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Full Length Research Paper

Effects of inquiry-based teaching approach on Secondary School Students' achievement and motivation in Physics in Nyeri County, Kenya

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The overall students' performance in physics at the Kenya Certificate of Secondary Examination (KCSE) has been poor coupled with very low student enrollment. The preferred mode of delivery by physics teachers in Kenyan secondary schools is the expository teaching approach. This approach is dominant despite growing evidence that it is not effective in inculcating the content knowledge, conceptual knowledge and science process skills that are part of quality physics teaching. Available literature shows that Inquiry-Based Teaching (IBT) approach is capable of promoting these attributes among students. However, there is little documentary evidence on the effects of Inquiry-Based Teaching (IBT) approach on secondary school students' achievement in physics in Kenyan secondary schools. This study aimed at finding out the effects of IBT approach on students' achievement in physics in Nyeri, County. The study adopted a Quasi-Experimental Research Design. Solomon-Four Non-equivalent Groups Design was involved. Stratified random sampling technique was used to select four boys' and four girls' county secondary schools in Nyeri, County. The four schools in each category were assigned to treatment and control groups by simple random sampling technique. Each group had one boys' and one girls' county secondary school. Each school provided one form two class for the study and a total of 370 students were involved. Students in all the groups were taught the same physics content but the experimental groups were taught using IBT approach while the control groups were taught through Regular Teaching Methods (RTM) such as lecture method and teacher demonstrations. The experimental group I and the control group II were pre-tested prior to the implementation of the IBT treatment. After four weeks, all the four groups were post-tested using the Students' Physics Achievement Test (SPAT). The instrument had been validated by five experts in education and pilot tested before use to estimate its reliability. The reliability coefficient using K-R21 was 0.87. The acceptable threshold for reliability coefficient is 0.7 and above. The instruments were scored and data was analyzed using t-test, one way ANOVA and ANCOVA at a significance level of coefficient alpha (α) equal to 0.05. The findings of the study showed that Inquiry-Based Teaching (IBT) approach resulted into higher students' scores in achievement in physics. The study recommends that Teacher training institutions, Kenya Institute of Curriculum Development (KICD) and physics teachers should enact IBT approach as the preferred physics teaching approach in Kenyan secondary schools.

Key words: Expository Teaching Approach; Inquiry-Based Teaching Approach; Students' Achievement in Physics

INTRODUCTION

Science educators and in particular physics teachers in secondary schools need to change their teaching

approaches to make them more effective and relevant to a much larger proportion of the student population than in the past (International Bureau of Education, 2000; Wieman and Perkins, 2005). This is as a result of rapid scientific and technological innovations over the past several decades. Many of the problems confronting society currently, such as global warming, terrorism, genetic modification, global market competition, energy and population crises, ethical issues involving biotechnology among other critical issues, require physics knowledge, if they are to be dealt with rationally (Safeer and Keenan, 2005; UNESCO, 2010). Modern knowledge-based economies are so heavily dependent on technology. Thus having a better understanding of physics and technology, and better technical problem-solving skills will enable people to meet the challenges and demands of the work place (Effandi and Zanaton, 2006; Porter, Ketels and Delgado, 2007). Furthermore, a modern knowledge-based economy will flourish only if it has a workforce with high level of technical understanding and skills (Wieman and Perkins, 2005).

Technological advancement has brought the Information Technology (IT) revolution. It is evident that any society that will be left out of this revolution risks total isolation from the global family (SMASSE, 2004). Consequently there are economic and social benefits both to individuals who study physics and to countries whose citizens include many individuals with extensive scientific and technical knowledge. Thus, a country requires scientifically and technically literate citizenry to advance her national development agenda. Hence, the need to structure secondary school physics teaching approaches in line with the twenty first century skills (Pacific Policy Research Center, 2010). The twenty first century skills include creativity and innovativeness, critical thinking and problem solving, communication and collaboration, information, media and technology, life and career skills among others.

Secondary school education is a critical level in any educational system. As a transitional level to higher education, it is important for economic development of a nation, socialisation and empowerment of the youth who are faced with massive levels of unemployment (United Nations Education Scientific and Cultural Organisation [UNESCO], 2005) Nations all over the world lay a lot of emphasis on secondary school education. The structure and content of the secondary school curriculum of a nation is constantly revised with the aim of making it relevant and sensitive to the country's educational goals and aspirations. In Kenya, numerous curriculum reforms aimed at making education responsive to the national development goals have been made. The 8-4-4 education system was launched in January 1985 and was designed to provide eight years of primary, four years of secondary and four years of university education (Ministry of Higher Education Science and Technology [MOHEST], 2004). The 8-4-4 education system aimed at introducing vocational and technical education so as to meet the demands of the economy, fostering national development, providing a relevant curriculum for the Kenyan youth, addressing the economic and regional disparities and providing a practical oriented curriculum (MOHEST, 2004). Thus, the system introduced a broad based curriculum at every level. Science subjects were initially classified into chemistry, physics, biology, biological sciences and physical sciences. However, the science curriculum has undergone several structural and fundamental changes and currently pure sciences are offered in all secondary schools in Kenya (Kenya Institute of Curriculum Development [KICD], 2002).

According to the Kenya National Examinations Council (KNEC), physics is clustered with biology and chemistry. However, students must select and pursue at least two science subjects at Form Three and Four (KNEC, 2005). Majority of the students opt for a combination of chemistry and biology due to subject clustering system which does not favour physics. Also, most of the students consider the concepts involved in the study of physics to be too abstract and difficult to understand. This may account for the current low students' achievement, motivation and enrolment in the subject. Performance in physics has been low and many students shun the subject as indicated in Table 1.

Table 1 show that performance in physics has been poor and the subject is unpopular amongst secondary school students compared to chemistry and biology. Several studies have investigated the causes of the appalling state of physics performance and low student enrolment. These causes were identified as low students' motivation to learn physics, poor teaching approaches used by physics teachers, poor content mastery by the physics teachers, teachers' use of language in classrooms, perceived difficulty of the subject, inadequate instructional materials and inadequate supervision from the Ministry of Education Science and Technology among other factors (Strengthening of Mathematics and Sciences in Secondary Education [SMASSE], 1998; Etkina, 2005; Ndirangu, 2000; Kiboss, 2002: Oyoo, 2009). In response to the low students' achievement and motivation to learn physics SMASSE project organized National and District In-Service Training (INSET) for teachers emphasizing the need to adopt ASEI/PDSI teaching approach. The ASEI/PDSI approach, which means Activity Student Experiments and Improvisation and Plan Do See and Improve respectively, advocated a shift from teacher-centred to student-centred physics teaching approaches (SMASSE, 1998).

The Kenya Certificate of Secondary Examination (KCSE) report for 2006 on students' performance advised teachers to give plenty of exercises, guide students into

Table 1. Performance in KCSE Physics Examination and Percentage Candidature for the Science Subjects from 2006 to 2011

Year	% Mean score in physics	% Candidature in physics	% Candidature in chemistry	% Candidature in biology
2006	40.32	29.69	97.28	89.41
2007	41.32	30.15	96.57	89.38
2008	36.71	30.61	97.92	89.79
2009	31.31	31.33	98.48	89.34
2010	35.13	30.73	97.87	88.76
2011	36.64	29.29	98.34	88.76

Source: Kenya National Examinations Council KNEC (2011)

Table 2. Performance in KCSE Physics Examination by Gender from 2006 to 2010

Year	2006	2007	2008	2009	2010
Female mean score %	39.07	39.04	36.10	29.93	33.46
Male mean score %	40.82	42.23	36.95	31.88	35.76
Mean difference %	1.75	3.19	0.85	1.85	2.30

Source: Kenya National Examinations Council (KNEC) (2011)

Table 3. Performance in KCSE Physics Examination in Nyeri County from 2006 to 2009

Year	2006	2007	2008	2009
% of students taking physics	30.04	32.15	31.28	36.15
Mean score on a 12 point scale	4.89	4.62	4.46	4.06
Mean grade	C-	C-	D+	D+

Source: Nyeri County Secondary Schools Examinations Analysis (2010)

the insight of the concepts taught and to cover the syllabus within the allocated time (KNEC, 2007). Despite these interventions and changes in the physics curriculum, KCSE physics results as indicated in Table 1 reflect a percentage performance of below 42%. Available data also indicate a gender disparity in performance in physics in Kenyan secondary schools as shown on Table 2.

Table 2 shows that the performance of girls is lower than that of boys in physics in Kenyan secondary schools. Thus, there is need to address the prevailing disparity in physics performance with respect to gender. In Nyeri County, students' achievement and enrolment in physics has been low as is the case nationally as indicated in Table 3.

Table 3 shows that students' achievement and percentage of students taking physics in Nyeri County has been low. The poor performance in physics may be attributed to in appropriate teaching methods and approaches used by physics teachers, poor distribution and utilisation of school resources, low student motivation to learn physics and incompetence in science processes and skills amongst secondary schools physics students among other factors (SMASSE, 1998). Considering that physics is a requirement for many vocational and technical courses in universities and other tertiary institutions, there is need to enhance students' achievement and motivation to learn the subject. The performance in physics is below the expectations that Kenya would require to actualize her goal of industrialisation and becoming a middle level income country by the year 2030 (Republic of Kenya, 2007). Hence, the poor performance reflects the challenge Kenya faces in having adequate number of qualified students enrolling in scientific and technological disciplines in educational and training institutions in the country.

Secondary school education in Kenya aims at ensuring

that students graduating at that level have adequate scientific knowledge while meeting the needs of those who terminate their studies after secondary school and those who proceed to tertiary institutions (Education Info Centre, 2006). Physics like any other science subject is compulsory in the secondary school curriculum in form one and two but majority of the students do not select physics in Form Three. Majority of the students consider the concepts involved as too abstract to understand and the content taught too difficult to learn. Available literature shows that majority of the students in Kenyan secondary schools have inadequate knowledge and understanding of physics concepts and principles (SMASSE, 2001). In effect, the topic Magnetic Effect of an Electric Current has constantly been difficult to learn by students or to teach by teachers. According to a SMASSE baseline survey 58% and 62% of the teachers and students interviewed indicated the topic as difficult to teach by teachers and to learn by students respectively (SMASSE, 2005). This is consistent with the KNEC reports which show that candidates have been performing dismally on questions in this topic (KNEC, 2006).

Considering that concepts and principles involved in the study of Magnetic Effect of an Electric Current are a prerequisite for the study of Electromagnetic Induction among other topics in the secondary school physics course. Therefore, there is need to equip students with a strong background in this topic. The principles, concepts and skills involved in the study of Magnetic Effect of an Electric Current are also widely used in the design and construction of electric motors, the television, loudspeakers, moving coil meters and electric bells (Muriithi and Ringeera, 2002). Approaches used in teaching physics have been identified as one of the factors contributing to the low student achievement in physics among other factors (American Association of Physics Teachers, [AAPT], 2009). Thus, a teaching approach that a teacher adopts may motivate students to learn and therefore affect their achievement in physics.

Inquiry-Based Teaching (IBT) approach is used to describe teaching strategies that are driven by scientific inquiry (Kahn and O'Rourke, 2005). The approach is deeply rooted in constructivism teaching practices. It is student-centred rather than teacher-centred and offers students opportunities to be actively involved in experimenting, questioning and investigating. The approach has been considered as being capable of promoting motivation among secondary schools students since it creates interest in the process of acquiring scientific knowledge and skills (Gibson and Chase, 2002). Research findings indicate that Inquiry-Based Teaching (IBT) may be very effective in enhancing student achievement and motivation to learn science as well as development of scientific process skills (Sola and Ojo, 2007; Khan and Iqbal, 2011). Students' academic motivation is their tendency to find academic activities meaningful and worthwhile and to try to derive the intended academic benefits from the teaching and learning process (Dowson and Mclnerney, 2001). High academic motivation has consistently been linked to increased levels of students' academic achievement (Kushman, Sieber and Harold, 2001). Thus, the development of students' motivation in Kenyan secondary schools is a valuable objective for physics teachers because of its inherent importance in enhancing students' achievement in the subject.

The study of Magnetic Effect of an Electric Current in the secondary school physics course is meant to enable the students, perform and describe experiments to determine the direction of the magnetic field round a current-carrying conductor, to determine magnetic field patterns on a straight conductors and the solenoid. The topic also aims at enabling the students to apply Fleming's Left-Hand Rule, to explain the working of simple electric motor, electric bell, loudspeaker, telephone receiver and magnetic relays among other applications. The concepts, skills and principles acquired in this topic are essential in the study of other topics such as electromagnetic induction, cathode rays and cathode ray oscilloscope, magnetism, mains electricity, electronics, radioactivity and x-rays in the secondary school physics curriculum (Kenya Institute of Curriculum Development, 2002). The above topics are highly examinable at KCSE level. Table 4 below shows the number of questions, the total mark and the percentage contribution of the topics in the KNEC physics examination paper 2 for the past five years.

Table 4 shows that the topic Magnetic Effect of an Electric Current and other closely related topics in the KNEC physics examination paper 2 for the years 2008 to 2012 contributed about twenty percent of the total mark. Given that the percentage performance in physics is below 42%, there is need to enhance the learning of the topic Magnetic Effect of an Electric Current in the secondary school physics course in Kenya and in Nyeri County in particular. Furthermore magnetic fields are widely used throughout modern technology, particularly in electrical engineering and electro-mechanics. This study aimed at finding out the effect of Inquiry-Based Teaching (IBT) approach on students' achievement in learning Magnetic Effect of an Electric Current in Nyeri County secondary schools.

Purpose of the Study

This study was designed to investigate the effect of Inquiry-Based Teaching (IBT) approach on secondary school students' achievement in the learning of physics based on the topic Magnetic Effect of an Electric Current.

Table 4. Number of Questions, Total Marks and Percentage Contribution of the Topic Magnetic Effect of Electric Current and Closely Related Topics in the KNEC Physics Examination Paper 2 from 2008 to 2012

Year	No. of questions	Marks Out Off 80	Percentage Contribution (%)
2008	3	18	22.5
2009	3	6	7.5
2010	4	16	20.0
2011	5	20	25.0
2012	4	16	20.0

(Karimi, Njenga and Mutwiri, 2013)

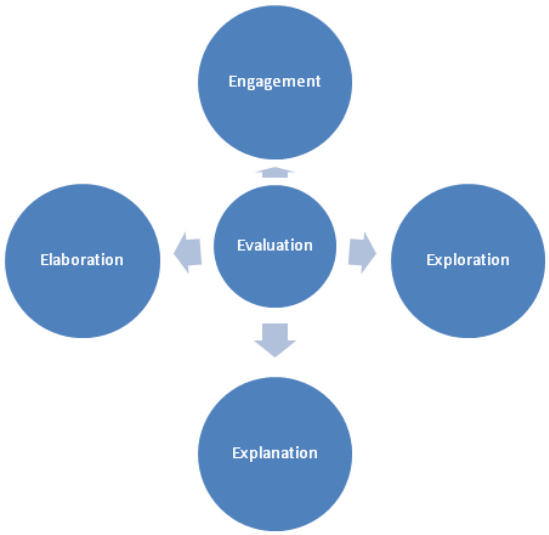

Figure 1. Bybees's 5E Learning Cycle Model
Source: Bybee, (2002)

Objectives of the Study

The objective of this study was to determine whether there is a difference in students' achievement in the learning of Magnetic Effect of an Electric Current of students exposed to IBT approach and those taught using the Regular Teaching Methods, RTM.

Hypotheses of the Study

To achieve the objectives of this study, the following null hypothesis was tested at a significance level of alpha equal to 0.05:
Ho1: There is no statistically significant difference in students' achievement in learning Magnetic Effect of an Electric Current between students' taught using IBT approach and those taught using the Regular Teaching Methods, RTM.

Theoretical Framework

The theoretical framework that guided this study was based on Bybee's 5E learning cycle model which is an Inquiry-Based Teaching (IBT) approach model (Llewellyn, 2005). The 5 E learning cycle model sequences learning experiences so that students have the opportunity to construct their understanding of a concept during the teaching and learning process (Bybee, 2002). The model leads students through five phases of learning that are easily described using words that begin with the letter E: Engagement, Exploration, Explanation, Elaboration and Evaluation. Bybee's 5E learning cycle model is represented in Figure 1.

Figure 1 shows Bybee's 5E learning cycle model. In the engagement phase the teacher captures students' interest and makes them curious about the topic and concepts to be learnt. This phase provides an opportunity for the teacher to find out what students already know or think they know about the topic and concepts to be developed (Bybee, 2002). In the exploration phase students interact with materials and ideas through classroom and small group discussions (Llewellyn, 2005). This helps the students to acquire a common set of experiences so that they can compare results and ideas with their classmates. In the explanation phase students are provided an opportunity to connect their prior experiences with current learning and to make conceptual sense of the main ideas. This phase also provides the opportunity for the introduction of formal language, scientific terms and content information that might make students' prior experiences easier to describe. In the elaboration phase students' are provided with the opportunity to apply introduced concepts to new experiences (Llewellyn, 2005). This phase helps students to make conceptual connections between new and prior experiences, connect ideas and deepen their understanding of concepts and processes. In the evaluation phase that is centrally placed in the model and takes place virtually in every phase of the 5E learning cycle model provides a summative assessment of what students know (Bybee, 2002).

Jones' Music Model of Academic Motivation was also applied in this study. The Music Model of Academic Motivation consists of psychological components that have been derived from research and considered to be critical to student engagement during content presentation (Jones, 2009). This model integrates aspects of existing motivation constructs that are important for secondary school physics teachers to consider in classroom settings. IBT approach combined with Bybee's 5E Learning Cycle model may provide students with a wider range of learning experiences within the concept of Magnetic Effect of an Electric Current. This may lead to deeper conceptual understanding and skills development which may enhance students' motivation to learn and students' achievement in the topic Magnetic Effect of an Electric Current.

Conceptual Framework

The conceptual framework of this study is represented diagrammatically in Figure 2.

The relationships between variables of the study are shown on Figure 2. In an ideal situation, the teaching approach would affect the students' achievement and motivation to learn Physics. In practical situations the students' achievement and motivation to learn Physics will be influenced by various factors which include, teacher training, teachers' epistemological views on teaching, learning and teaching resources as shown in Figure 2. These are extraneous variables which need to be controlled. The study involved trained physics teachers to control the teacher variable because teacher training determines how effectively a teacher will enact the teaching approach. Also the involved teachers taught the same content from a common syllabus to all students for the same university entrance examination. The students' age and hence their class determines what they are taught. Form two students who are approximately of the same age were involved in the study. To control for teachers' epistemological views on teaching the involved teachers were inducted through a training program and the researcher closely monitored the implementation of the Inquiry-Based Teaching (IBT) Approach intervention to the treatment groups.

In this study students' achievement in physics was measured using the students score in SPAT. The Students' Physics Achievement Test (SPAT) was constructed based on the topic Magnetic Effect of an Electric Current in the secondary school physics course. This is because the concepts involved are considered too abstract to understand and the content too difficult. The concepts, principles and skills involved in the topic are essential in the study of other topics such as electromagnetic induction, magnetism, mains electricity, cathode rays and cathode ray oscilloscope, current electricity, x-rays and electronics. These topics are highly examined in the KNEC physics paper two as indicated on Table 4

METHODOLOGY

Research Design

The study was Quasi-experimental involving Solomon Four Non-Equivalent Control Group design. This is because there was non-random assignment of students to the groups. Secondary school classes exist as intact groups and school authorities do not normally allow the classes to be dismantled and reconstituted for research purposes (Shadish, Cook and Campbell, 2002). Quasi-experimental researches are widely used in the evaluation of teaching interventions because it is not practical to justify assigning students to experimental and control groups by random assignment (Randolph, 2008). Quasi-experimental research offers the benefit of comparison between groups because of the naturally occurring treatment groups (Cohen, Manion and Morrison, 2007). The experimental group was exposed to the treatment and the control group received no

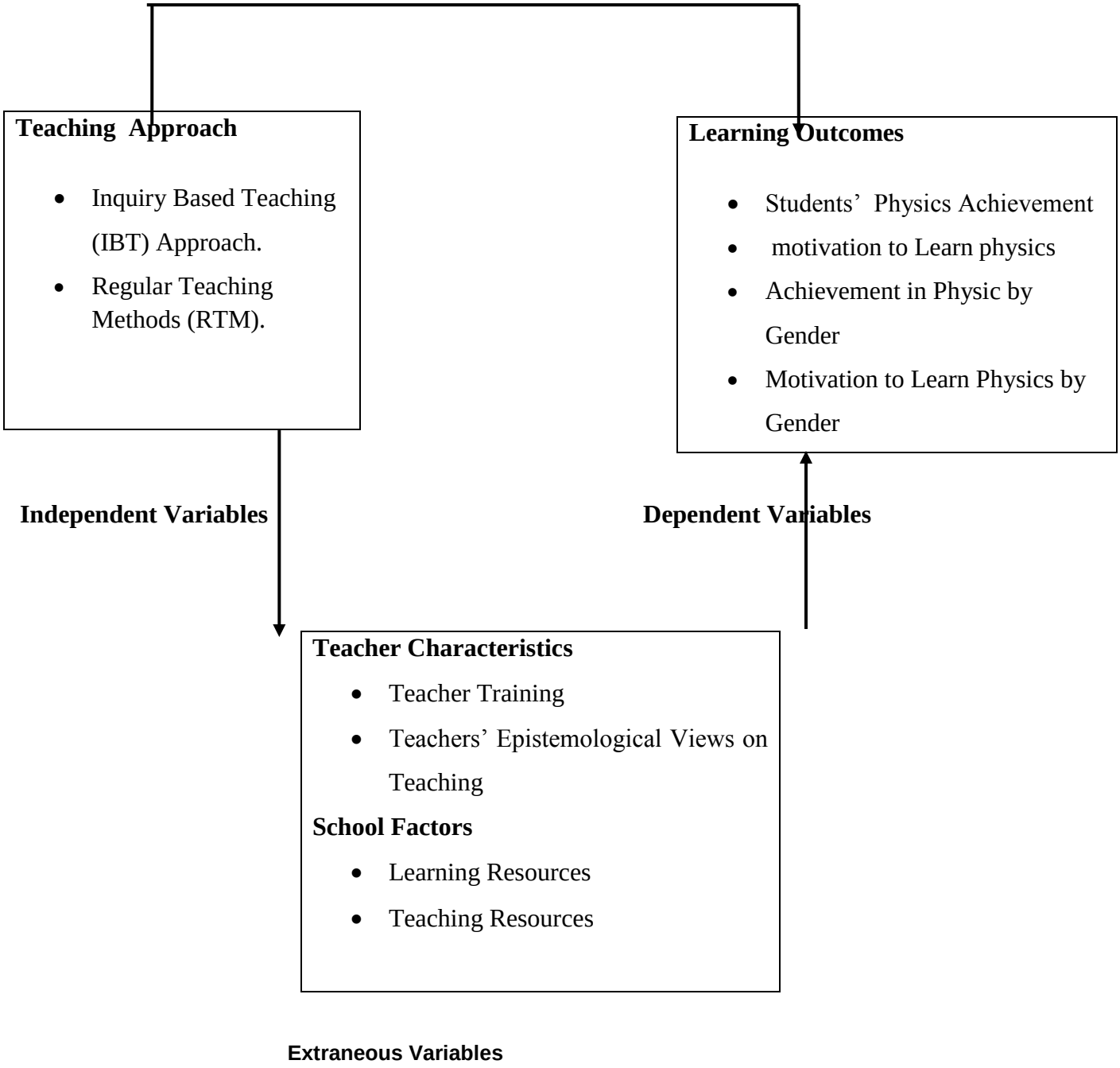

Figure 2. The Conceptual Framework showing the Interaction of Variables.

treatment. The performance of the two groups was then compared after data collection to determine whether there was any treatment effect. Solomon Four Non-Equivalent Control Group Design was involved since it controls the major threats to internal validity except those due to interaction, and history, maturity and instrumentation (Sekaran, 2006). The Solomon Four Non-Equivalent Group Control Design involves setting up two experimental groups and two control groups for the study. The effect of treatment is then calculated in a number of different ways to the extent that the researcher comes up with almost the same results in each of the

Group I	O_1	X	O_2
Group II	O_3	-	O_4
Group III	-	X	O_5
Group IV	-	-	O_6

Figure 3. Solomon Four Non-equivalent Group Control Design. Source: Sekaran (2006. p.161)

Table 5. Sample Size for the Study

Category of school	Number of Schools	Number of Students
County Boys' schools	4	185
County Girls' schools	4	185
Total	8	370

calculations. Hence the effect is attributed to the treatment, thus establishing a cause and effect relationship. This increases the internal validity of the results. In this study, schools were assigned to the four groups by purposive sampling technique. Figure 3 shows the Solomon Four Non-equivalent Group Control Design.

Figure 3 shows the research design that was used for the study. Where O_1 and O_3 were pre-test; O_2, O_4, O_5, O_6 were the post-test; X was the treatment where students were taught using Inquiry-Based Teaching (IBT) approach. The broken lines separating the parallel rows indicate that assignment of students to the experimental and control groups was not by random assignment.

i) Group I was the experimental group which received the pre-test, treatment X and the post-test.

ii) Group II was the control group that received a pre-test, followed by the control condition and then the post-test. This group helped to see whether or not history, maturation, testing, regression or mortality was a threat to internal validity.

iii) Group III received the treatment X and post-test but did not receive the pre-test. This group helped to establish whether or not testing effects were a threat to internal validity. The difference if any between O_2 and O_5 were attributed to testing effects. However, if O_2 and O_5 were equal then the internal validity was not affected by testing effects.

iv) Group IV received the post-test. This group helped to establish whether or not the changes in the post-test scores of the experimental group were a function of the combined effects of history and maturation by comparing O_6 with O_1 and O_3. If all the scores were equal, history and maturation was not a threat to internal validity.

Schools in the experimental groups I and III were taught using IBT approach while those in the control groups II and IV were taught using the Regular Teaching Methods (RTM).

Sampling Procedures

The unit of sampling was the secondary school rather than individual students because secondary schools operate as intact groups (Randolph, 2008). Stratified random sampling technique was used to select four county boys' and four county girls' secondary schools. Stratified random sampling technique was used in order to obtain a representative sample of the whole population with respect to gender (Cohen et al., 2007). The assignment of one form two stream per school selected to either experimental or control group was done by simple random sampling technique. Since majority of the county secondary schools have more than one stream per form, simple random sampling technique was used to select one stream for the study. Table 5

Sample Size

Table 6 shows that four county boys' secondary schools and four county girls' secondary schools were involved in the study. The sample size for the study was 370 students comprising of 185 boys and 185 girls in eight intact classes. Fraenkel and Wallen (2000) recommend

Table 6. Independent Samples t-test of the Pre-test Mean Scores on SPAT

Variable	Group	N	Mean	sd	df	t-value	p-value
SPAT	1	96	6.46	3.20	181	0.47	0.44(ns)
	2	87	6.24	3.05			

Critical values {df=181, t=1.65 p ≤0.05} Calculated values {df=181, t=0.47 p =44}

at least 30 subjects per group. Thus, the sample size was considered adequate for this study.

Instrumentation

The Students' Physics Achievement Test (SPAT) was used to assess students' achievement in learning Magnetic Effect of an Electric Current in the secondary school physics course. The Students' Physics Achievement Test (SPAT) was constructed from the Kenya National Examinations Council (KNEC) past examination papers which were modified to make them suitable for this study. The test items were constructed based on the topic Magnetic Effect of an Electric Current and were used as pre-test and post-test to allow for comparison between pre-test and post-test results. The SPAT consisted of 16 structured questions with a maximum score of 39 marks testing on conceptual knowledge and application of the concepts and principles learnt. The SPAT was pilot tested using a school in a County that was not included in the actual study but had similar characteristics as the sampled schools to avoid contamination.

Validity is defined as the accuracy and meaningfulness of inferences which are based on the research results (Cohen et al., 2007). In other words validity is the degree to which results obtained from the analysis of the data actually represent the phenomena under study. There are three major types of validity: face validity, content validity, and construct validity. The SPAT was validated by four research experts from the department of CI&EM of Egerton University, Njoro, for content, construct and face validity. Also the content validity of the questions was reviewed by five experienced secondary school physics teachers who are physics examiners with KNEC. The reliability coefficient of SPAT was estimated using Kuder-Richardson formula 21 (Gronlund, 1990). The K-R21 formula is suitable in cases where the items can be scored dichotomously. Kuder-Richardson estimates of reliability tests whether all the items measure the same quality or characteristics. The reliability coefficient of the SPAT using K-R21 formula was 0.87. According to Fraenkel and Wallen (2000), a reliability coefficient of alpha value 0.7 and above is considered suitable to make possible group predictions that are sufficiently accurate.

The Development and use of Inquiry-Based Teaching (IBT) Instructional Materials

Physics as a science subject is activity based and the suggested method for teaching it which is Inquiry-Based Teaching (IBT) approach is resource-based (Franzer, Okebukola and Jegede, 1992). The instructional materials and the content used in the class instruction were developed in line with the revised KICD (2002) physics syllabus. A guiding manual was developed for the teachers involved in the implementation of IBT approach and was used throughout the treatment period. The teachers of the experimental groups were trained on how to use the manual by the researcher. The teachers were trained on how to enact IBT approach on a different topic other than Magnetic Effect of an Electric Current for one week to make them conversant with Inquiry-Based Teaching (IBT) approach. After the training period the pre-test was administered to groups I and II. The treatment period was four weeks as recommended in the KICD (2002) physics syllabus. After the treatment period a post-test was administered to all the groups.

Data Collection

The researcher obtained permission from Graduate School, Egerton University through a letter which was used to secure a research permit from the National Commission for Science, Technology and Innovation (NACOSTI). The researcher sought clearance from the Nyeri County Director of Education. The principals and physics teachers of the participating schools were informed of their schools' inclusion in the study and their co-operation requested. Before the treatment, pre-test was administered to the experimental Group I and the Control Group II. The students in the experimental Group I and Group III were taught the topic Magnetic Effect of an Electric Current using IBT approach while those in the Control Group II and Group IV were taught using RTM. After four weeks the post-test was administered to all the groups.

Table 7. The SPAT Post-test Mean Scores obtained by the Students in the Four Groups

Group	N	Mean Score	sd
1	96	22.46	6.46
2	87	15.51	4.74
3	100	21.7	5.81
4	87	16.2	6.4
Total	370	19.15	6.66

Data Analysis

The SPAT was scored and quantitative data generated. Data was analyzed using one-way ANOVA, analysis of covariance (ANCOVA) and a t-test with the aid of Statistical Packages for Social Science (SPSS) computer program. Analysis of variance (ANOVA) was used to determine if the four groups differed significantly among themselves on experimental variables. Analysis of covariance (ANCOVA) was used to cater for the initial differences
among the groups. A t-test was used to test differences between two means because of its superior quality in detecting differences between twomeans (Coolican, 1994, Gall, Borg and Gall, 1996). All tests of significance were tested at a significance level of 0.05.

RESULTS

Solomon Four Non-equivalent Control Group Design was used in this study. This enabled the researcher to have two groups sit for the pre-test. Group 1 and 2 sat for pre-test SPAT. The researchers were able to assess the entry behaviour of the students (Gall et al., 1996). Table 7 shows the independent samples t-test for SPAT.

The results of the pre-test SPAT, Table 6 shows that the mean scores of Group 1 and 2 were not statistically significantly different since $t(181) = 0.47$, $p > 0.05$. This meant that the groups used in the study exhibited comparable characteristics. The pre-test was administered to the experimental group 1 and the control group 2 to determine whether the groups were similar. The groups were therefore regarded suitable for the study

Effects of Inquiry-Based Teaching Approach on Students Achievement in Magnetic Effect of an Electric Current

To determine the effect of Inquiry-Based Teaching Approach on students' achievement in Magnetic Effect of an Electric Current, the analysis of Post-test SPAT mean scores was carried out. Hypothesis one, H_o1 of the study stated that there is no statistically significant difference in students' achievement in the learning of Magnetic Effect of an Electric Current between students exposed to Inquiry-Based Teaching (IBT) Approach and those that were exposed to Regular Teaching Methods (RTM). The groups had been given both the pre-test and the post-test. Thus the testing effects across all the groups had been nullified and the post-tests of each of the experimental groups could be compared with that of the control groups to detect the effects of treatment. The mean scores of the four groups are shown on Table 7.

The results on Table 7 show that the mean scores of the experimental groups 1 and 3 were higher than those of the control groups 2 and 4. The results of the mean scores on SPAT are represented in a bar graph in Figure 4.

The graph shows clearly that the schools in the experimental groups 1 and 3 performed better in the Post-test than the schools in the control groups 2 and 4. To establish whether the mean scores were statistically significantly different, analysis of one–way variance (ANOVA) was carried out and the results are shown on Table 8.

The results on Table 8 shows that at 0.05 alpha level, the SPAT mean scores of the experimental and control groups were statistically significant $F(3,366) = 30.34$, $p < 0.05$). Also F calculated > F tables meaning that the difference between the SPAT mean scores of the experimental and control groups were statistically significant. ANOVA is a statistical procedure that compares the amount of between-groups variance in individual scores with the amount of within-groups variance (Gall, Gall and Borg, 2007). The ratio of between-groups variance to within-groups variance was sufficiently high, indicating that there was a higher difference between the groups in their scores than there was within each group. After establishing that there was a significant difference between the means, further tests were carried out on the various combinations of means to find out where the difference occurred. The tests were conducted using Scheffe's procedure at 0.05, alpha level. The Post Hoc is a statistical procedure used to determine in which of the multiple groups the difference lie

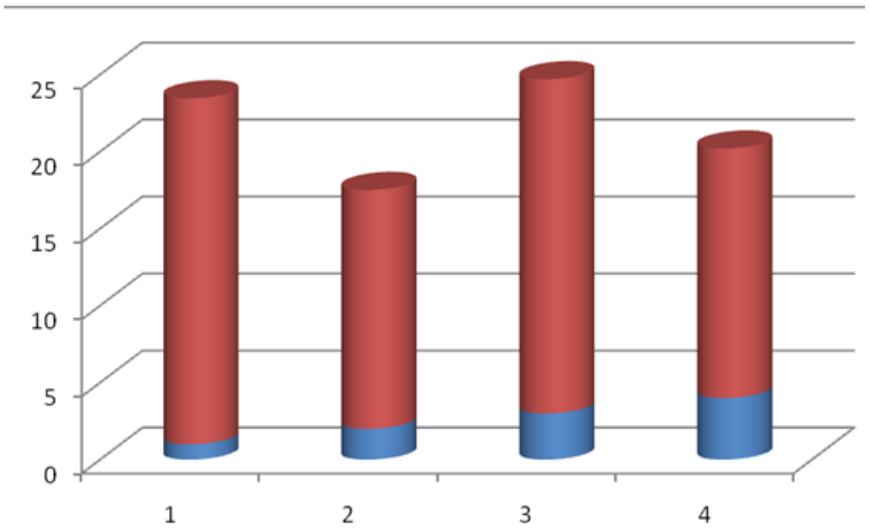

Figure 4. SPAT Post-test Mean Scores

Table 8. Analysis of Variance (ANOVA) of the Post-test Scores on SPAT

Group	Sum of Squares	df	Mean Squares	F	p-value
Between Groups	3622.49	3	1207.45	30.34	0.00
Within Groups	12766.33	366	34.88		
Total	16388.82	369			

Critical values {df=3,366, F=2.60 p ≤0.05} Calculated values {df=3,366, F=30.34 p =0.00}

Table 9. Post Hoc Comparisons of the Post-test of SPAT Means Scores for the Four Groups

	(I) Group	(J) Group	Mean Difference (I-J)	p-value
Scheffe	1	2	6.96*	0.00
		3	0.79	0.84
		4	6.27*	0.00
	2	1	-6.96*	0.00
		3	-6.19*	0.00
		4	-0.69	0.90
	3	1	-0.77	0.84
		2	6.19*	0.00
		4	5.50*	0.00
	4	1	-6.27*	0.00
		2	0.69	0.90
		3	-5.50*	0.00

* - The Mean difference is significant at p < 0.05

(Sekaran, 2006). The results of Post Hoc comparisons are shown on Table 9.

Table 10. Adjusted SPAT Post-test Mean Scores for ANCOVA with KCPE as Covariate

Group	N	Adjusted SPAT Mean Scores
1	96	22.47[a]
2	87	15.51[a]
3	100	21.70[a]
4	87	16.20[a]

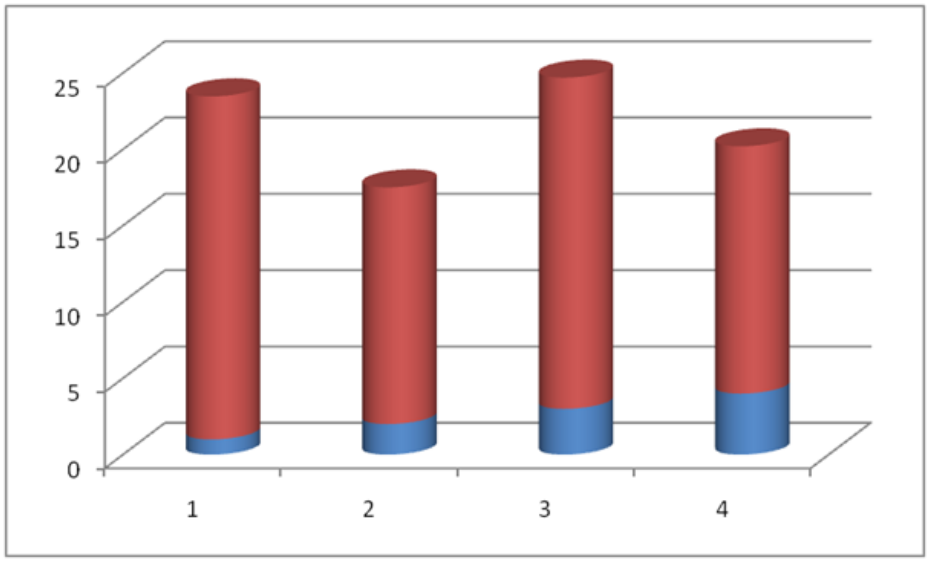

Figure 5. Adjusted SPAT Post-test Means Score for ANCOVA with KCPE as Covariate

The results on Table 9 indicate that the pairs of SPAT mean scores of groups 1 and 2, groups 1 and 4, groups 2 and 3 and groups 3 and 4 were statistically significantly different at 0.05 alpha level. However, the mean scores of group 1 and 3 and groups 2 and 4 were not statistically significantly different. 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., 1996). 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) marks as the covariate. This was to reduce the effects of initial group differences statistically by making compensating adjustments to the post-test mean scores of the groups involved. Table 10 shows the adjusted SPAT Post-test mean scores.

The results were represented on a bar graph to show the adjustments as shown in Figure 5.

Figure 5 shows that the adjusted SPAT post-test mean score for ANCOVA with KCPE as covariate was high in the experimental groups 1 and 3 compared to the control groups 2 and 4. The results of the adjusted SPAT Post-test mean scores enabled an analysis of covariance to be done and the results are shown in Table 11.

The results on Table 12 shows that there was still a statistically significant difference since $F(3,164) = 12.26$, $p < 0.05$. F calculated > F tables meaning that the difference between the SPAT mean scores of the experimental and control groups were statistically significant. To establish where the differences occurred, a Post Hoc pair-wise comparisons based on ANCOVA was carried out and the results shown on Table 12.

The Least Significant Difference (LSD) test results on Table 12 indicate that there was a statistically significant difference at 0.05, alpha level between groups 1 and 2, groups 1 and 4, groups 2 and 3 and groups 3 and 4. However, there was no statistically significant difference at 0.05, alpha level between groups 1 and 3 and groups 2

Table 11. ANCOVA of the Post-test Scores on the SPAT

	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		

Critical values {df=3,164, F=2.60 p ≤0.05} Calculated values {df=3,164, F=12.26 p =0.00}

Table 12. ANCOVA pair-wise Comparisons on SPAT Post-test Mean Scores

	(I) Group	(J) Group	Mean Difference (I-J)	p-value
LSD	1	2	6.29*	0.00
		3	0.88	0.30
		4	5.83*	0.00
	2	1	-6.29*	0.00
		3	-5.41*	0.00
		4	-0.46	0.61
	3	1	-0.88	0.29
		2	5.41*	0.00
		4	4.95*	0.00
	4	1	-5.83*	0.00
		2	0.46	0.61
		3	-4.95*	0.00

* - The Mean difference is significant at $p < 0.05$

Table 13. Comparison of the Mean Scores and Mean Gain by Students in SPAT

	Overall N = 183	Group 1 N = 96	Group 2 N = 87
Pre-test Mean	6.35	6.46	6.24
Post-test Mean	18.99	22.47	15.51
Mean Gain	12.64	16.01	9.27

and 4. This confirms the ANOVA results to be correct. This therefore means that the teaching approach used to teach the experimental groups had significant effect on students' achievement as compared to the approach used on the control groups. A comparison of the SPAT Pre-test and Post-test means scores was carried out and the results are shown on Table 13.

Table 13 shows that students in the experimental group 1 had a higher mean gain than those in the control group 2. This meant that Inquiry-Based Teaching (IBT) Approach resulted in higher students' achievement in the learning of Magnetic Effect of an Electric Current than the Regular Teaching Method (RTM). This confirms the results of the ANOVA and ANCOVA. Therefore hypothesis one, H_o1 which stated that there is no statistically significant difference in students' achievement in learning Magnetic Effect of an Electric Current between students taught using Inquiry-Based Teaching (IBT)

Approach and those taught using the Regular Teaching Methods (RTM) is rejected.

DISCUSSIONS

An examination of Table 8 reveals that the difference between the experimental group 1 and the control group 2 is statistically significant $F(1,366)=30.34$, $p<0.05$. This would, therefore, suggest that Inquiry-Based Teaching (IBT) Approach enhanced the achievement of students who were in the experimental group compared to those in the control group. The results of this study indicate that the students taught using Inquiry-Based Teaching (IBT) Approach achieved significantly higher mean scores in the SPAT than those taught through Regular Teaching Methods (RTM). This implies that Inquiry-Based Teaching (IBT) Approach is more effective in enhancing students' achievement than Regular Teaching Methods (RTM). A study conducted by Vanosdall, Klentschy, Hedges and Weisbaum (2007) involving fifth grade students in California State showed that the use of Inquiry-Based Teaching Approach (IBT) approach led to higher achievement in learning of mixtures and solutions in chemistry than did those taught using the regular teaching methods.

Khan and Iqbal (2011) studied the effectiveness of Inquiry-Based Teaching Approach (IBT) on the development of scientific processes and skills among nineth grade secondary schools students of biology. The findings of the study affirmed the impact of Inquiry-Based Teaching Approach (IBT) on the students' learning outcomes in that the mean gains of the students in the treatment groups were significantly higher than that of the students in the control groups. Also, the results indicated that the mean difference between the experimental and the control groups were statistically significant in favour of the treatment group. Sola and Ojo (2007) studied the effect of inquiry models of teaching. The results of this study showed that inquiry models of teaching were very effective in enhancing student achievement and skill development. They reported that student achievement scores and analytical skills were either raised or greatly enhanced. Marx, Blumenfeld, Krajcik, Fishman, Soloway, Geier and Revital (2004) in their study involving sixth, seventh and eighth grade physics students over a three year period found out that students who took part in the inquiry curriculum made statistically significant gains in achievement. The researchers concluded that an inquiry approach led to higher gains in knowledge of the content, understanding of the process, and overall achievement. Amaral, Leslie and Klentschy (2002) in their study involving fourth and sixth grade students in Latino school district in southern California studied the effect of inquiry-based approach in science and mathematics. The results of the study indicated that inquiry-based approach led to greater proficiency in science and mathematics. The researchers concluded that the hands-on activities allow learners to construct context, to develop positive attitudes toward learning and to engage in authentic conversation with other students.

CONCLUSIONS

Inquiry-Based Teaching Approach (IBT) produced a significant difference in students' achievement in the learning of Magnetic Effect of an Electric Current in the secondary school Physics course between students taught through it and those taught through Regular Teaching Methods (RTM). The post-test SPAT mean scores of Experimental Groups 1 and 3 was 22.46 and 21.70 respectively, while that of Control Groups 2 and 4 was 15.51 and 16.70 respectively. Comparison of the mean scores and mean gain by students in SPAT indicated students in the experimental groups gained more than those in the control groups.

Implications of the Study

Students taught through the Inquiry-Based teaching approach attained higher scores in the SPAT than those taught through the regular teaching methods. Therefore, education authorities in Kenya should encourage physics teachers to use this approach and teacher training institutions to make it part of their teacher training curriculum content.

Recommendations of the Study

The findings of this study suggest that the use of Inquiry-Based Teaching (IBT) Approach can be an effective approach in enhancing students' achievement in learning Magnetic Effect of an Electric Current. Based on these findings, this study proposes the following recommendations:

i) Teacher training should be designed to produce teachers capable of planning and implementing Inquiry-Based Teaching approach.

ii) Teachers in schools should be given training in planning and implementing Inquiry Based Teaching approach through in-service courses. This may be an effective teaching approach in providing suitable learning conditions for students of diverse learning styles and academic abilities that is common in most classroom settings.

iii) Students taught through Inquiry-Based Teaching approach performed better and had higher mean scores

than those taught through the Regular Teaching methods that Inquiry-Based Teaching (IBT) approach would be suitable for teaching both boys and girls. Therefore, education authorities in Kenya should encourage physics teachers to use this approach.

Suggestions for Further Research

The findings of the study indicate that Inquiry-Based Teaching (IBT) approach is effective in enhancing students' achievement and motivation in learning magnetic effect of an electric current in the secondary school physics course. However, there are areas that warrant further investigation.
These include the following;

i) A comparative study involving single sex and co-educational schools setting to establish whether the findings apply to the two categories of schools since they are the most prevalent in Kenya.
ii) Studies involving the impact of Inquiry-Based Teaching approach on the motivation of teachers. Since Inquiry-Based Teaching approach is quite demanding on both the teachers and students may be an in depth study of the impact on teachers would be helpful.
iii) Studies involving larger sample sizes in terms of participating schools, students and teachers to confirm whether or not the present findings hold.
iv) A long-term study preferably on another relatively longer topic investigating more variables to find out how such variables interact with Inquiry-Based Teaching approach to bring meaningful learning.
v) Studies involving more topics in physics or involving other science subjects since the science subjects are similar in teaching context approach.

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