Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.4, No.8, 2013

School Characteristics, Use of Project Method and Learner Achievement in Physics

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Abstract
The purpose of this study was to investigate how school characteristics affect the usage of the PM and the consequent impact on learner achievement in physics (LAP). Data was collected using Students Achievement Tests (SAT) and questionnaire for physics teachers. Stratified Sampling was applied to select 84 schools comprising boys, girls and mixed schools from seven provinces of Kenya. Statistical Package for Social Sciences (SPSS) was used to analyze the data. ANOVA, chi-square and multiple-regression were used to test the hypothesis. The key findings of the study were that PM enhances the learning of physics; Single sex schools performed better than mixed schools; the type of schools in terms of gender, whether day or boarding were not factors in the usage of project method. In view of these research findings, the researchers recommend that the government come up with a policy that enhances the establishment of more single sex schools, enhance resource mobilization for the teaching of physics, review the teacher training component so as to encompass the PM as an alternative teaching strategy, and in-service physics teachers on the role of school characteristics in the study of physics.
Key words: Physics; Learner Achievement in Physics (LAP); Project Method PM; School Characteristics (SC);

1 Introduction

Physics has been recognized as one of the fundamental sciences (Taylor, 1984) which promote innovations for sustainable development. In addition other sciences depend on physics, an indication that it is a base for technological development (Zhaoyao, 2002). For example, all apparatus and machines used in other science subjects apply various principles of physics. For instance, Chemistry requires the use of spectrometer, microscope, and telescope among other apparatus thus confirming the contribution of Physics in modern technology. Biology uses apparatus whose application depends on the principles of physics while Geology requires the use of carbon dating to detect the age of fossils and this solely draws its application from physics. These among others show the crucial role Physics plays in education by promoting technological development.

The study of Physics involves the pursuit of truth, honesty and diligence (Das, 1985) in improving the productive capacity of the life of the citizenry. It is in this sense that physics has capacity to provide learners with skills that enable them to live in harmony with the environment (Kleeves and Aikenhead, 1995). Based on this realization, Physics forms a critical role which emphasizes development through the application of science and technology and human resource development in this area would play a crucial role in rolling out increased output for sustainable development (Changeiywo, 2001). Further, physics occupies a central position in enabling developing countries like Kenya to realize their goals of industrialization. For instance, Kenya aims to be industrialized by the year 2030 as indicated in her development blueprint known as *Vision 2030*. To achieve this, more emphasis in science education should be inbuilt in the school curriculum across the tiers of education system, particularly, Physics (GoK, 2007).

1.1 Statement of the problem

Students have continued to perform poorly in the summative evaluation which comes after the four year cycle as evidenced by the results of the Kenya Certificate of Secondary Education (KSCE). This scenario occasion a major disadvantage to students as most science oriented courses that are offered at higher levels of learning requires one to have a good grade in physics. This low performance has been blamed on a number of factors, chief among them the pedagogical approaches that are applied by the teachers. Methods that promote active learner participation have been cited to produce better results as compared to methods that make learners inactive in the learning process. It is in this regard that the researchers intend to assess the impact of PM on learner achievement in the study of physics.

1.2 Research design

This study employed quasi-experimental research design involving Solomon's Four Non-Equivalent Control Group. Borg and Gall (1989) defined a research design as the process of creating an empirical data to support or refute a knowledge claim while Kothari (2004) defines it as the blue print for data collection, measurement and analysis of data. This design was suitable for this study because the achievement of the group taught with the project method was compared to the achievement of those not taught using the same method. It is of the nonequivalent design because the learners used in the study varied in number and characteristics. Experimenting with the project method was done without affecting the existing class-room set up. Regular teachers were used to teach their normal classes without the presence of the researcher. This helped in controlling the reactive effect where the learners would have behaved in a way as to please the researcher had they known that they were being observed for a particular purpose.

1.2.1 Research Setting

This research was conducted in Kenya which has a centralized education system administered by the Ministry of Education. The education system follows the 8-4-4 system of education which comprises of eight years of primary education, four years of secondary education and four years in the University for the First Degree Courses.

1.2.2 Target Population

According to Kothari (2004), target population or universe of a study is all the members or objects involved in the study. This study involved all form two students taking physics and their physics teachers in the selected public provincial secondary schools in Kenya.

1.2.3 Sampling Technique and Sample Size

The study applied stratified random sampling procedure to obtain a sample of eighty four schools out of the eight hundred and ninety provincial public secondary schools. According to Ary (2006), Orodho (2003) and Mutai (2000), the use of stratified random sampling helps in reducing unsuspected bias in the sample, hence ensuring that the sample represents the population in every characteristic under study. Mugenda and Mugenda(2008) that stratified random sampling ensures that the sample selected is representative, efficient, reliable, and flexible and helps in reducing sample error. Table 2 shows the selected sample.

Table 1: Sample Frame

S/N	Province	Boys	Girls	Mixed	Total
1	Nairobi	4	4	4	9
2	Central	4	4	4	8
3	Rift Valley	4	4	4	9
4	Nyanza	4	4	4	8
5	Western	4	4	4	12
6	Eastern	4	4	4	12
7	Coast	4	4	4	12
	Total	**28**	**28**	**28**	**84**

Two Boys' school, two Girls' school and two mixed provincial schools from each province, except the north Eastern province, constituted the treatment group while the other category comprising two Boys', two Girls' and two mixed schools in each of the seven provinces constituted the control group. All Physics teachers in the selected schools were involved in the study. They taught the topic as agreed, tested the students, marked the tests and also filled the teachers' questionnaires

1.2.4 Research Instruments

The researchers collected data using Student achievement Test (SAT), questionnaires for teachers and classroom observation schedule.

a). Student Achievement Test

The Student Achievement Test (SAT) consisted of seven semi-structured questions covering the topic under investigation, namely, the magnet effect of an electric current. The test was used to check learners' achievement in the test for both pre-test and post-test scores. SAT1 was used in the pre-test while SAT 2 was used in the post test. The test items in SAT 1 were similar to those in SAT 2 but the order and the colour of the question papers were different. The change of colour and order of questions was necessary to give the impressions to the students that they were doing a different set of papers. The tests were marked out of fifty and these scores were used in testing the hypothesis:

Ho_1 There is no statistically significant difference between the achievements scores of students exposed to Project Method and those who are not so exposed.

b). Teachers' Questionnaire

Teachers' questionnaires were used to solicit information on their age, academic background, qualification and other methods commonly used by the teachers. Teachers' views were also sought on several areas that affect the usage of project method in the study of physics. This information was used to test the other hypothesis:

Ho_2: There is no relationship between school characteristics in the usage of project methods and learners' achievement in Physics in Kenyan secondary schools.

c). Observation Schedule

Learners were observed during the learning process so as to gather information on the use and success of the project method.

1.2.5 Data Collection

In order to cover the seven provinces, the researcher trained eight research assistants who assisted him in the data collection process. The training involved the use of project method and how to collect the required data. For uniform training of the physics teachers, the researchers developed a module of the project method. The module helped the teachers to internalize the use of the project method. The researchers and the research assistants then visited the identified schools and sought permission from the school principals. The researchers and the research assistants then discussed with the physics teachers the project method of teaching physics, schemes of work, lesson plans and lesson notes to be used during the research process. An agreement was made when the topic under investigation was to be taught and the time for making observations of the lesson when students' projects were to be discussed. To ensure uniformity, all the selected schools used the same scheme of work. Teachers administered the Students Achievement Test I (SAT 1) at the start of the teaching period so as to determine the entry behavior of the learners. The use of physics teachers in a normal lesson was necessary to reduce the impressionistic effect. This ensured that the students were not aware that they were participating in the study and therefore learnt in a normal classroom setting. Students were observed during the specific lessons meant for making the specified projects of the electromagnet and the electric bell.

1.2.6 Data Analysis Techniques

Data analysis seeks to fulfill the research objectives and provide answers to research questions (Bryman and Cramer, 1997). The choice of the method to analyze data depends on the nature and the scales of measurement of the variables in question (Kothari, 2008). SAT I and SAT II were marked out of fifty. The mean mark of each school was then calculated for both experimental and control groups. The Analysis of Variance (ANOVA) was used to determine whether there was any difference in learners achievement between the group exposed to project method and those who were not. According to Mutai (2000), Analysis of Variance (ANOVA) is one of the most useful statistical procedures available for analyzing data. Significant level of 0.05 was used to test the null hypotheses.

The teachers' questionnaire was used to collect data on teachers' perception on various variables affecting the usage of project method and its impact on learners' achievement in physics. The researchers decoded the responses given by the teachers in their questionnaires. The values of one, two, three and four were assigned to the responses Not at All (NA), Less Often (LO), Often (O) and Very Often (VO) respectively. The same coding was used for Never (N), Rarely (R), Often (O) and Always (A). The Chi-square χ^2 value of each question or statement was then calculated and compared to the teacher' ages and professional qualifications and thereby test the hypotheses. The value of the calculated Chi-square was compared with the tabled value at the given degree of freedom. When the calculated value was less than the tabled value, then the null hypothesis was accepted that there is no significant difference between the valuables calculated. When the calculated value was greater than the tabled value at given degree of freedom, then the null hypothesis was rejected and the directional hypothesis accepted that there was significant differences between the valuables compared.

To further compare the variables under investigation, the data was further subjected to multiple regression analysis. By so doing, the contribution made by each variable in the usage of the project method and its impact on learner achievement in physics was made. All these calculations were made using a computer software programme namely Statistical Package for Social Sciences (SPSS). The research findings were then organized and discussed.

1.3 Research findings and discussion

The objective of the study was to investigate the effects of school characteristics in the usage of project method on learners' achievement in physics in Kenyan secondary schools. This objective was achieved by analyzing data of the mean score obtained by the students in the post test in various categories of schools classified as either single sex or mixed schools. Data was further analyzed from the views of the teachers who were asked how the nature of the school affected their usage of the project method and how the usage affected learners' achievement in the examinations. Table 2 shows the mean score of students' achievement in various categories of schools in the provinces attained in the post test.

Table 2: Mean score of Students

Province/ School type	*Coast*	*Nairobi*	*Western*	*Eastern*	*Nyanza*	*Central*	*Average mean*
Boys'	21.342	25.432	22.876	20.534	22.381	26.546	23.41
Girls'	19.547	22.654	19.684	20.124	25.497	20.274	20.21
Mixed	17.219	19.539	21.543	14.538	18.597	16.766	17.34

From Table 2, it can be observed that the average mean score for boys' schools were higher than those of girls and that the mean score of girls' schools were also higher than that of mixed schools with the average means of 23.41, 20.21 and 17.34 respectively. In order to check whether this difference in performance was significant or not, the results were further subjected to analysis of variance. Boys' schools were compared to girls and mixed schools. Girls' schools were also compared to boys and mixed schools. Table 3 shows the results of this analysis.

Table 3: Comparison of Boys' and Girls' performance

	Sum of Squares	**Mean Square**	**F**	**Sig.**
Between Groups	1046.911	33.771	1.862	.340
Within Groups	54.400	18.133		
Total	1101.311			

Table 3 indicates that the calculated value of F is 1.862 which is greater than the tabled value thus indicating that there was significant contribution of the experimental effect, implying that boys' schools performed better than the girls' schools when the project method was used.

To check whether there was any significance difference in performance between boys' schools and mixed schools, further analysis of variance was calculated between the two categories of schools.

Table 4 shows the results of this analysis.

Table 4: Comparison of Boys' and Mixed Schools performance

	Sum of Squares	**Mean** Square	**F**	**g.**
Between Groups	98.733	19.74 7	13.591	.0
Within Groups	2.645	1.453		
Total	101.378			

Table 4 indicates that the calculated value of F, 13.591is greater than the tabled value, thus indicating that there was significant contribution of the experimental effect implying that boys' schools performed better than the mixed schools when the project method was used. To check whether there was any significance difference in performance between girls' schools and mixed schools, further analysis of variance was performed between the two categories of schools. Table 5 shows the results of this analysis.

Table 5 Comparison of Girls and Mixed schools

	Sum of Squares	Mean Square	F	g.
Between Groups	98.733	19.74 7	1.862	.023
Within Groups	2.645	10.602		
Total	101.378			

Table 5 indicates that the calculated value of F is which is greater than the tabled value thus indicating that there was significant contribution of the experimental effect implying that Girls' schools performed better than the mixed schools when the project method was used.

The analysis indicates that on the average, Boys' schools performed better than girl's schools which also performed better than the mixed schools. In order to the teachers' view on how school characteristics affect the usage of project method and its impact on leaners' achievement in physics, several questions were asked using the teachers' questionnaire. They were asked on class size, number of streams, whether the school was rural based or urban, single or mixed school and how the availability of resources affected their usage of the project method. They were asked to tick if each of these variables affected their usage of project method as either always, often, rarely or never. Their responses are summarized in Table 6.

Table 6: School Characteristics, Usage of PM and LAP

	Never		Rarely		Often		Always		n	% score
	F	%	F	%	F	%	F	%		
Class size	14	15.2	21	22.8	23	25.0	34	37.0	2.21	55.16
No. of streams	12	13.0	21	22.8	28	30.4	31	33.7	2.15	53.8
Rural or urban	45	48.9	27	29.3	12	13.0	8	8.7	3.14	79.62
Single/mixed	11	12.0	33	35.9	31	33.7	11	12.0	2.35	58.70
Availability of lab	28	30.4	20	21.8	24	26.1	16	17.4	2.56	64.13
Availability of resource	32	34.8	39	42.4	14	15.2	4	4.3	3.01	75.27

Table 6 indicates that the factors that affect teachers' usage of project method are the class size at 55.16%, number of streams at 53.13% and the state of school as either single or mixed at 58.70%, the status of the school as either rural or urban at 79.62%, availability of laboratory at 64.13% and availability of other resources at 75.27%. These results indicate that learner achievement in physics is affected by several factors, the highest being the location of school as either rural or urban, followed by the availability of resources and physics laboratory, the status of the school as single or mixed, class size and finally the number of streams in the school.

To check whether the given percentages were significant or not, the values were tested using the chi-square. Table 7 indicates the value of significance which leads to the acceptance or rejection of the hypotheses. The acceptance of the chi square indicates that the variable was not a factor in the usage of the project method while rejecting the decision implied that the variable under investigation was a factor that influenced teachers' usage of the project method.

Table 7: Chi-Square Analysis of School Characteristics

Variable	Calculated χ^2	Tabled χ^2	Level of significance	df	Decision
Type of school	25.111	35.17	.005	23	accept
Boarding/day	6,984	11.070	.005	5	accept
No. of streams	12.592	4.980	.005	6	reject
Class size	43.773	31.123	.005	48	reject
Physics lab	7.815	24.845	.005	3	reject
Rural or urban	15.507	23.547	.005	8	accept
Availability of resources	7.815	17.817	.005	3	reject

Table 7 indicates that the calculated value of chi square for the type of school is 25.111 which is less than the tabled value of 35.172 at 0.05 level of confidence. This implies that teachers' usage of the project method was not influenced by the type of school, thus indicating that the usage will not depend on whether they are teaching in single sex or in mixed school. This result contradicts earlier findings that indicated that students in single sex are likely to perform better than those in the mixed schools. Additionally, this signifies that learners' achievement is independent of the methods used by the teachers

Table 6 further indicates that the calculated value of chi square for the boarding and day school is 6.984 which is less than the tabled value of 11.070 at 0.05 level of confidence. This implies that teachers' usage of the project method will not be influenced by the type of school, implying further that the usage will not depend on whether they are teaching in boarding or day schools. The students in boarding schools are likely to have more time for the projects while those in day school may use their time travelling back home after classes. However, those in day schools are likely to be exposed to more locally available resources than those in boarding schools as they interact with the environment outside the school compound. The use of project method requires students to get more time to complete the projects and this explains why those in boarding schools are likely to use the project method more than those in the day schools. This may explain why teachers are likely to use the project method at the same measure irrespective of the nature of the school where they teach.

Table 7 indicates that the calculated value of chi square for the number of streams in a school is 12.592 which is greater than the tabled value of 4.980 at 0.05 level of confidence. This implies that teachers' usage of the project method will be influenced by the number of streams in a school indicating that the usage will depend on whether teachers have many or few classes to handle. The teachers with many classes feel that the usage of the project method is more demanding and time consuming as more classes means more students to handle and hence more time for the projects. The use of project method requires students to get more time to complete the projects and this explains why those in schools with many streams avoid the usage of the project method more than those in

the schools with fewer streams. This result agrees with the results relating to class size where the size of the class determines the usage of the project method. The calculated value of the chi square was 43.773 which were greater than the tabled value of 31.123 implying that class size influences the usage of the project method.
Table7 show that the usage of the project method is influenced by the number of streams, class size, availability of physics laboratory and resources. The usage of project method by the teachers is not affected by the nature of the school, whether day or boarding, single sex or mixed; neither is it affected by its locality whether rural or urban. Analysis of the variables of the school characteristics were done and recorded in Table 8

Table 8: Variables on School Characteristics

R	R Square	Adjusted R Square	Std. Error of the Estimate
.380a	0.145	0.057	4.070166

Coefficient of determination explains the extent to which changes in the dependent variable can be explained by the change in the independent variables or the percentage of variation in the dependent variable (physics performance) that is explained by all the school characteristics independent variables. The coefficient of determination is 0.145; therefore, about 14.5% of the variation in the physics performance is explained by school characteristics.
The independent variable (school characteristics) explains 14.5 percent of the variable (R Square) in performance of physics, which is significant as indicated by the F-value of 1.165 below. This therefore means that other factors contribute 85.5.5% to the physics performance.
The residual plot shows a random scatter of the points (independence) with a constant spread (constant variance). The standardized residual plot shows a random scatter of the points (independence) with a constant spread (constant variance) with no values beyond the ±2 standard deviation reference lines (no outliers). The normal probability plot of the residuals shows the points close to a diagonal line; therefore the residuals appear to be approximately normally distributed and hence the assumptions for regression analysis appear to be met. An examination of the T-values indicates that school characteristics in the usage of project method contribute to prediction of physics performance.

Table 9: School Characteristics and PM

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	
		B	Std. Error	Beta	T
1	(Constant)	36.373	1.521		23.907
	Type of school (Boys, Girls, Mixed)	-0.437	0.524	-0.107	-0.834
	School category (boarding, day, day &boarding)	-0.183	0.199	-0.101	-0.919
	Size of school (number of streams)	0.237	0.628	0.055	0.377
	Class size	0.644	0.63	0.15	1.022
	School setting (rural or urban)	0.452	0.567	0.101	0.796
	Availability of physics laboratory	0.758	0.353	0.264	2.144
	Motivation of teachers	-0.095	0.115	-0.092	-0.827
	Availability of resources	-0.065	0.595	-0.014	-0.109
a. Dependent Variable: mean performance					

As per the R generated table above, the equation ($\mathbf{Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon}$) becomes:

$\mathbf{Y}$= -0.437$\mathbf{X_1}$- .183$\mathbf{X_2}$+ 0.237 $\mathbf{X_3}$ + 0.644 $\mathbf{X_4}$ + 0.452 $\mathbf{X_5}$ + 0.758 $\mathbf{X_6}$ - 0.095 $\mathbf{X_7}$ - 0.065 $\mathbf{X_8}$ + 36.373

Where Y is the dependent variable (physics performance),

X_1 is the Type of school (Boys, Girls, Mixed) variable

X_2 is the School category (boarding, day, day &boarding variable

X_3 is the Size of school (number of streams) variable

X_4 is the Class size variable

X_5 is the School setting (rural or urban) variable

X_6 is the Availability of physics laboratory variable

X_7 is the Motivation of teachers' variable

X_8 is the Availability of resources variable.

According to the regression equation established, taking all factors into account, the performance will be 36.373 which is equivalent to 72.74%, indicating that 27.26% of the learner performance is contributed by the school characteristics

The Standardized Beta Coefficients give a measure of the contribution of each variable to the model. A large value indicates that a unit change in this predictor variable has a large effect on the criterion variable. The t and Sig (p) values give a rough indication of the impact of each predictor variable – a big absolute t value and small p value suggests that a predictor variable is having a large impact on the criterion variable. At 5% level of significance and 95% level of confidence, type of school (Boys, Girls, Mixed) variable had a 0.407 level of significance; school category (boarding, day, day &boarding variable had a 0.361 level of significance; size of school (number of streams) variable had a 0.707 level of significance; class size variable had a 0.31 level of significance; school setting (rural or urban) variable had a 0.428 level of significance; availability of physics laboratory variable had a 0.035 level of significance; Motivation of teachers variable had a 0.411 level of significance; availability of resources variable had a 0.913 level of significance.

1.4 Conclusions

This study found out that there is a positive relationship between school characteristics in the usage of project method and learner performance in physics. The study found that single sex schools performed better than mixed schools. The order of academic achievement was that boys' schools performed better than girls' schools which, in turn performed better than mixed schools. The F value when boys' schools were compared to girls' schools was 1.862 and a significant level of 0.340 at 0.05 level of confidence. Comparison of boys' and mixed school gave the F value of 13.591 indicating a big gap in performance between these schools. The variables under the school characteristics which did not influence the usage of project method were type of school in terms of gender, whether day or boarding and whether the school was rural or urban. However, the usage of project method is influenced by the number of streams in the school such that teachers were likely to use the project method when in a school with fewer streams. This may be explained by the fact that teachers in a school with many streams are likely to have a large work load and thereby shun from the usage of project method which is seen to be involving in terms of preparation and is time consuming. The availability of physics laboratory and learning resources are also factors that affect the usage of project method. It was found that a unit increase in the availability of physics laboratory leads to a 0.758 increase in physics performance indicating that availability of physics laboratory alone will boost learner achievement in physics.

1.5 RECOMMENDATIONS

Based on the conclusions discussed in the previous section, the study makes the following recommendations

- **Workshop and seminars**

  There is need for in-service courses for physics teachers on the importance of positive attitude towards their learners irrespective of whether the schools are in urban or rural areas.

- **Resource Mobilization**

  The government needs to come up with a policy of mobilizing resources for the teaching of physics. Schools which are better equipped are more likely to generate better results than those that are not.

- **Teaching Load**

  There is needed to come up with a policy indicating an optimum number of lessons a teacher may have for an effective learning outcome. Teachers with more work load are more likely to avoid the usage of project method which is time consuming and tiresome in terms of preparation, implementation and evaluation process. The government also needs to employ more Science teachers so as to reduce the workload of those in the field.

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