Improving Students' Application of Moment of Force Concepts in Physics through Experimental Approach, a case of Secondary Schools in Marakwet West Sub-County, Elgeyo Marakwet County, Kenya

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Abstract

An investigation was carried out to ascertain the effectiveness of experimental approach on students' application of moment of force concepts in Physics in secondary schools in Marakwet West Sub-county, Elgeyo Marakwet County, Kenya. This investigation was informed by the reviewed literature which showed that students are not able to apply moment of force concepts to solve moment of force problems in physics examination due to predominant lecture method of teaching used in physics lessons. The study was carried out in seven selected secondary schools in Marakwet West Sub-county, where students have persistently scored low grades in the subject. The objective was therefore, to investigate the effect of this approach on students' application of moment of force concepts. In the investigation, a quasi-experimental nonequivalent group design was used. Stratified sampling was used to cluster schools into four strata. Simple random sampling technique was used to select two schools from each stratum. Simple random sampling was further used in placing the selected schools into either experimental or control group. Data was collected from a sample of 271 students sampled from 1500 target population. Tests on moment of force were used as vital instruments for collecting data. The data obtained was analyzed using t-independent tests with the aid of SPSS. The findings showed that students taught through experimental approach performed better in retention and application tests in posttest as compared to those students taught through lecture method. From the findings, it was recommended that all schools laboratories should be equipped with teaching/learning materials as well as improvisation of these materials whenever they are inadequate for moment of force concepts to taught experimentally. These results will be useful to Physics teachers, curriculum developers (KICD), and policy makers.

Keywords: experimental approach, students' application of moment of force concepts

INTRODUCTION

Experimental approach entails any science teaching and learning activities in which students are allowed to observe, interact and manipulate learning materials with the aim of making them to develop deep mastery of scientific concepts (Abraham & Millar, 2008). Most importantly, in this approach the teacher allows the students to interact with the learning materials as he/she facilitates the learning process. Experimental approach is a learner-centered approach in the sense that it views the teacher as a facilitator who provides guidance and support for students throughout their learning process without owning the entire process of learning. Students therefore, play an active and participatory role in the learning process (Lak et al., 2017). Experimental

approach has been viewed as fundamental to improvement of science teaching (Agostini & Delizoicov,2009) which implies that the declining performance in sciences especially in Physics is due to limited or absence of students' experiments. According to Soares et al. (2016), science experiments play the role of arousing the learners' interest to learn, enable learners to have better assimilation of the content and increase the learning ability in learners. Based on these three importance of science experiments, limited or absence of experiments jeopardizes learners' interest to learn which in turn affect their application of scientific concepts in their daily lives.

Application is a third order skill according to Bloom's cognitive domain. It involves using a concept in a new situation or unprompted use of abstraction. The learner is required to use what was learnt in the classroom into novel situations. It is important to note that when learners are able to tackle application questions in a test is an indication of learners' understanding of concepts taught by the teacher. In the context of this study, application refers to the ability of the learner to use the formula of a moment of a force, principle of moments and other concepts of moments to solve problems involving moments. The rationale for teaching moment concepts in secondary school physics syllabus is to prepare students to work in various sectors of economy such as transport industry and construction industry. Therefore, students' application of moment of force concepts in physics is of great importance. However, students perceive moment of force concepts as difficult to be conceptualized due to lecture approach used by physics teachers as indicated by Menjo (2013). This finding was also supported in KNEC (2016) Physics report which indicated that candidates were not able to apply principle of moments and other moment of force concepts to solve problems. It was on this background that the current study was carried out.

LITERATURE REVIEW

Literature reviewed reveal that students perceive moment concepts as difficult and hence they perform dismally on moments. For instance, a study by Kiptum (2015) investigating difficult physics topics in Kenyan secondary school students in Uasin Gishu County found that 28% of the students sampled perceived the topic on moment of force as difficult and 44.4% of teachers interviewed indicated the same topic was difficult to students. Another study which showed similar results was a study by Erinosho (2013) which investigated challenging concepts in Physics to students found that 20% of the students sampled indicated moment concepts as difficult to them, citing the cause of difficulty as hard to recall moment concepts due to absence of experiments organized by physics teachers.

The difficulty in learning moment of force concepts by students has been linked to lecture method of teaching as pointed out in a study by Ganyaupfu (2013) that poor performance in physics is attributed to conventional method of teaching. Conventional method of teaching is said to dominate physics teaching as pointed by Jones and Wyse (2004) that most science lessons are not taught through experiments. KNEC (2016) Physics report pointed out that candidates were not able to apply the principle of moments to answer questions demanding the application of the principle. This was an indication that students have poor mastery of moment concepts. The current study explored experimental approach to teaching moment of force concepts and its effect on students' application of moment concepts. The researcher opted for this approach after studies revealed that teachers are not using this approach effectively. For instance, it was established that science teachers do little to organize practical activities to support students' development of scientific ideas (Abrahams &Millar,2008). There is therefore sufficient evidence to link students' poor performance on moment of force concepts to

teacher-centered approaches. For instance, a study by Sakala (2013) on factors contributing to excess use of the lecture method of teaching among high school teachers highlighted overcrowded classes, inadequate teaching and learning materials and rush for syllabus completion. Therefore, students' poor performance on moments is due to the usage of lecture method. It was shown by the results of the current study that students' application of moment of force concepts improved when students are taught through experimental approach.

A study by Sogoni (2017) also highlighted that Physics teachers commonly use the lecture method in their daily teaching as a result of this approach, students have developed difficulty in applying moment of force concepts. The current study opted for experimental approach to teaching of moment of force concepts since it has been shown that experimental approach enhances better retention and application of scientific concepts in learners. For example, a study by Martins-Omole et al. (2016) showed that the usage of experimental approach enhances greater retention of biological concepts in learners. It has also been reported that experimental approach is a suitable approach which enhances students' motivation and development of inquiry mind (Dhanapal & Wan Zi Shan, 2013). The results obtained from this investigation also showed that experimental approach improved students' application of moment of force concepts better than lecture method. However, a study by Bala et al. (2017) showed contradictory results that lecture method of teaching is better than other methods of teaching, citing the ability of lecture method to present content in more organized manner.

There is sufficient background to attribute students' poor mastery of moment of force concepts to predominant usage of lecture method as physics teachers hardly use experimental approach due to lack of laboratories in schools, limited space in the laboratory and insufficient laboratory resources (Kapting'ei & Rutto, 2014).Similar results were obtained by Makunja (2016) who reported that insufficient teaching and learning resources was a challenge facing implementation of competence-based curriculum in Tanzania. Based on the literature reviewed, experimental approach to teaching and learning science concepts despite being recommended as suitable approach of learning science is not effectively used by physics teachers due to various challenges such as inadequate teaching and learning materials, overcrowded classes and rush for syllabus completion. This literature also shows little have been done on experimental approach of teaching on students' application of moment of force concepts. The gap was filled by this study in that it has shown that experimental method of teaching enhances better application of moment of force concepts and physics teachers are encouraged to frequently use this approach when handling moment of force concepts

METHODOLOGY

Study Population

The study targeted 1500 Form Two students in Marakwet West Sub-county. Form two class was suitable for this study because the topic moments is in form two physics syllabus.

Sample Size

A sample is a subset of the population (Sekaran & Bougie, 2010). A sample in research is of great important in that it saves money and time. The study area (Marakwet west sub-county) had a total of 26 secondary schools. Stratified and simple random sampling techniques were used in this study. The researcher used stratified sampling to

divide the schools into four strata namely National, Extra-County, County and Sub-County. The name and the category of each school was written in a small piece of paper, then the paper was folded into smaller size. Schools falling under the same stratum were grouped together. Simple random sampling was used to select two schools from each stratum, except for the national category which had only one school and hence, the school was automatically picked. The selected schools from each stratum were mixed up in a small box then simple random sampling was further used. The first three schools to be picked from the box were identified and assigned experimental group while the remaining four schools in the box were also identified and assigned control group. The number of students who were in control group was 149 while those who were in experimental were 122. Hence, the total number of Form two students in the 7 schools which participated in in the study was 271. The sample size was below the expected number because in all the schools sampled, students had selected the subjects and few students had chosen physics subject.

Instruments of the Study

Research instruments are measurement tools designed to obtain data on a topic of interest from research subjects. Before the commencement of the main treatment (Experimental method of teaching), the subjects in the experimental and control groups were pretested using Moment Test 1 to determine the abilities of the two groups.

Thereafter, experimental group was taught through experimental method of teaching while the control group was taught through lecture method of teaching for a period of one week as per Kenya Institute of Curriculum Development (KICD) Physics syllabus. The researcher was assisted by the teachers of Physics in the selected schools to administer the tests. Moment Test 2 was administered as post-test to both groups after a period of four weeks to assess the effect of the treatment.

Validation of the Instruments

An instrument is said to be valid if it measures what is designed to measure (Robson, 2011). In quantitative research validity is the extent to which any measuring instrument measures what it is intended to measure (Thatcher, 2010). Criterion referenced tests; Moments Test1 and Moments Test 2 were developed by KCSE Physics Paper One examiners using Form 2 Physics textbooks approved by KICD and questions from Kenya National Examination Council (KNEC) past papers. Physics Paper One examiners were chosen since the topic moment of a force is tested in Paper 1 in KCSE examination. Therefore, the tests met face, construct and content validity.

Data collection procedure

An introductory letter from the University was obtained, then the letter was attached with other documents and permit was applied from National Commission of science Technology and Innovation (NACOSTI) charged with responsibility of issuing the permits for research in Kenya. Upon issuance of the permit by the commission, the researcher reported to County Commissioner and County Director of Education offices before carrying out data collection of the study. During the survey of the selected schools and actual data collection the purpose of the research study was explained. The researcher inducted Physics teachers on how to teach the topic moment of a force through a comprehensive prepared instructional manual for Physics teachers.

Data Analysis

The analysis was performed using inferential statistics (t-test) in (SPSS) version 23, to determine whether there was significant difference in the pre-test scores between the control and experimental groups and in post-test scores.

RESULTS

Pre-test Scores

A pre-test was administered to experimental and control group of students by the inducted physics teachers in their respective schools at the beginning of the research period. The results obtained were as follows:

Table 1: Students' Mean and Standard Deviation in Pre-test

	Type of Group	N	Mean	SD
Pre-test Score	Control Group	149	36.95	13.095
	Experimental Group	122	36.16	13.201

Table1 shows the means and standard deviations of the control and experimental group during the pre-test. The mean recorded by the group of students to be taught through lecture method was 36.95% while those to be taught through experimental approach were 36.16%. The mean difference between the two groups was 0.79%. The researcher subjected the pre-test scores of both the groups to a t-test to determine the equality of their means. The results were as presented as shown by Table 2:

Table 1: T-test for Equality of Means in Pre-test

	t-test for Equality of Means						
	T	Df	Sig.(2-tailed)	Mean Difference	Std.Error Difference	95%Confidence Interval of the Difference	
						Lower	Upper
Pre-test Scores	-0.496	269	.620	-0.7973	1.6060	-3.9593	2.3647

Table 2 contains the results of a t-test comparing the mean scores of the pre-test between the two groups.

The p-value that was obtained was 0.620. Since the p-value was greater than 0.05, it was inferred that there was no significant difference in the means of the control and experimental groups. It was therefore concluded that the two groups of students were of equal ability which was a necessary condition for the research to have proceeded. The participants in the experimental group were then subjected to the treatment.

Treatment

After the pretest (Moment Test 1), the control groups were taught through lecture method of teaching where by the students were instructed with traditionally designed physics lessons in which the teacher majorly used lecture method to teach moment concepts in physics. The experimental group on the other hand was instructed through experimental method where the teacher guided the learners as they do experiments involving moments. During the instruction process, moment concepts were covered for one week as per Physics syllabus approved by KICD. The classroom instruction of the groups lasted for 40 minutes for a single lesson and 80 minutes for a double lesson. For teachers teaching the experimental groups, students were allowed to manipulate learning materials to actively explore moment concepts and the teacher discusses the results with the learners at the end of every experiment. After the completion of the instruction period of one week, the two groups were given a post test (Moment Test 2) after a period of four weeks to test for the effect of the treatment on the experimental group.

Post-test Scores

Table 3: Students' Means and Standard Deviations in Post-test Application Tests

Type of Group	N	Mean	SD
Control group	149	40.68	11.265
Experimental Group	122	55.02	10.082

Table 3 shows that the Application Test scores of the post-test for both the experimental and control groups. The mean score of application test for control group was 40.68% while that of the experimental group was 55.02%. It was observed that experimental group performed better than the control group in application test since the mean difference was 14.34%.

Hypothesis Testing

The hypothesis of the study stated that there is no significant mean difference in the application of moment concepts in physics between learners instructed through experimental method and those instructed through lecture method of teaching. This was determined by conducting a t-test on the post-test application scores to establish if there was any significant mean difference between the two groups.

Table 4: T-test for equality of Means in Post-test Application Test

	t-test for Equality of Means						
	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Post-test Application Scores	10.926	269	.000	14.340	1.313	11.756	16.924

Table 4 shows the results of a t-test that was carried out on moment application test scores administered to the students. The p-value that was obtained was 0.000. Since, the p-value was less than alpha at 0.05, the null hypothesis was rejected. Hence, it was concluded that there was a significant mean difference in the application of moment of force concepts between learners instructed through experimental method and those instructed through lecture method. This implies that experimental method enhanced application of moment of force concepts better than the lecture method of teaching. It is evident from these results that students taught through experimental approach were able to conceptualize concepts which in turn enhanced their application. This is because experimental method enables students to experience phenomenon.

DISCUSSION

The analysis of pretest scores showed that the two groups of students had equal ability. Hence, there was no significant difference between their means. The results show that students taught through experimental method of teaching were able to apply moment of force concepts taught than those students taught through lecture method. The researcher attributed the difference in means to treatment given to experimental group. Experimental method of teaching enhanced better application of moment concepts among the learners than the lecture method because it enabled students to experience the phenomenon being discussed in the classroom. This method is more efficient than lecture method of teaching in that it incorporates 5Es instructional model in the teaching process as explained by Thuo, (2017). The model ensures that the learners are

engaged (E) in the setting of experiment, they are allowed to explore (E) through trial and error as the make their observations, they are given opportunity to explain concepts using their own language (E) as the teacher correct them where necessary. The demonstrate deep understanding, the teacher may ask the learners to elaborate (E) their answers by giving related examples and they are able to evaluate (E) their understanding. This enhances deep learning as evidenced by the post-test scores of the experimental group. The researcher viewed experimental method of teaching as the most suitable for teaching moment of force concepts. A study by Duru (2010) showed that experimental approach enhances better retention of knowledge and comprehension of geometrical concepts in students than those who were taught through lecture method. These findings were in agreement with the results of the current study. It was also observed that experimental approach enhances application of moment of force concepts among students. The findings of Amadalo and Ocholla (2012) which showed that intensive practical activities have a positive influence on students' achievement in physics concurs with the findings of the current study. However, the first study was not specific on the content area in physics unlike the present study which was on moment of force concepts. Despite experimental approach being seen as the most effective method of teaching and learning science, science teachers frequently use lecture method due to overcrowded classes, limited teaching and learning resources and demand for early coverage of syllabus (Sakala, 2013). This shows that learner-centered approaches are hardly use and hence students' inability to retain and apply scientific concepts as indicated by Kenya National Examination (KNEC) physics reports.

The results of this study were also consistent with the findings of a study by Martins-Omole et al. (2016) which indicated that the use of experiments makes better retention levels than use of lecture method. However, the current study was focusing on experimental method of teaching versus lecture method on moment of force concepts unlike the latter study which was focusing on experimental techniques verses concept mapping and lecture method in teaching biological concepts. It is evidenced from the results of this study that students who were taught through experimental method developed positive interest in the topic moment of force as indicated by their better performance in application tests compared with those taught by lecture method. However, the results of this investigation were inconsistent to those of Chaudhury (2011) on an extensive meta-review of the lecture method which revealed that lecture method is effective as any other method of teaching. Another study which disagreed with the findings of this study is a study by Loveland (2014) who found out that students disliked practical activities and prefer being passive.

CONCLUSION

It was concluded that students' application of moment of force concepts was improved through experimental approach. This was evidenced by better results posted by students taught through the approach. The researcher noted that despite experimental approach being seen as the most effective method of teaching and learning science, science teachers frequently use lecture method due to overcrowded classes, limited teaching and learning resources and demand for early coverage of syllabus by school administrators which have mounted a lot of pressure on them and hence opting for lecture method.

RECOMMENDATIONS

Firstly, experimental method of teaching should be adopted in teaching and learning of moment of force concepts. Secondly, the challenges of inadequate learning materials should be addressed by schools' administration and teacher's improvisation. Thirdly,

Teachers Service Commission to employ more physics teachers to reduce heavy work load as it was observed that heavy work load has resulted to physics teachers not having adequate time to plan for practical activities hence students have developed negative attitude towards physics subject and physics experiments.

Lastly, the Ministry of Education (MoE) in collaboration with other stakeholders should strictly ensure that all schools are covering syllabus up to third term as most schools' administrations put a lot of pressure to physics teachers to complete syllabus as early as March. This has resulted to teachers rushing without organizing for students' practical activities.

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