in magnetic effects of an electric current.

The problem

The students' enrolment and achievement in physics at KCSE has continued to decline. Prominent among the factors which have been identified as contributing to the persistent low enrolment and poor level of achievement in physics are the teaching methods adopted by physics teachers. Teachers need to improve the teaching approaches used in order to keep students motivated to learn physics, thus perform better. The computer is being used to assist in the teaching/learning process in many areas. One of such areas is Computer-Based Instruction which has been used in the teaching and learning of various courses and subject areas with promising results. While physics teaching may benefit from the inclusion of such a teaching/learning strategy, no study has been done to investigate the effectiveness of CBS module on the teaching and learning of magnetic effect of an electric current. This study therefore, intended to fill this gap by developing a CBS module and establish its effect when used in teaching, on students' achievement in understanding of magnetic effect of an electric current in Nyeri County.

The following null hypothesis was tested at a significance level of 0.05

Ho_1: There is no statistically significant difference in the understanding of magnetic effect of an electric current between students exposed to the CBS module and those taught using regular teaching methods (RTM).

METHODOLOGY

Research design

The study employed a quasi-experimental research involving Solomon Four Non-equivalent Control Group Design. This design uses two experimental groups and two control groups. One experimental group and one control group are given pretest and posttest, while the other two groups are given only posttest (Sekaran, 2010). Research participants are not randomly assigned to the experimental and control groups. This is because secondary school classes exist as intact groups and school authorities do not normally allow the classes to be dismantled and reconstituted for research purposes (Gall, Gall and Borg, 2007; Fraenkel, Wallenand Hyun, 2011).Notationally, the research design is conceptualized as shown in figure 1.

Figure 1, Solomon Four Non-equivalent Control Group Research Design.

Where 0_1 and 0_3 were pre-tests;0_2, 0_4, 0_5, 0_6 were post-tests and X was the treatment, where students were taught using CBS module.

The sample

A total of 170 form two students from four county boys secondary schools in Nyeri County served as the subjects of the study. The subjects were randomly selected from four intact classrooms in four schools. All the groups were comparative enough in terms of number, age and quality of learning facilities made available to them by their schools. Moreover, the pretest analysis showed no significant difference on all the dependent measures (Thiong'o, 2013).

Instrumentation

A Physics Achievement Test (PAT) was used to assess students' academic achievement in understanding the

Table 3: Independent Samples t-test of the Pre-test Mean Scores on PAT
Group 1, N = 41 Group 2, N = 42

Variable	Group	Mean	SD	df	t-value	P-value
PAT	1	6.39	3.76	81	1.76	0.082 (ns)
	2	7.83	3.70			

df = 81, t-critical = 1.96, P < 0.05

Table 4: The PAT Post-test Means Scores Obtained by the Students in the Four Groups

Group	N	Mean	SD
1	41	26.24	4.15
2	41	21.12	4.09
3	44	26.41	5.27
4	43	20.35	4.77

concept of magnetic effect of an electric current. This instrument was developed for the purpose of this study. It was reviewed by a group of experts knowledgeable in physics and physics education. It consisted of 39 structured short answer questions on magnetic effect of an electric current and was to be marked out of a total of 40 marks. After it was piloted, a reliability coefficient of 0.81 was obtained using K-R21 formula. This established that the instrument was valid and reliable because the reliability coefficients obtained were higher than the suggested suitable level of 0.70 (Fraenkel et al., 2011).

Development of CBS module

A CBS module in Physics on the topic 'magnetic effect of an electric current' was developed. The contents were based on the approved KIE syllabus and relevant textbooks. The design of the CBS module was done using Hypertext Markup Language (HTML). The simulations were developed using PowerPoint and linked to the HTML for display on a computer screen. The CBS materials were organized in a format that rendered learning of magnetic effect of an electric current easier and interesting. The developed CBS module was given to two computer education experts and three high school teachers knowledgeable in physics education to assess the general design, format, sequencing of learning activities, language level and grammar, coverage of relevant subject matter and pedagogical issues. Form two secondary school students from one school in Nyeri County took part in pilot testing phase. The problems detected were rectified before the CBS module was finally implemented in a real classroom setting.

Data collection and analysis procedures

For this study PAT was used to collect data. Before treatment, pretest was administered to experimental group I and control group II. Then treatment took four weeks and was given to the two experimental groups after which posttest were administered to all groups. The researcher then scored the PAT. Data were analyzed using t-test, One-way ANOVA and ANCOVA which were undertaken using SPSS for Windows Version 17.

RESULTS

Results of the Pre-test

Experimental group 1 and control group 2 sat for PAT pre-test. Table 3 shows the results of the independent samples t-test for PAT.

An examination of Table 3 shows that the mean scores of Group 1 and 2 on PAT are not statistically significantly different since t-computed = 1.76 at df = 81, P > 0.05. This means that P value was large, and therefore the obtained difference between the sample means is regarded as not significant. This indicated that the groups used in the study exhibited comparable characteristics and were therefore regarded suitable for the study.

Effects of CBS module on students achievement in magnetic effect of electric current

To determine the effect of CBS module on students' achievement in magnetic effect of electric current, the analysis of post-test PAT means scores was carried out. Hypothesis one, H_o1 of the study sought to find out whether there was statistically significant difference in achievement scores in magnetic effect of an electric current between students exposed to CBS Module and those that were exposed to RTM. Table 4 shows the post-test mean score for PAT in the four groups.

An examination of the Table 4 shows that the mean scores for groups 1 and 3, the experimental groups, were higher than those of groups 2 and 4, the control

Table 5: Analysis of Variance (ANOVA) of the Post-test Scores on PAT

Group	Sum of squares	df	Mean squares	F	P-value
Between Groups	1339.56	3	446.52	21.01	0.00
Within Groups	3506.36	165	21.25		
Total	4845.97	168			

df = (3,165), F-critical = 2.604, P < 0.05

Table 6: Post Hoc Comparisons of the Post-test of PAT Means Scores for the Four Groups

	(I) Group	(J) Group	Mean Difference (I-J)	P-value
LSD	1	2	5.12*	0.00
		3	- 0.17	0.87
		4	5.90*	0.00
	2	1	-5.12*	0.00
		3	-5.29*	0.00
		4	0.77	0.44
	3	1	0.17	0.87
		2	5.29*	0.00
		4	6.06*	0.00
	4	1	-5.90*	0.00
		2	-0.77	0.44
		3	-6.06*	0.00

* - The Mean difference is significant at P < 0.05

groups. This shows that CBS module had an effect of improving performance as compared to the RTM.

To establish whether the mean scores were statistically significantly different, an analysis of one-way variance (ANOVA) was carried out and the results were as shown on Table 5.

Results on Table 5 shows that at an alpha level of 0.05, the PAT mean scores of the experimental and control groups were statistically significant F (3,165) = 21.01, P < 0.05. This means that the F factor is significant at P < 0.05 level and between means square is statistically significantly greater than within means square. This shows that there is a highly significant overall treatment effect.

After establishing that there was a significant difference between the means, it was important to carry out further tests on the various combinations of means to find out where the difference occurred. The tests were conducted using Fishers LSD procedure, at an alpha level of 0.05. The results of LSD post Hoc comparisons shown on Table 6.

The results show the following trend: mean scores of Groups 1 and 2, Group 1 and 4, Group 2 and 3, and Group 3 and 4 were statistically significantly different at 0.05 alpha level. However, the mean scores of Groups 1 and 3 and Groups 2 and 4 were not significantly different. This suggests that students exposed to the treatment outperformed those who were not, hence significant learning gains may be attributed to the treatment administered to the groups.

The main threat to the internal validity of non-equivalent control group experiments is the possibility that group differences on the post-test may be due to initial or pre-existing group differences rather than to treatment effect (Gall et al., 2007). Since this study involved non-equivalent control groups, it was necessary to confirm the results by performing analysis of covariance (ANCOVA) using students' Kenya Certificate of Primary Education (KCPE) scores as the covariate. This was to reduce the effects of initial group differences statistically by making compensating adjustments to the post-test means of the groups involved. KCPE scores correlate closely with the scores used in this study.

Table 7 shows the ANCOVA of the post-test PAT scores with KCPE scores as covariate. The results on Table 7 shows that there is a statistically significant difference in the PAT mean scores of the four groups F (3,164) = 12.26, P < 0.05. This confirms that the difference between the means is statistically significant at 0.05 α-level. Therefore, the differences were as a

Table 7: ANCOVA of the Post-test Scores on the PAT

	Sum of squares	df	Mean squares	F	P-value
Groups	727.89	3	242.63	12.26	0.00
KCPE	261.84	1	261.84	13.23	0.00
Error	3244.51	164	19.78		

result of the treatment effect. This means that CBS module resulted in higher student achievement than the regular teaching method (RTM). Therefore hypothesis H_o1 which stated that there is no statistically significant difference in achievement in magnetic effect of an electric currentbetween students exposed to CBS module and those taught using RTM, is rejected.

DISCUSSION

The results of this study indicate that the students who were taught through CBS module achieved significantly higher scores in the PAT than those taught through RTM. This implies that CBS module was more effective in enhancing students' achievement than the regular teaching methods. In the light of this, these findings reaffirm previous studies that concluded that the use of computer-based programs tend to improve achievement scores of students as compared to the use of regular methods of instruction. In a study, Hancer (2008) showed that computer assisted teaching was more effective than teacher-centred methods in increasing academic achievement and acquiringof more durable learning.Kiboss and Ogunniyi (2005) studied the effectiveness of a Computer-Augmented Physics (CAP) learning program on teaching the topic of 'Measurement' to first-year physics secondary school students. The findings of the study affirmed the impact of the innovation on the students' learning outcomes in that the mean score gains of the participants in the CAP treatment were statistically significantly higher than that of their counterparts in the regular program. Also, the results indicated that the mean difference between the experimental and the control groups were statistically significant in favour of the treatment groups.

In another research study comparing teaching effectiveness of Computer-Assisted Instruction (CAI) and the traditional methods of teaching basic statistics, it was shown that the combination of CAI and collaborative work, improved learning. The research further found that CAI served to establish more effective learning situations than traditional teaching methods which involved teacher presentation, question and answer technique and discussion (Ragasa, 2008). Kiboss, Wekesa and Ndirangu (2006) assessed the effects of a Computer-Based Instruction Simulation (CBIS) program developed for the teaching cell theory in school biology. Because of the abstract nature of this concept, it was found that the recommended teaching methods were ineffective in showing the dynamic nature of the processes involved. The results showed that the CBIS program resulted in significant learning gains as well as more motivation to learn. Mwei, Too and Wando (2011) in their study that investigated the effects of Computer-Assisted Instruction (CAI) on students' attitude and achievement in matrices and transformations in mathematics reported a higher achievement with CAI treatment groups. They further gave a possible explanation for the effectiveness of learning through CAI on students' active involvement in the learning process through frequent student-machine interactions.

The use of computers in teaching has been argued to provide hands-on activities, supports cooperative learning, provides active learning experiences and produces greater peer interaction (Basturk 2005). Thus the assertion by Ayersman (1996) that the use of computer-based instructional programs involves the students more actively in the learning process often resulting into higher academic achievement than those that put them in a passive role, is confirmed by the findings of this study. It was for this reason that CBI simulation module used in this study was designed to be highly interactive and allow students to manipulate variables. The study also corroborates earlier findings on the effectiveness of the use of educational media and hypermedia to improve students' academic achievement. It concludes that the innovation has major implications for improving those areas of science that are difficult to teach and learn using the regular methods, and should therefore be integrated into the existing school curriculum.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this study, it can be concluded that CBS module produced a statistically significant difference in academic achievement in magnetic effect of an electric current between students taught through it and those taught through RTM. Consequently, incorporation of this teaching strategy is likely to improve the endemic poor performance in physics as well as other science subjects. Therefore, teacher training programmes should incorporate computer studies in order to enable teachers to design computer-based instructional resources. Serving teachers should be given training in computer literacy through in-service courses. This would create a culture for better utilization

of the computer in the teaching-learning process especially in science instruction in schools. In order to encourage the use of computers in schools, the government should equip schools with computers and internet connectivity.

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