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EFFECT OF DISCOVERY METHOD ON SECONDARY SCHOOL STUDENT'S ACHIEVEMENT IN PHYSICS IN KENYA

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ABSTRACT

In Kenya, the teaching of physics faces the challenge of poor performance due to inadequate laboratory equipment and trained teachers. These challenges have caused students to lack motivation in pursuing the subject. Further, some students have missed to get into careers that are physics based due to under achievement. Earlier studies have revealed that teaching through experiments greatly improves students understanding and retention of scientific facts. This study specifically sought to determine the effects of Discovery Experimental Method (DEM) on secondary school student's achievement in physics in Kenya. The Solomon four group experimental research design was used in the study. The study was carried out in four secondary schools in Uasin Gishu County in Kenya. Students in experimental groups were taught using the DEM while those in control groups were taught using the Teacher Demonstration Method (TDM). Pre-test exam was administered to one experimental group and one control group to determine whether students had any pre- existing knowledge on the topic of cells and simple circuits in the form two physics syllabus. This study established the effects of discovery method (DE) on secondary school students' achievement in physics. The study revealed that the DEM had significant effect on the achievement of students by enhancing knowledge retention and instilling confidence.

Keywords: Discovery Experiments Method, Teacher Demonstrated Experiments, Teacher Demonstrated Experiments and Achievement

INTRODUCTION

The realization of the millennium development goals is pegged on a productive education system. A productive education system is that which has minimum wastage in terms of school dropouts, mass failure in national exams, unemployment and low economic growth (Bishop, 1985). Acquisition of relevant scientific skills is an avenue to adequate food supply and preservation, good health and the way to advancing physical infrastructure and telecommunication systems.

Physics, a science subject is like a pivot joint in the Kenyan secondary school curriculum since it bridges other subjects like chemistry, biology geography and mathematics. The learning of physics develops the scientific habits in students, which are transferable to other areas in life. Such habits involve non reliance on superstition, critical thinking and respect for other people's opinions. The above qualities if well learned can be useful not only in career placement but also in adaptability to life (Okere, 1996). Physics also prepares students for vocations and career at tertiary levels of learning and in life generally. The teaching of physics should, therefore be done such that learners understand and like it.

Many countries are strengthening and investing in new methods and approaches to teaching and learning mathematics and science courses in order to produce more and better qualified candidates for higher level technical and scientific skills. Traditional methods of teaching and learning are being revised for maximum outputs while student centered approaches have been embraced to sustain students motivation and cultivate in them a feeling of ownership.

The teaching and learning of physics has been affected by the low students' achievement as revealed by Kenya national examinations council (KNEC), K.C.S.E (2006-20011). Table 1 below shows the overall candidature and the scores obtained by students in the K.C.S.E results between 2006 and 2011

Table1. Performance in Physics in Kenya National Exams

Year	*Paper*	*Candidature*	*Maximum Score*	*Mean Score*	*Std. Deviation*
2006	1	72,298	80	24.00	15.62
	2		80	35.75	17.05
	3		40	20.88	7.22
	Overall		200	80.63	37.00
2007	1	83,162	80	23.46	13.43
	2		80	33.33	17.93
	3		40	23.85	7.14
	Overall		200	82.64	35.00
2008	1	93,692	80	25.32	14.66
	2		80	24.17	16.34
	3		40	23.92	7.31
	Overall		200	73.42	35.43
2009	1	104,883	80	26.73	16.17
	2		80	20.77	14.23
	3		40	15.22	06.29
	Overall		200	62.62	34.02
2010	1	104,811	200	26.11	16.95
	2			21.82	13.83
	3			22.37	7.81
	Overall			70.22	35.37
2011	1	120,074	80	21.64	14.49
	2		80	29.43	16.41
	3		40	22.24	8.84
	Overall		200	73.28	36.72

Source: KNEC 2012

The overall enrolment has increased from 72,298 in 2006 to 120,074 in 2011. This could be attributed to free primary and secondary education. In order to reach out to the large numbers of students in the classroom, the teachers should embrace use of approaches that are student and group centred. As noted, about the performance per paper, p_3 which is practical oriented is better performed than $_P1$ and p_2 which are theoretical. Perhaps the dismal performance in P_1 and p_2 could be corrected by the use of experiments, since learning through experiments enhances memory retentions Aggarwal (1995).

The overall standard deviation recorded in 2006 was 37 compared to 36.72 in 2011. This reflects huge disparity between the high and low achievers. There is need to find methods that can be used effectively to reduce this disparity. The overall performance mean has reduced from 80.63 in 2006 to 73.28 in 2011. This is a worrying trend since much effort has been put in by the stake holders.

The SMASSE programme which was piloted in 1998 and implemented in 2002 has made significant steps in advocating for the student centred approaches in the teaching of science and mathematics in secondary schools. A similar program has now been extended to the

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primary school teacher education to strengthen the foundation in science studies. Jean (1955) said that teaching must entail an active method as opposed to mere verbal transmission.

Tsuma (1998) seconded Albert Einstein's' statements that pure logical thinking cannot yield as any knowledge of the empirical world. In fact all knowledge of reality starts from experience and ends in it. The discovery method of teaching is fashioned from the constructivist's view where the learner constructs and even creates his/her knowledge. He then assimilates it with existing knowledge. The Nuffield approach to learning which emphasized learning of science by discovery or the problem solving method did not succeed because most of the materials that were used were imported and were unsuitable for the Kenyan. Given that science teachers are trained of improvisation, it is possible to use Discovery Experiments Method (DEM) to generate new knowledge. The knowledge encoded from data by learners themselves is more likely to be flexible and transferable than knowledge encoded for them by experts and transmitted to them by an instructor or other delivery agents (Cushing, 1998).

According to Hanrahan (1998), a teaching method that involves students' contributions and activity is more likely to lead to productive learning than a formal method of teaching Von and Juilfs (1957) noted that the learning of physics is rooted in experiments, in active, inquisitive and skilful intercourse with nature. However all experiments are blind if they are not guided or at least interpreted subsequently, by theoretical consideration. Thus for maximum learning to take place the student has to be active and should make an attempt to make meaning from every step of the experiment by being actively involved. Aggarwal (1995) says that clear images or concepts are formed when we see, hear, touch, taste and smell as our experiences are direct, concrete and permanent. The DEM method of learning provides learners with opportunity to firsthand experience with nature thus reinforce retention of knowledge and concepts learned.

Bruce, Marsh & Emily (2009) described self actualization as a state that not only enables people to venture and take risks but also to endure the inevitable discomfort felt when attempting to use unfamiliar skills. The DEM approach to learning exposes students to pleasant discomforts which promote learning and self actualization and hence provides positive reinforcement.

Learning that is meaningful to students is developed through discoveries that occur during exploration motivated by curiosity (Bruner, 1964). Okere (1996) discussed that teachers should maximize the degree to which learners expand their knowledge by developing and testing hypothesis rather than merely reading or listening to verbal presentations of information. Emphasis is to be put on activities that encourage students to search, explore analyze or actively process input rather than merely respond to it. When this approach to teaching is practiced in physics, the students mind is opened to understanding how the general physics principles and laws came about.

Failure in discovery learning is seen as a positive circumstance (Bonwell, 1998). Thomas Edison tried 1,200 designs for light bulbs before finding one that worked (Love, 1996). He never got discouraged because he felt that he had learnt thousands of designs that do not work. Therefore learning also occurs through failure. This is in agreement with (Shank & Clearly, 1994), psychologists who showed that failure is central to learning. They argued that if a student does not fail while learning, the student probably has not learnt something new. The DEM approach to learning exposes students to circumstances of failure hence learning through mistakes.

Students exposed to DE go through a natural progressive process which enhances learner's internalization of concepts (Papert, 2000). This makes learning more permanent as opposed to traditional methods of learning that are fact based that result in rote learning (Mosca & Howard 1997, Bonwell, 1998 & Papert, 2000).

Employers are now interested more in employees with good problem solving techniques. Learners in huge business enterprises such as general motors, Microsoft, Safaricom and Rank Xerox look for employees who can easily adapt to change by requiring little training once they are hired (Lunenburg, 1998). Graduates from schools are expected to collaborate, work in teams, teach others and negotiate (Rice & Wilson, 1997). Further business and society expects graduates to acquire, interpret and evaluate data to learn reason and solve problems. It is possible to sharpen these skills by training students through DE in physics. By this century, there is little research that has been done to compare the DE with traditional methods of teaching. The design adopted in this study was to fill this gap.

HYPOTHESIS OF THE STUDY

The following null hypothesis was postulated and tested at 0.05 $\propto$ level of significance.

$H0_1$: there is no significant difference between the achievement scores of the students taught through DE and TDE.

METHODOLOGY

Research Design

The study adopted a quasi-experiments Design, specifically the Solomon four group quasi experiment design.

E_1	O_1	X	O2
C_1	O_3	_	O4
E_2	_	X	O5
C_2	_	_	O6

E_1 and E_2 were experimental groups. X was the treatment (DEM) while C_1 and C_2 were control groups. The students in the control groups were taught through teacher demonstration methods.

The design adopted was suitable for this research since it is thorough and rigorous. The pre-tests were used to determine whether the students had similar entry characteristics. Comparison between experimental group 1 and control group 1 may be used to reveal any achievements due to pre-test. Comparison between experimental group 2 and control group 2 reveals the effects of the DEM on the physics achievement. Comparison between experimental groups reveals the effect of pre-test on the student's achievement.

Participants

The target population was form two physics students in secondary schools in Kenya. The three schools that participated in the research were randomly sampled from lists of schools purposefully sampled within the County. Full classes participated in the research because the students could not be re organized for research purposes. Twenty scripts from each group were randomly sampled marked and used for analysis

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Research Instrument

The Physics Achievement Test (PAT) was administered to the students to measure the level of achievement. The test items were about cells and simple circuits as discussed in KLB (2007) physics book one. The test items had been validated by physics teachers who have also been participating in the marking of Kenya national examination council (KNEC) physics exams

Pilot Testing and Data Collection

The research instrument (PAT) was pilot tested on students in a different mention the County who had similar characteristics. The Pearson co-relation coefficient was found to be 0.79 meaning that the instruments were reliable. Each group consisted of twenty form two students. Students in group one were exposed to a twenty test item before being taught concepts on cells and simple circuits by using the DEM method. A post test was then administered to them after instruction. The students in the group 2 did not participate in the pre-test but participated in the post-test similarly the students in group 3 were exposed to pre-test and post test without the treatment (DEM). The fourth group consisted of students who were involved in the post test without the treatment (DEM).

The head teachers of the schools to be involved in the research were informed about the requirements of the DEM strategy. The researcher then used the DEM manual to train the teachers. Post-tests were administered two weeks after the pre-test had been administered.

The mean scores and standard deviations for each group were computed. The responses were analyzed using descriptive and inferential statistics. All teachers who were used in this study were of the same training and gender.(level of training and gender is not mentioned)

RESULTS AND DISCUSSION

Effects of DE on student's Achievement

The students in the first experimental and control groups were pre-tested and post-tested using the PAT on the cells and simple circuits. The mean, mean gain and standard deviations for the groups are shown in table 2

Table 2. Mean scores, mean gains and standard deviation as obtained by the students on the PAT

Scale	*E_1 N= 60*	*E_2 N= 60*	*C_1 N= 60*	*C_2 N= 60*
Pre- test mean	37	-	38	-
Standard Deviation	13	-	16	-
Post- test mean	62.9	62	53	51
Standard Deviation	14	13	16	18
Mean Gain	25	-	15	-

Before the commencement of the instruction process the experimental group registered a mean of 37 on the pre-tests while the control group registered a mean of 38. The control group had a high standard deviation meaning that it was less cohesive. The experimental groups registered a high mean (62.9) compared to that of the control group (53) during the post-test. The post test scores for the experimental groups had a high standard deviation compared to those of the control groups. However experimental groups realized high mean gain (25) compared to that of the control group (15).

To test for significant difference in achievement the t-test was carried out on the pre-test scores. The result is presented on table 3.

Table 3. The t- test of the pre-test scores on the PAT at 19df

Scale	*t- Value*	*Critical Value*
PAT	0.288	1.729

The t value of 0.288 obtained was less than (1.729) the critical value at 19 df and ∝ level of 0.05. This revealed that there were no significant differences between the experimental and control groups. Therefore variations in the scores could be attributed to the treatment. To test on the distribution of scores between percentiles the results of pre-test and post-test were tabulated on a frequency distribution table. The frequency distribution of the pre-test and post-test scores obtained by subjects on the PAT is presented in table 4.

Table 4. Frequency distribution of the pre-test and post- test scores on PAT

Class	*Test*	E_1	E_2	C_1	C_2
0-24	Pre- Test	6		8	
	Post- Test	0	0	0	1
25-29	Pre- Test	42		37	
	Post- Test	8	12	18	7
50-74	Pre- Test	12		14	
	Post- Test	39	34	35	10
75-99	Pre- Test	0		1	
	Post- Test	13	14	5	2

Experimental group 1 (E_1) had 13 students within the upper quartile while experimental group 2 (E_2) had 14 students in the upper quartile. The control groups C_1 and C_2 had 5 and 2 students in the upper quartile respectively

Within the experimental groups no student scored marks in the lower quartile compared to the control groups where there was 1 student within the lower quartile. Both experimental groups had the same distribution of scores around the mean which implies that the pre-test had no effect on the achievement of students within those groups.

This was unlike the control groups where the pre-test greatly affected the distribution of marks around the mean. The scores for the experimental and control groups were exposed to the t-test. The t-test result is displayed on table 5 below

Table 5. The t-test results of the post test scores on the PAT 19 df

Scale	*Calculated Value*	*Critical Value*
PAT3	0.946	1.729

The t-test revealed that there was no difference between the post-test scores obtained by experimental groups and control groups at 19 df and 0.05 ∝ level. The null hypothesis was accepted.

DISCUSSION OF RESULTS

The results of this study indicated that there was a significant difference in the physics achievement of students in experimental and control groups among secondary schools students in favour of the DEM. The results are in line with Wachanga (2002) who communicated that a method that promotes positive interaction trains students to use conflict to stimulate the search for more information and rethinking of conclusions.

The DEM approach enhanced memory retention and instilled confidence in students. It also assisted students to remember and apply knowledge accurately. The findings of this study are consistent with Nelson and Fayer (1972) discussion on the use of discovery experiments for better retention of concepts learnt.

The DEM assisted students to remember and apply knowledge correctly. Okere (1996) cited four tenets of scientific creativity which comprised: Sensitivity to problems, Recognition of relationships, and Flexibility in reasoning and planning for an investigation. The DEM approach stimulated recognition of relationship which enabled students to form correct concepts. It also allowed for flexibility in reasoning which assisted students to correct misconception that had been earlier formed. Research findings by Okere (1986) on scientific creativity amongst A-level and first year university physics students in Kenya revealed low levels of creativity. This was attributed to lack of necessary learning equipments and little practice. Exposure of students to the DEM approach therefore increases creativity in students and thus enables students to respond to unique problems and situations.

Meissiner (2000) discussed that creativity is a strong mental catalyst to logical and divergent thinking beyond the normal mental box in solving daily problems. One of the objectives of teaching physics at secondary schools is to produce problem solvers. The DEM increased creativity in students. Through this approach the above objective may be achieved with much ease.

CONCLUSIONS

The findings of the study led to the following conclusions. That there was a difference between the achievement scores of students taught through DEM and TDE in favour of DEM. Further, the study also revealed that there was less disparity between the scores taught through DEM (SD= 18) and of those taught through TDE. Therefore DEM can be used to bridge gaps between high and low achievers.

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