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EFFECTS OF PROBLEM BASED LEARNING APPROACH ON SECONDARY SCHOOL STUDENTS' MOTIVATION TO LEARN PHYSICS IN ISIOLO COUNTY, KENYA

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ABSTRACT

This study investigated the effects of Problem-Based Learning (PBL) approach on secondary school students' motivation to learn physics in Isiolo County, Kenya. Physics is an important subject because of the role it plays in industrial, technological, and economic development of countries. Despite the importance of physics, students' enrolment and performance in the subject in Isiolo County has generally been low. This has partly been attributed to low levels of motivation to learn physics. Teaching approaches have been cited as one of the factors that affect students' motivation. The study employed the Solomon's Four Non-Equivalent Control Group design. The target population was 640 form two students in public co-education secondary schools in Isiolo County. The accessible population was 265 forms two students in public co-education schools in Isiolo Sub County. Simple random sampling techniques was used to select the four co-educational schools which participated in the study. Two of these schools were in the experimental group while the rest were in the control group. The sample size comprised of 128 forms two students. A Teaching Manual was utilized to induce teachers from experimental schools on use of PBL approach for one week. Data was collected using the Learner's Motivation Questionnaire (LMQ). Analysis of Variance (ANOVA) and the t-test were used to test the hypothesis at $\alpha = .05$ confidence level. The findings indicated that students exposed to PBL had a higher level of motivation than their counterparts taught through conventional methods. The findings also indicated that the difference in motivation to learn physics between the two groups was not statistically significant. It was concluded that PBL boosts students' motivation to learn physics. However, the approach is not more effective in improving students' motivation to learn physics when compared to those taught using conventional teaching methods.

Keywords: Effects, motivation, problem-based learning approach.

INTRODUCTION

Physics is a branch of science that examines causes of natural phenomena, and laws and principles that govern them. It is concerned with properties of matter, energy, motion, and force. Physics is among the science subjects that are taught in secondary schools, tertiary institutions, and universities in Kenya. This could be due to the significant role the subject plays in industrial and technological development, which are among the pillars of Vision 2030. The Vision calls for use of Science, Technology, and Innovation (STI) to increase productivity and efficiency in economic, social, and political pillars of Kenya. The Vision aims to transform Kenya into a country with a high standard of living and be competitive globally by 2030 (Kibe, 2021).

The Ministry of Education in Kenya has recognized physics as one of the key subjects for industrial development and has encouraged secondary school students to study it (Ngatia, 2019). The aims of teaching physics are to promotion scientific knowledge about the physical world, sharpen logical thinking and technological advancement of learners, enhanced their scientific attitudes and ability to solve societal problems (Strengthening of Mathematics and Sciences in Secondary Education [SMASSE], 2004). Physics is a core subject in the first and second years of secondary school education but is an elective in the third and fourth years (Kitavi, 2019).

Physics is a fascinating subject, one would assume it would attract many students, However, the number of students who enroll for physics is generally low as they tend to avoid it when they are provided with alternatives as it is considered difficult (Njoroge, et al, 2014). Reports from Kenya National Examination Council (KNEC) show that the number of students who enrolled for KCSE in 2016 were 574, 125 while those who sat for physics were 149,790 (KNEC, 2016). In 2019, the number of students who enrolled for KCSE were 697,222 while those who registered for physics were184,589. Low enrolment was also recorded in 2020 as only 199251 registered for the subject against 752602 who sat for KCSE. Low enrolment in KCSE physics has also been observed in counties such as Isiolo. The number of candidates from Isiolo who registered for KCSE for the years 2018 and 2020 were 1351 and 1650 respectively (KNEC, 2021). The number of candidates who sat for KCSE physics during that period were 214 and 279 respectively (County Director of Education, 2020).

Students' performance in physics has also been unsatisfactory as shown by results from the Kenya National Examination Council (KNEC, 2016, 2018, 2020, 2022). These results indicate that the national mean scores for the years 2015 to 2021 were 31.84%, 37.50%, 35.05%, 34.27%, 32.59%, 35.52% and 29.70% respectively. Unsatisfactory performance in KCSE physics has also been observed in many counties among which is Isiolo. The county comprises of three sub-counties, namely; Isiolo, Merti, and Garbatula. Students performance in KCSE physics in the three sub counties of Isiolo county has generally been low as shown in Table 1.

Table 1: Isiolo County Students' Physics KCSE mean Scores by Sub County

Sub-Counties	Year					
	2015	2016	2017	2018	2019	2020
Garbatula	20.89	29.42	24.91	25.11	21.09	19.23
Merti	20.02	25.89	25.42	28.90	23.89	19.90
Isiolo	19.91	22.91	27.87	23.97	19.06	18.99
Isiolo County	20.27	26.07	26.06	25.99	21.35	19.37

(Source: Isiolo County Education Report 2016, 2018, 2021)

Data in Table 1 reveal that performance in the subject was low as the mean scores for all the six years were below 30%. Several reasons have been advanced to explain low enrolment and poor performance in physics. They include availability of instructional materials, instructional leadership, school and teacher chracteristics, and home environments among others (Kiptum, 2016; Sakwa, 2018; Rotgans & Schmidt, 2019; Usaini et al., 2015). Low motivation to learn physics has also been cited as one of the factors that affect enrolment and performance in the subject (Njoroge et al., 2014).

Motivation is is a psychological term which refers to the desire of wanting something and working on getting it (Montevelli et al., 2020). Argaw et al. (2017) refers to it as a willingness, need, desire and compulsion to participate in and be successful in doing something. Motivation can either be intrinsic or extrinsic. Intrinsic motivation is an encouragement and drive that comes from within which leads to satisfaction (Tokan & Imakulata, 2019). Extrinsic motivation on the other hand is concerned with behaviours that are driven by external rewards or reasons and not self-satisfaction. Extrinsic motivation generally consists of recognition and praise for good work. Hanus and Fox (2015) contend that motivated students learn better because they are more engaged, retain information better, and are generally happier than other students. However, many students today lack the motivation to be successful in school as evidence by low levels of effort, inattention, poor task persistence, class cutting, and high rates of discipline problems exhibited by students (Tran, 2019).

Studies have shown that motivation to learn is affected by many factors (Holubova, 2015,; Motevalli, 2020). The factors include self-efficay and poor relationships between teachers and students. Argew et al. (2016) found that students' self-efficacy affected their effort and persistence to perform difficult tasks. Learners with low self-efficacy tended to avoid challenges, did not put a lot of effort in their work, and believed that they were not in control of their learning (Schunk & Zimmerman, 2012). Fan and Williams (2018) attribute poor relationships to lack of interest in students and degrading comments by teachers. Academic achievement is also a factor, since when students have a history of failure in school, it is particularly difficult for them to sustain the motivation to keep trying (Anderman & Koenka, 2017). Student's motivation to learn is also depend on availability of professional teachers, adequate laboratory facilities and teaching approaches (Ngatia, 2019; Weiner, 2014).

Various teaching approaches are used in physics instruction, among these are the lecture, experiments, demonstration, discussions, project work and field excursions (Namasaka et al. 2017; Smith et al., 2018). PBL is also among the approaches used in the teaching of physics (Tran, 2019). PBL is a teaching approach in which students are taught concepts and principles via the use of challenging real-world problems rather than through the direct presentation of facts and concepts (Tsybulsky & Muchnik-Rozanov, 2019). It involves students working in groups, each student takes on a formal or informal role within the group, which is frequently switched. The approach aims at enhancing a student’s ability to learn through setting learning objectives, reflection and reasoning, clarifying words, defining the problem(s), brainstorming, organizing and hypothesis (Puccio et al., 2020). Individual study, and synthesis are also part of the PBL process.

PBL has been shown to boost students’ motivation as as evidenced by their improved interest and enthusiasm to learn , problem solving and intrinsic drive to become self-directed learners (Horak & Gallagher, 2015). Rotgans and Schmidt, (2019) noted that exposure to PBL impacted positively on students’ motivation to learn a subject compared to conventional teaching methods. They attributed this to the fact that PBL arouses students’ interest in learning and has a significant effect on their liking, and value of the subject. Mahanan et al. (2021) also noted that the PBL aproach improved students’ motivation to learn physics. The enhanced motivation was attributed to PBL’s ability to provide students with opportunities to interact and make fun as they learn. A study by Holubova (2015) observed improved motivation to learn Biology by students exposed to PBL approach. The study attributed the high levels of motivation among students exposed to PBL to its real-life nature and collaborative learning.

Purpose of this study

The purpose of this study was to investigate the effects of PBL approach on secondary school students' motivation to learn physics, with special reference to the topic, Measurement two. The topic was selected because students consider it difficult (Protus & Shikuku, 2020).

Objective of the Study

The specific objective was to compare motivation to learn physics between students taught using PBL approach and those taught using conventional teaching methods in secondary schools secondary schools in Isiolo County.

Hypothesis of the Study

There is no statistically significant difference in motivation to learn physics between secondary school students' taught through the PBL approach and those taught using conventional methods.

Methodology

This study employed the Quasi-experimental Solomon Four Non-Equivalent Control Group research design. The design was deemed appropriate because secondary school classes exist as intact groups once they are formed, and cannot be reconstituted for research purposes. Wango (2009) contends that it is unethical and contrary to Ministry of Education regulations to reconstitute classes for research purposes. The intact classes were randomly assigned to the four groups of this design. Figure 1 depicts the research design.

Group	Notation		
E_1	O_1	X	O_2
C_1	O_3	_	O_4
E_2	_	X	O_5
C_2	_	_	O_6

Source: Turner (2010)

Figure 1: Solomon Four Non- Equivalent Control Group Design

Where:

X was the treatment where learners were taught using the PBL approach.
E_1 was the experimental group that received a pre-test, treatment X, and a post-test.
C_1 was the control group, which received a pre-test followed by the control condition and a post-test.
E_2 was given treatment X and a post-test.
C_2 received the post-test only.
C_1 and C_2 were taught using conventional teaching methods.

The study was conducted in Isiolo County. The County is bordered on the north by Marsabit County, on the east by Wajir County, on the south by Garissa and Tana River counties, on the southeast by Meru County, on the southwest by Laikipia County, and on the west by Samburu County (King-Okumu et al., 2016). It covers an area of 25,336 square kilometers. The County comprises three sub-counties namely; Merti, Garbatula, and Isiolo. The Somali, Borana, Meru, Turkana, Samburu, and Rendile are the most populous ethnic communities in the County. The County's economy is mainly based on pastoralism and agriculture. There were 38 secondary schools in the County, with 16 of them being co-educational. The study location was selected due to the low levels of motivation to learn physics as evidence by low numbers of students who enroll for the subject and poor performance in national examinations. (KNEC, 2016, 2018, 2020).

The study targeted all form 2 students in public co-education secondary schools in Isiolo County. There were 16 co-education public secondary schools in the county with a total of 640 forms 2 students (Isiolo County Director of Education, 2021). The accessible population was 265 form 2 students in the 7 public co-education schools in Isiolo sub-county. The sub-County was chosen because it has been recording the lowest performance in KCSE physics compared to Merti and Garbatula (KNEC, 2016, 2018, 2020). Co-education public schools were chosen as a way of ensuring that those selected had similar characteristics in terms of teaching or learning resources, and learners' entry behavior. The form twos were selected because the topic Measurements Two is taught at that level and it is not an examination class (Kigo et al., 2018).
Simple random sampling technique was used to select the four public co-educational secondary schools which took part in the study. The four schools were randomly assigned to either treatment or control conditions. A form two class was then selected from each school. In schools that had more than one form of two streams, all of them were taught using the assigned teaching method for ethical reasons, and then simple random sampling used to pick one stream for the study. The sample size of students was 128, which was the sum of all students in the four classes which participated in the study.

A Teaching Manual was developed and utilized to induce teachers from experimental schools on use of PBL approach for one week. In situations where an experimental school had more than one physics teacher, all of them were inducted into the use of the approach. The other teachers who taught using the conventional methods were not inducted in the use of PBL. The Learner's Motivation Questionnaire (LMQ) was used to collect data. The instrument was adopted from Githua's (2013) student motivation questionnaire and modified to suit this study. It contained items on students' profile and indicators of motivation that are in literature. Motivation was measured using 28 close-ended 5-points Likert scale items based on the extent to which respondents agreed with them. The scale was; strongly Agree (SA), Agree (A), Undecided (U), Disagree (D), Strongly Disagree (SD).

The content and face validity of LMQ was examined by experts from the department of Curriculum Instruction and Educational Management, Egerton University. The comments and recommendations of these experts were used to refine the instruments before they were used to gather data. Reliability of LMQ was also estimated using a sample of 32 students from a school that was not part of the study but located within Isiolo County. The reliability coefficient of LMQ was estimated using the Cronbach Alpha method. The method was selected because it is recommended for estimating the reliabilities of instruments constructed using close-ended Likert-type items, and are administered once (Warmbrod, 2014). LMQ yielded a reliability coefficient of 0.793. It was deemed reliable since its coefficients was above the 0.7 thresholds recommended by (Mohajan, 2017).

A permit to conduct the study was sought from the National Commission for Science, Technology, and Innovation (NACOSTI) after getting clearance from the Board of Post-Graduate Studies at Egerton University. Once the permit was issued, the researcher sought permission to collect data from the Isiolo County Commissioner and Director of Education.

The researcher then formally contacted the physics teachers and students through their respective principals. The purpose of the study was explained to the respondents and their consent to take part in it was sought. Training on how to implement the module for teachers in the experimental schools was done for one week. Thereafter LMQ pre-test was given to C1 and E1 groups before the commencement of teaching the topic Measurement two. The experimental groups, E1 and E2 were taught utilizing the Problem Based Learning approach for three weeks, while the control groups C1 and C2 were taught using conventional methods. At the end of the teaching, LMQ was administered to each of the 4 groups (E1, E2, C1, C2), and the data generated was used as the posttests during analysis.

The collected data were checked for errors and entered in a data file prepared using SPSS. The difference in motivation to learn physics between secondary school students' taught through the PBL approach and those taught using conventional methods was determined using the ANOVA and t-test. It involved testing the study hypothesis at the .05 level of confidence. The statistical procedures were chosen because, when parametric assumptions are not violated, a t-test is ideal for determining differences between two groups, while ANOVA is recommended for comparing means of more than two groups (Field, 2018).

RESULTS AND DISCUSSION

The entry behavior of the students was examined by pretesting groups E1 and C1 on motivation to learn Physics. Pre-testing was conducted to ascertain whether the study groups were homogeneous. The pretest entailed comparing students' mean scores on motivation to learn physics teaching approach. The comparison was conducted using the t-test, the results of which are shown in Table 2.

Table 2: Results of the t-test comparing students' Motivation to Learn Physics Pretest Means Scores by Teaching Approach

Scale	Group	N	Mean	SD	Df	t-value	p-value
Motivation	E1	38	3.14	0.54	75	1.086	.281
	C1	39	3.26	0.47			

Critical values (df = 70, t = 1.990, p = .05)

Critical thinking skills: Calculated values (df = 77, t = 1.086, p = .281)

Table 2 shows that motivation mean score (M = 3.26, SD = 0.47) of C1 was not statistically significantly different from that (M = 3.14, SD = 0.54) of E1, t (75) =1.086, $\rho > .05$. These results are evidence that the two groups were homogenous before commencement of the research. The groups were therefore suitable for the study given that this is a requirement of the Solomon Four Non-Equivalent control group research design that was adopted.

Gain is the difference between the pre-test and post-test mean scores and is an indicator of changes (increase or decrease) in groups after undergoing treatment. Gain analysis was conducted to give an insight into the relative effects of treatment on groups that were pretested. The mean gains of E1 and C1 were calculated using their pretest and post-test scores as shown in Table 3.

Table 3: Students' Motivation to Learn Physics means Gain and their Standard Deviations by Teaching Approach

Group	Pretest		Posttest		Mean Gain
	Mean	SD	Mean	SD	
E1 (n = 40)	3.14	0.56	3.24	0.73	0.10
C1 (n = 39)	3.26	0.47	3.23	0.43	-0.03

Table 3 show that the motivation to learn physics mean of E1 (M = 3.14, SD = 0.54) and C1 (M = 3.26, SD = 0.47) were similar before the treatment. After the treatment, the mean score of E1 increased to 3.24 (SD = 0.73) while that of C1 declined to 3.23 (SD = 0.43). The mean gains of E1 and C1 were 0.1 and -0.03 respectively. The improvement in the mean score of E1 was thus higher relative to that of C1. A t-test was conducted to establish whether the difference between the mean gains of the two groups was significant. The results of the t-test are given in Table 4.

Table 4: Comparison of Students' Motivation to Learn Physics Mean Gain of E1 and C1

Category	N	Mean	SD	Df	t-value	p-value
Experimental	36	0.10	0.97	69	.704	.484
Control	35	-0.03	0.70			

Critical values (df = 70, t = 1.994, p = .05)
Calculated values (df = 69, t = .704, p = .484)

The t-test results indicate that the difference between the mean gain of E1 and C2 were not statistically significant, df (69) = .704, p> .05). The ANOVA and t-test analysis comparing students' motivation to learn physics by teaching approach posted statistically insignificant differences. Based on these results, the null hypothesis which states that the difference in motivation to learn physics between students taught through the PBL approach and those taught using conventional methods is not statistically significant was rejected.

The specific objective of study was to find out the difference in motivation to learn Physics between students exposed to PBL and those taught using conventional methods. The difference was determined using posttest mean scores of groups E1, E2, C1, and C2. The motivation to learn Physics posttest mean scores and their standard deviations for the four groups are summarized in Table 5.

Table 5: Students' Motivation to Learn Physics Posttest mean scores and their SD

Group	N	Mean	SD
E1	36	3.24	0.73
E2	27	3.27	0.40
C1	35	3.23	0.43
C2	30	3.11	0.33

An examination of the results in Table 5 indicates that motivation to learn physics posttest mean scores of groups E1 (M = 3.24, SD =0.73) and E2 (M = 3.27, SD = 0.40) were higher than those of the control groups C1 (M = 3.23, SD = 0.43) and C2 (M = 3.11, SD = 0.33). The results further indicate that the standard deviations of all the groups were less than 1. This is an indication that there was small variations among individual mean scores in the groups. The higher mean scores of the groups (E1 and E2) that were exposed to PBL suggest that the teaching approach affected motivation to learn Physics. The ANOVA test was used to find out whether the difference among the groups was statistically significant. This test compares variability in means scores between groups with that of within groups. The F-ratio, which is the variance between groups divided by variance within groups was computed and used as an indicator of differences. The results of the ANOVA test are presented in Table 6.

Table 6: Comparison of Motivation to learn Physics between students exposed to PBL and those taught using Conventional Methods

Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
Between Groups	.453	3	.151	.588	.624
Within Groups	31.856	124	.257		
Total	32.309	127			

Critical values: (df = 3,120, F= 2.680, p = .05)
Calculated values (df = 3,124, F = .588, p = .624)

The ANOVA test results show that the differences among the motivation mean scores of E1, C1, E2, and C2 were not significant at the .05 level, F (3,124) = .588, ρ > .05. An examination of the results in Table 6 show that the F-ratio was small, meaning that the variability within groups was wider than that of between groups. What does this mean Further analysis was conducted to establish whether they was any significant differences between pair groups. The difference between pair groups was determined using the Post Hoc test as shown in Table 7.

Table 7: Post Hoc test comparing Student's Motivation to Learn Physics by Teaching Approach

Paired group		Mean Difference (I – J)	p-value
I	J		
E1	E2	-0.03	.997
E1	C1	0.01	.999
E1	C2	0.13	.777
E2	C1	0.03	.997
E2	C2	0.16	.707
C2	C1	-0.13	.792

Table 7 shows the differences between all the pair groups E1 and E2 (p>.05), E1 and C1 (p>.05), E1 and C2 (p>.05), ‘E2 and C1 (p>.05), E2 and C2 (p>.05), and C2 and C2 (p>.05) were not statistically significant. This means that PBL was not more effective in boosting students’ motivation to learn compared to conventional teaching methods.

Additional analysis was conducted to find out whether there was a significant difference between the combined posttest means scores of treatment groups (E1 and E2) and control groups (C1 and C2). A t-test analysis was utilized during the comparison. The results of the test are in Table 8.

Table 8: Comparison of Students' Motivation to Learn Physics Posttest mean Scores between Control and Experimental groups

Category	N	Mean	SD	df	t-value	p-value
Experimental	63	3.25	0.60	126	.829	.409
Control	65	3.18	0.39			

Critical values (df = 120, t = 1.980, p = .05)
Calculated values (df = 126, t = .829, p = .409)

The t-test results revealed that the mean score of the treatment group was higher than that of the control group. However, the difference was not statistically significant, t (126) = .829, p > .05. These results reveal that PBL did not have more impact on motivation compared to conventional methods.

The comparisons by teaching approach done on motivation to learn Physics showed that PBL approach was not more effective in improving students' motivation to learn Physics compared to conventional teaching methods. These findings are in line with those of a study by Argaw et al. (2017) which showed insignificant improvement in motivation to learn between students exposed to the PBL approach and those taught using conventional methods. They argued that PBL was effective only if students were organized and facilitated to work in groups, consulting and sharing experiences that arouse interest in learning and enhanced their liking and value of a subject. These experiences which enhance motivation may not be realized if PBL is not implemented well. The study attributed the observation to the pedagogical view that students require adequate background knowledge in a subject area to effectively engage in problem-based learning processes. Perhaps this was lacking given that those who were involved in the study were form twos who had not covered much of the secondary school physics curriculum.

However, the findings are contrary to Rotgans and Schmidt, (2019) assertion that exposure to PBL impacted positively students' on motivation to learn a subject compared to conventional teaching methods. They argue that PBL arouses students' interest in learning and has a significant effect on their liking, and value of the subject. The results are also not in harmony with those of Mahanan et al. (2021) who noted that PBL strategy improved students' motivation to learn physics. The enhanced motivation was attributed to the fact that PBL provides students with opportunities to interact and make fun as they learn. The insignificant effect of PBL on motivation could perhaps be due to the way it was implemented. Woodrow et al. (2020) argue that motivation is enhanced only if the students are provided with adequate learning materials, lessons are well-planned and organized, and the psychological needs of learners are taken care of. The insignificant effect of PBL could also be due to the Physics knowledge base of the students. The respondents have formed 2 students whose general knowledge of Physics was low as they have not covered a large percentage of the syllabus. Barber et al. (2015) contends that prior knowledge is a key determinant of the success of PBL in enhancing motivation to learn since group dynamics, interest, and achievement of knowledgeable students are higher.

The observed insignificant difference in enhancing students' motivation to learn physics between the PBL approach and conventional methods could also be attributed to the fact that it's not easy to change students' motivation to learn physics given that the treatment took only three weeks. Soh et al. (2022) argue that motivation is a construct that is affected by many factors and requires time to change. They further argue that motivating student requires not only a change in teaching methods but greater knowledge of what motivates learners and ways of maintaining their engagement in academic activities,

CONCLUSION

Based on the findings of this study, it was concluded that PBL boosted students motivation to learn physics. However, the approach was not more effective in improving motivation to learn physics when compared to the conventional teaching methods. Even though the findings showed that PBL did not enhance motivation compared to conventional teaching methods, it can successfully be used to enhance students' motivation to learn Physics if it is implemented correctly and teachers are alive of the fact that form two students are in the early stages of development as self-directed learners.

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