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All papers should be written in English and they must be computer- typed, double line spaced and not more than 15 pages of A4 paper length.

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MATHEMATICAL CONCEPTS PRE-TEACHING STRATEGY AS PREDICTOR OF SENIOR SCHOOL STUDENTS' PERFORMANCE IN PHYSICS IN ILORIN, NIGERIA

O. T. BADMUS, M. A. AKANMU and A. O. AKANBI

Abstract

*Students' performance according to scholars often follow a given pattern and that the principle of individual differences is further reflected in variations that exist in individual ability. Thus, students' performances in related subjects from empirical evidences may follow the same pattern. This study, therefore investigated predictive effects of the mathematical concepts pre-teaching on physics students' performance. A total of 62 ($F=30$; $M=32$) students drawn from intact class of two purposively selected schools (experimental and control) in Ilorin, Kwara State, Nigeria that participated in the study formed the sample frame for this study. Three research hypotheses with corresponding research questions were tested and answered respectively. Being a quasi-experimental study, Physics Performance Test (PPT) of five theory questions based on projectile motion covered in the study was used to elicit data and analysis was done with the use of *t*-Test and Analysis of Variance at 0.05 level of significance. Amongst others, it was found that students exposed to pre-teaching of mathematical concepts performed significantly better than their counterpart not exposed to same treatment. This study like other studies also affirmed that gender had no role in students' academic performance. Recommendations in line with the findings were made.*

Keywords: Pre-teaching, Performance, Predictor, Mathematics, Physics

Introduction

Physics is one of the subjects taught at the senior secondary level of the Nigeria educational system. Physics as an important subject is central to technological development of any nation. Thus, its place as one of the core subjects to the advancement of science and technology cannot be over emphasized. It is regarded as basic science and closely related to other sciences such as Astrology, Geology, Chemistry, Biology and Mathematics. For instance, Astrology interprets its result according to physical principles and so does geology. Without a good background in science particularly in physics, Omosewo (2009) opined that it may be increasingly difficult to cope with the emphasis on molecular approach in biology.

Physics, as one of the basic science subjects offered at the senior secondary school, is the study of matter in relation to energy. Physics serves as the bedrock of modern technology which has found wide applications in several fields including medicine, agriculture, mining, communication, engineering, architecture and food science. Physics offers students an opportunity to think critically, reason analytically and to acquire the spirit of enquiry. The description of the nature of Physics as subject that provides learner the opportunity to think critically thus creates synergy between Mathematics and Physics.

Consequently, Fakuade (1981) adduced that Mathematics is the science of relationship among quantities, magnitudes, properties and logical operations where unknown quantities,

magnitudes and properties may be deduced. Hence, the importance of mathematics to everyday life, science and mathematics-related subjects and, the relationship that exists particularly between Mathematics and Physics cannot be underestimated. It implies that, mathematical-related subjects requires substantial amount of mathematics and its application to solve problem which remains the hall mark of mathematics. In the same vein, Salman (2005) referred to mathematics as an indispensable tool in the study of sciences while Fajemidagba (1986) had earlier regarded mathematics as both queen and servant of all the sciences. This implies that students may not be able to perform well in science subjects without the knowledge of mathematics. In line with these assertions, Uwadiogwu (1985) observed that one of the problems of physics students is their inability to comprehend mathematical concepts and to apply these concepts to the physical problems that lie in the heart of the topics in Physics.

Manapure (2011) also posited that a student needs basic knowledge of mathematics such as change of subject of formula to understand density, which appears under major topics like ecology in biology, diffusion in chemistry and floatation in physics. For example, vector quantity, which is taught in physics, requires a great deal of mathematics. Consequently relationships between variables such as volume, pressure, temperature, are revealed through the use of mathematical concepts. Different mathematical topics such as vectors, calculus, logarithms and arithmetic are applied to solve scientific problems (Onwuka & Iweka, 2010). The situation is the same for many topics in science subjects (Biology, Chemistry and Physics) with inter-related concepts and overlaps areas of intersection in the content and scope. The implication of this, is that, students' performance in mathematics, good or bad, may have direct influence on their performances in other science or mathematics-related subjects.

According to Fakayode (2000), students' performances often follow a given pattern and that the principle of individual differences as they reflect variations in individual ability such as high, average and low academic performance may also cut across other fields of endeavours. Ayinla (2011) reported that Mathematics achievement among students' with high academic ability had a mean score which is significantly greater than that obtained by students with low academic ability. The scholar found out that the performances of the sampled students followed almost the same pattern when compared to other science related subjects. The regression equation obtained revealed that increase in academic ability of students in science based subjects is largely associated with increase in achievement in mathematics. It was submitted that many factors which includes learners' learning styles, instructional modes and pre-teaching of mathematical concepts could have accounted for the finding. Of all these factors, pre-teaching was said to have contributed significantly and thus, should be encouraged for enhanced performance among students.

Researches such as those of Lalley and Miller (2006); Gelderblom (2008) affirmed that when the component skills of handling mathematical procedures are pre-taught, students learn to solve mathematics related problems much faster than when the components and the procedure were learned at the same time. Pre-teaching concept in the views of these scholars is efficient because integrating recently mastered components is easier than simultaneously mastering the components and integrating them to form a more complex skill. This strategy which usually includes teaching key component skills prior to working with the lesson or unit is appropriate for elementary and senior school students of all abilities. It is purposed to

the learners' development by helping them not to concentrate on every word or

facilitate an item that might be unknown to Gelderblom (2008), pre-teaching works preventively and provides more confidence in the pupils concerned. For them, additional instruction and learning time could be very effective. Pre-teaching can be done by the teacher, but the class must be organized so that time is made available for it. Studies, however revealed that the concept of pre-teaching is not been fully embraced in Nigeria. Hence, the poor performance of Nigerian students in ordinary level Physics which span the years (Akanbi, 2009; Omosowo, 1999). An account of the results of Senior School Certificate Examinations (SSCE) conducted by the West African Examinations Council (WAEC) between 2008 and 2012 showed that less than 50% of candidates who registered for Physics and Mathematics obtained credit passes. Specifically, in 2008 and 2009 for Physics and 2009, 2010 and 2011 for Mathematics candidates obtained less than 50% as shown in Table 1. The data on table 1 shows the enrolment and performance of students at the SSCE level.

Table 1
Enrolment and students' performance in Senior School Physics and General Mathematics Certificate Examinations between 2008-2012

Physics		A ₁ -C ₆		Mathematics		A ₁ -C ₆	
Year	Total Sat	Credit Passes	%	Total Sat	Credit Passes	%	
2008	415,113	200,345	48.38	1,268,213	726,398	57.28	
2009	429,174	186,940	43.56	1,348,528	634,382	47.04	
2010	463,755	237,756	51.30	1,306,533	548,065	41.95	
2011	563,161	360,096	63.94	1,508,965	608,866	40.35	
2012	624,658	429,415	68.74	1,658,357	838,879	50.58	

Source: Statistics Division, WAEC, Kwara State Branch Office, Oko-Olowo, Ilorin

The percentage of candidates who passed Physics in 2009, that is, 43.56% was below expectation but the results obtained improved steadily to 68.74% in 2012. On the other hands, total passed percentage for General Mathematics (which comprised of both Commercial and Arts students) followed undulating pattern. The implication of this is that as a country, the stability and progress expected to guarantee technological breakthroughs are yet to be achieved. The graphical illustration is as captured in figure 1.

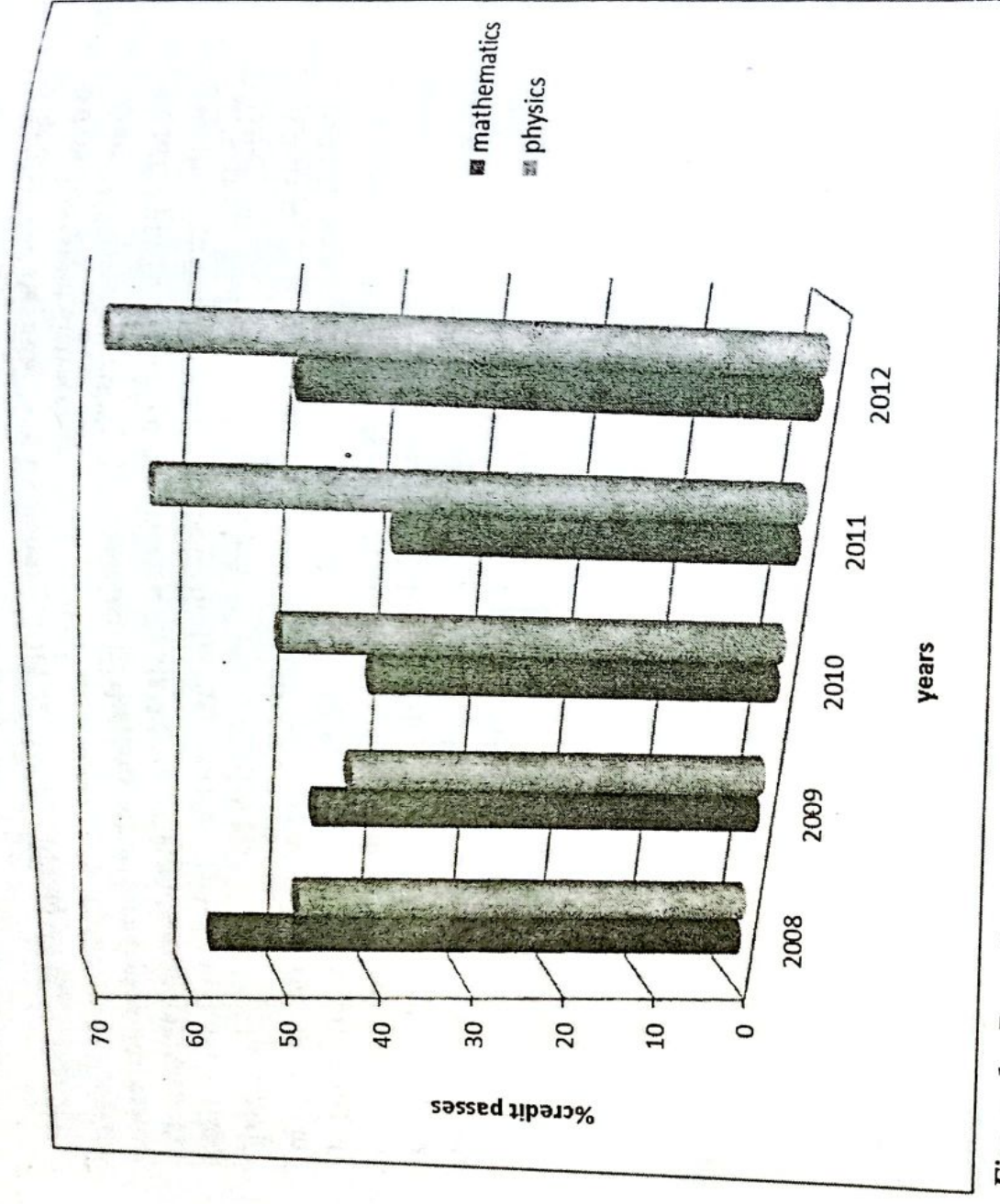


Figure 1: Bar chart illustrating students' performance in Physics and General Mathematics in SSCE (2008-2012)

Based on the data presented on table 1 and figure 1, it can be deduced that steady and similar progress pattern in both Mathematics and Physics are needed for the Nigeria nation's quest for technological greatness in the committee of nations. The main purpose of this study was therefore to investigate the effects of pre-teaching of mathematical concept as predictor of senior school students' performance. The study focused on projectile motion an aspect of motion in physics being an aspect that has reported repeated failure among students and yet, questions are drawn from almost every year on the concept (WAEC Chief Examiner Reports, CER, 2014).

Research Questions

In this study, answers were provided to the following research questions:

1. Will there be any significant difference in the posttest mean gain scores of students' exposed to and those not exposed to mathematical concepts pre-teaching strategy when taught projectile motion?
2. Is there any significant difference in the posttest mean gain score of male and female students' exposed to mathematical concepts pre-teaching strategy when taught projectile motion?
3. Is there any significant difference in the posttest mean gain scores of students' exposed to and those not exposed to mathematical concepts pre-teaching strategy when taught projectile motion?

exposed to mathematical pre-teaching strategy when taught projectile motion based on scoring ability levels?

Research Hypotheses

As a guide, the following research hypotheses were formulated and tested in this study:

H₀₁: Students exposed to and those not exposed to mathematical concepts pre-teaching strategy when taught projectile motion will have no significant difference in their posttest mean gain scores.

H₀₂: No significant difference will exist in the posttest mean gain scores of students' exposed to mathematical concepts pre-teaching strategy when taught projectile motion based on gender

H₀₃: There is no significant difference in the posttest mean gain scores of students' exposed to mathematical concepts pre-teaching strategy on the basis of scoring ability levels when taught projectile motion.

Methodology

This study being a quasi-experimental research adopted the use of pre-test and post-test, non-randomized, non-equivalent factorial design of 2 x 2 x 3. The instrument used for this study was the Physics Achievement Test (PAT). Five theory questions based on the content area covered, that is, projectile motion were adopted from the past WAEC Physics questions (1995 - 2010). The test was administered to both the experimental and the control group before and after the treatment. A total of 62 senior secondary school II (SSS2) students drawn from two purposively selected co-educational public schools formed the sample frame for this study. Three research questions were raised with corresponding hypotheses formulated and tested at 0.05 level of significance. Hypotheses 1 and 2 were tested using t-test while hypothesis 3 was tested using one-way Analysis of Variance (ANOVA) with the use of Statistical Package for Social Science (SPSS 21.0 version) for data analysis.

Results

The experimental group was made up of 23 students (11 male and 12 female students) while the control group had 39 students (20 male students and 19 female students) respectively.

Demographic Data

Table 2: Sample Frame

Group	No	Male	%	Female	%
Experimental	23	12	52	11	48
Control	39	20	51	19	49

H₀₁: Students exposed to and those not exposed to mathematical concepts pre-teaching strategy when taught projectile motion will have no significant difference in their posttest mean gain scores.

Table 3 shows that the p-value is 0.03 is less than 0.05. Therefore, the null hypothesis 1 was rejected and the alternative hypothesis which states that, there is significant difference in the posttest mean gain scores of students' exposed and those not exposed to pre-teaching of mathematical concept related to projectile motion in Ilorin was upheld. This implies that the performance of students exposed to pre-teaching was not due to luck but the treatment they

were exposed to given the mean posttest score of 10.70 and 6.30 for experimental and control group respectively.

Table 3: *t-test Analysis Showing Differences in Post-test Mean Gain Score of Students in Control and Experimental Groups*

Group	No	Pre-test $\bar{X}_1$	Std.	Post-test $\bar{X}_2$	Std.	Diff. $\bar{X}_2 - \bar{X}_1$	p-value
Experimental	23	21.2	7.13	42.1	10.70	20.9	0.03
Control	39	19.5	4.67	28.3	6.30	8.8	

*Correlation is significant at the 0.05 level **

H_{01} : No significant difference will exist in the posttest mean gain scores of students' exposed to mathematical concepts pre-teaching strategy when taught projectile motion based on gender

Table 4 reveals that the p-value of $0.94 > 0.05$ which implies that gender had no significant difference in the performance of students' exposed to the treatment. Thus, hypothesis 2 is hereby retained. It can be deduced that when given similar task and exposed to same treatment, both male and female would perform almost equally; this is evident in the close margin of the mean (2.33) though in favour of female students.

Table 4

t-test Analysis Showing the Difference in Post-test Mean Gain Score of Respondents Based on Gender.

Variables	No of Students	Mean	Standard Deviation	t-value	p-value
Female	11	30.91	10.97	0.52	0.94
Male	12	28.58	10.60	0.52	

*Correlation is significant at the 0.05 level **

H_{02} : There is no significant difference in the posttest mean gain scores of students' exposed to mathematical concepts pre-teaching strategy on the basis of scoring ability levels when taught projectile motion.

Table 5 using one-way ANOVA with respect to scoring levels reveals that the p-value of 0.00 is less than t-value of 0.05. Therefore, the alternative hypothesis which states that, There is significant difference in the posttest mean gain scores of students' exposed to pre-teaching of mathematical concepts related to projectile motion in Ilorin based on high, medium and low scoring levels is upheld. However, the high scorers benefitted the most, followed by medium scorers and then the low scorers.

Table 5

One-way ANOVA of the Scoring Levels

Groups	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2291.225	2	1145.613	128.978	.000
Within Groups	177.644	20	8.882		
Total	2468.870	22			

*Correlation is significant at the 0.05 level **

To further ascertain where the difference lie, Duncan post-hoc test was conducted as shown on table 6. The analysis was done at alpha level 0.05 and it was discovered that there is significance across board since the level of significance is above the alpha level. Largely the high scoring students benefitted the most with 40.11, followed by the medium scoring students with 28.22 and then the low scoring students with 13.60 the least significance.

Table 6
Duncan Post-hoc Test for Testing Homogeneity of the Mean Groups

Scoring levels	Number of Students	Subset for alpha= 0.05		
		Low scorer	Medium scorer	High scorer
Low scorer	5	13.60		
Medium scorer	9		28.22	
High scorer	9			40.11
Sig.		1.00	1.00	1.00

Summary of Major Findings

Based on the field survey, the following are major findings of this study:

- i. There was statistically significant difference in the posttest mean gain scores of students' exposed and those not exposed to pre-teaching of mathematical concept related to projectile motion in Ilorin. The experimental group benefitted the most from the two groups;
- ii. There was no statistical significant difference in the posttest mean gain scores of male and female students' exposed to pre-teaching of mathematical concept related to projectile motion in Ilorin. Which implies that male and female students performed equally better when exposed to the pre-teaching; and
- iii. There is significant difference in the posttest mean gain scores of students' exposed to pre-teaching of mathematical concepts related to projectile motion in Ilorin based on high, medium and low scoring levels. The high scoring students benefitted the most, followed by the medium and low scoring students respectively. The outcome is suggestive of the need to have sequence of teaching methods to boost the performance of the low scoring students.

Discussion of Results

Available empirical evidence from this study reveals that the experimental group exposed to pre-teaching of mathematical concepts performed significantly better in projectile motion than their counterparts in the control group. This lay credence to the efficacy of the pre-teaching of mathematical concepts as a strategy for improving students' academic performance in projectile motion which could be replicated for other topics in physics as a subject. This finding is in coherence with the findings of Fakuade (1981), Dirac (2003), Angell (2004) and Manapure (2011), where the researchers, though in separate studies, agreed that there exist a synergy between mathematics and physics; also, that prior understanding of mathematics certainly influences the performance of students in physics. With respect to students' academic scoring levels, the findings of this study is not at variance

with the outcome of Akanmu and Fajemidagba(2013) study that, though the three categories, that is, high, medium and low scoring students benefitted from the treatment, the high scorers benefitted more, followed by the medium and low scoring students. It can be deduced that low scoring students generally will need regular intervention to meet up with other members of the class in term of academic performance.

Recommendations

Based on the findings of this study, the following recommendations were considered appropriate:

- i. The pre-teaching of mathematical concepts related to all topics in physics is recommended as shown in this study. Thus, the need to identify, collate and incorporate such topics in the physics textbooks in order to sustain learners' interest via basic requisite mathematical knowledge for desired performance in physics.
- ii. Male and female students should be given equal task and similar opportunity to express their critical thinking ability since gender, from this study, has been seen as playing no role in academic performance of learners.
- iii. Authors of physics textbook could as a way of improving the content of their text assemble the relevant mathematical concepts in each physics topic and treat them as requisites to the physics topics. This may enhance better self-study among students and improve their performance towards absolute education.

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