Mathematics Skills as Predictors of Physics Students' Performance in Senior Secondary Schools

Awodun, Adebisi Omotade[1], OJO, Olanrewaju Adeniyi.[2]

[1] Department of Physics, College of Education, Ikere-Ekiti, Ekiti State, Nigeria

[2] Department of Mathematics, College of Education, Ikere-Ekiti, Ekiti State, Nigeria

Correspondence: Awodun, Adebisi Omotade , Department of Physics, College of Education, Ikere-Ekiti, Ekiti State, Nigeria

Abstract: This paper investigated the predictive influence of mathematics skills (Computation skills, geometry skills, algebra skills, interpretation of graphs and table skills, measuration skills and Probability and statistics skills) on Physics students' performance in Senior Secondary Schools in Ado Local Government Area, Ekiti State of Nigeria. The design of this study was an ex-post-factor of survey type. The targeted population for the study was Senior Secondary III (SS III) Physics students of public secondary schools in Ado Local Government Area of Ekiti State, Nigeria. The population of the study was all public Secondary Schools (Physics Students). A simple random sampling technique was used to select twenty (20) Physics students each from the five (5) selected secondary schools from Ado Local Government Area of Ekiti State. A total of One hundred (100) Physics students were used as samples for the study comprises of sixty eight (68) male and thirty two(32) female. Two research questions were generated and were tested at 0.05 level of significance. Among others, the study revealed that; all mathematics skills (Computation skills, geometry skills, algebra skills, interpretation of graphs and table skills, measuration skills and Probability and statistics skills) has strong positive influence and strongly predictive value on physics students' performance in Senior Secondary Schools. Conclusion and recommendations were also made in this paper.

Key words: Mathematics Skills, Physics s, academic performance and predictors

1. Introduction

Mathematics is one of the oldest subjects in primary and secondary school curricular. Mathematics has been the bedrock of several subjects in the school curriculum and it is indispensable to national goal and objectives. Every student with an objective of attaining a height in the knowledge of science must possess an average knowledge of mathematics.

In this scientific Age, we cannot underestimate the importance of mathematics. Mathematics has its limb in virtually all fields of study whichever mathematical or non-mathematical, not to discuss its influence in the mathematically related fields. In fact, Mathematics is the pivot on which all sciences, engineering, Business and even Social sciences revolve. Because of its importance many institutions of higher learning require a credit pass from senior secondary school students who seek admission to study various courses in these institutions.

[9] cited Chorin and Wright that mathematics is an intrinsic component of science and serves as a universal language and indispensable source of intellectual tools. Mathematics is widely regarded as the language of science and technology. Mathematics is the bedrock that provides the spring board for the growth of technology, it is also the gate and key to sciences. The importance and contribution of mathematics to the modern culture of science and technology stated that that "Without Mathematics, there is no science and without science there is no modern technology and without modern technology there is no modern society. In other words, mathematics is the precursor and the Queen of science and technology and the indispensable single element in modern societal development". Mathematics Education is therefore indispensable in nation building. Mathematics form a strong foundation for the study of physics either simple operations or more advanced all requires some form of mathematics.

Mathematics and Physics pose a threat to some students where mathematics may be regarded as a fearful subject which involves massive use of symbols and mathematics proofs [8] whereas Physics is a subject which involves a lot of abstract formulas for them to visualize [7]. Physics curriculum had similar aims with mathematics curriculum since as both emphasize skills in decision making and problem solving [9].

Mathematics serves as symbolic expression in Physics to show the structure of the relationship between different factors [5]. Similarly, [9] asserts that symbolic expression allows learners to have a better understanding of Physics contents and improve their procedural knowledge to interrelate various symbols during solving Physics problem. Correspondingly, [4] opined that Physics involves a lot of representation like experiments, formulas and calculations, graphs, and concept explanation. [6] in their study affirm that there is strong interrelationship between Physics and mathematics in historical views. A student who is excellent in mathematics is expected to be excellent in Physics as well [9].

Physics is one of the science subjects taught at the senior secondary level of Nigeria Educational system. Its importance as a discipline cannot be over-emphasized especially in the area of science and technology. Physics is closely related to other sciences such as Astronomy, Geology, Chemistry and Biology. Physics as a science course of study is perceived generally to be very interesting, vast, mathematical and experimental. Almost all aspects of life science, both living and non-living have something to do with physics, ranging from Engineering to mathematics,

biology and chemistry. Physics is one of the pre-requisite subjects for the study of Engineering technological, medical and other applied sciences courses in the university.

The Nigerian Economy requires Mathematics that can effectively put science and technology in the forefront of nation building. Mathematics Education in Nigeria has come a long way in the traditional society, before the introduction of formal Education; Mathematics was used mainly in taking stock of daily farming and trading activities. Most traditional societies have their number systems which were either base five (5) or twenty. These could be seen in their market days and counting system. Despite the importance of Mathematics in the study of Physics, a large number of Physics students still perform badly in this important subject. There has been a great concern in the world over by Mathematics educator about the level of mathematical understanding displayed by students in secondary schools. This occur because of the scientific – technological revolution, the significance of mathematics for production, technology and other sciences which is continuously growing.

The development of any nation, which depends on science and technology, hinges on the nation's science education. In Nigeria, in spite of the enormous role (importance) that Physics provides for national development and efforts of government and other stake holders in improving science education, Physics results in most certified examinations like the West African Senior School Certificate Examination (WASSCE) and National Examination Council (NECO) have not been satisfactory. The broad aims and expectations of any teaching and learning programme is productivity and positive-evaluated end-product (achievement). But in recent times, Observations on students academic performance in science generally, and Physics, in particular over the years in the results of Senior Secondary Certificate Examination (SSCE) conducted by West African Examination (WAEC) and National Examination Council (NECO) revealed that a very few number of students perform better in Physics examination compared with other subjects. Parents and government are in total agreement that their huge investment on education is not yielding the desired dividend and that despite their hug investment on education, students' performances still remain poor. Teachers, also complain of students' low performance at both internal and external examinations [1]. In particular, reports on WAEC results of Senior Secondary School Certificate Examination in Ekiti State over the years often revealed low performance of students in Physics. A summary of students' performance in Physics at WAEC from 2005-2012 are as given below:

Table 1: Summary of WAEC results in Physics in Ekiti State

Year	*No Registered*	*A1- C6*	*D7- E8*	*F9*
2005	3738	2156 (57.7%)	1104 (29.5%)	478 (12.8%)
2006	4157	2661 (64.0%)	1004 (42.2%)	492 (11.8%)
2007	4435	2524 (56.9%)	1243 (28.0%)	668 (15.1%)
2008	3385	1274 (37.6%)	797 (23.5%)	1314 (38.9%)
2009	4289	2296 (53.5%)	1036 (28.7%)	937 (17.8%)
2010	5459	2569 (49.8%)	1825 (31.6%)	1065 (18.6%)
2011	6859	4020 (58.6%)	1124 (16.4%)	1715 (25.0%)
2012	5081	2514 (49.5%)	1379 (27.1%)	1188 (23.4%)

Source: [2].

A cursory look at table 1 shows that not very many of the candidates had credit pass in the subject over the period of observation. This shows that the level of performance is not good enough. Against this backdrop, this study is out to investigate the effect mathematics skills on Physics students' performance in Senior Secondary Schools in Ado Local Government Area, Ekiti State of Nigeria.

For the purpose of this study and in accordance with Odili as cited by [3], the following mathematics skills were considered:

- *Computation skill:* number bases, word problems, numbers in standard form, addition, subtraction, multiplication and division of fractions and decimals rate, ratio and proportion.
- *Algebraic process skills:* common factors, factorization of simple algebraic and quadratic expressions, solving equations, simple equations and equation involving factions, simultaneous equations and word problems leading to equations and variation.
- *Geometry skill*: geometrical constructions using ruler and compasses, finding the angles between two lines, angles in a right angled triangle and using trigonometric ratios.
- *Measuration skill*: areas of plane shapes (eg. Rectangle, triangle, trapezium, circle etc), volumes of common solids (cuboids, cylinder, cone etc) and areas and volumes of similar figures.
- *Tables and graph Interpretations skill*: interpretation of cost, travel and conversion tables and graphs, interpretation of statistical tables and graphs and interpretation of proportion graphs (direct and indirect).
- *Probability and statistics skill*: probability became of major importance in Physics when quantum mechanics entered the scene. A course on probability begins by studying coin flips, and the counting of distinguishable vs. indistinguishable objects. The concepts of mean and variance are developed and applied in the cases of Poisson and Gaussian statistics.

2. Research Questions

The following research questions were formulated and tested at $P< 0.05$:

1: What is the composite effect of the independent variables (Computation skills, geometry skills, algebra skills, interpretation of graphs and table skills, measuration skills and Probability and statistics skills) on Physics students' performance in Senior Secondary Schools?

2:What are the relative effects of each of the independent variables (Computaion skills, geometry skills, algebra skills, interpretation of graphs and tableskills, measuration skills and Probability and statistics skills) on Physics students' performance in Senior Secondary Schools?

3. Methodology

The design of this study was an ex-post-factor of survey type. The targeted population for the study was Senior

Secondary III (SS III) Physics students of public secondary schools in Ado Local Government Area of Ekiti State, Nigeria. The sample of the study consists of twenty (20) Physics students randomly selected from five (5) Public secondary schools selected for the study. A total of One hundred (100) Physics students were used as samples for the study comprises of sixty eight (68) male and thirty two(32) female A validated test of mathematics titled "Mathematics Skills (MS)" was used for the study. The test was made up of 60 multiple choice questions with 10 questions on each mathematical skills considered in the study. The Physics mock scores of the students used for the study were collected from their records. The mock examinations took place a week before the "mathematics skills (MS)" test was conducted. A pilot study was carried out to validate the instrument and the reliability of the instrument was tested using the test-retest method to established the stability principle and the coefficient is 0.81. The data was subjected to statistical test and analysis, using Regression analysis at 5% level of significance.

4. Results

Research Question 1: What is the composite effect of the independent variables (Computation skills, geometry skills, algebra skills, interpretation of graphs and table skills, measuration skills and Probability and statistics skill) on Physics students' performance in Senior Secondary Schools?

Table 2: ANOVA: Showing the prediction of the six mathematical skills to the Physics students' performance.

Model	*Sum of Squares*	*df*	*Mean Squares*	*F*	*Sig*	*R*	R^2	*Adj.* R^2	*SE*
Regression	1984.46	6	330.74	16.2	0	0.927			
Residual	3467.42	94	36.89		0		0.86	0.86	9.89
Total		100			0				

*P<0.05

Table 2 shows that mathematics skills jointly influence the performance of Physics students (R = .927). This implies that the skills are quite relevant in explaining students' performance in Physics in secondary schools. The table also shows adjusted R value of 0.859 which indicate 85.9% of total variance in Physics.

Research Question 2: Which of the independent variable (Computaion skills, geometry skills, algebra skills, interpretation of graphs and tables kills, measuration skills and everyday statistics) will predict academic performance of Physics student' in senior secondary schools?

To test the hypothesis, scores of the independent (Computaion skills, geometry skills, algebra skills, interpretation of graphs and tables kills, measuration skills and Probability and statistics skills) and dependent variable (Physics students' academic performance) were subjected to statistical analysis using multiple Regression analysis at 0.05 level of significance.

The regression model is specified as follows: Y = f (X)

$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + U_i$

Where X_1= computation skills, X_2= Geometry skills, X_3= Algebraic skills, X_4 = Graph and Tables interpretation, X_5 = Measuration skills and X_6 = Probability and statistics skills

Table 3: Regressions coefficient of mathematics skills in the prediction of students' performance in Physics.

Model	B	Std. Error	Beta	t-value	Sig. T	Remark
Constant	6.402	2.142	-	10.142	.018	Significant
Computation Skills	.473	.613	.266	6.142	.895	Significant
Geometry Skills	.983	.733	.249	4.161	.000	Significant
Algebraic Skills	.821	.642	.112	3.182	.814	Significant
Graph and Tables interpretation Skills	.732	.214	.147	6.012	.361	Significant
Measuration Skills	1.842	.561	.112	2.166	.043	Significant
Probability and statistics skills	1.916	.671	.114	2.992	.000	Significant

Dependent Variable: students' academic performance.

The implication of these results is that each of the six mathematics skills significantly predicts Physics students' performance. The final regression model was as follows:

$Y = 6.402 + .473X_1 + .983X_2 + .821X_3 + .732X_4 + 1.842X_5 + 1.916X_6$

5. Discussion

The results of the study were discussed based on the two research question stated:

Table 2: reveals the joint effect of the independent variables (that is, (Computation skills, geometry skills, algebra skills, interpretation of graphs and table skills, measuration skills and Probability and statistics skills) on Physics students' performance in Senior Secondary Schools at $p < 0.05$. R^2 which is the co-efficient of determination shows that the independent variable (mathematical skills) account for a high proportion of about 86% of Physics student performance. Also, the standard error of the estimated means is 9.887%. This implies that the skills are relevant towards the determination of the dependent measure (student academic performance in Physics). This is in line with the research outcome of [6] that there is strong interrelationship between Physics and mathematics in historical views and the result also agree with the findings of [9] that Physics curriculum had similar aims with mathematics curriculum since as both emphasize skills in decision making and problem solving.

Table 3: shows the regressions coefficient of the six mathematics skills in the prediction of students' performance in Physics. Computer skills is the single best predictor of physics students' academic performance with beta weight of .266 (26.6%). This was closely followed by geometry skills with a beta weight .249 (24.9%), graph and table interpretation skills is with beta weight .147 (14.7%), probability and statistics skills has beta weight .114 (11.4%), while Algebraic skills and measuration skills has the same value of beta weight .112 (11.2%) respectively.

The result indicated that the contributions of the six mathematics skills to the prediction of students' performance in Physics were significant at $p < 0.05$. This shows that all the six mathematics skills do have predictive effects on physics academic performance. The result agrees

with the findings of [9] and [4] that the language of physics is mathematics. The educational implication of these is that mastering of the basic mathematics skills by the physics students is among the most important factors for success in physics in secondary school. Hence, there is the need for coordination between the curricula of physics and mathematics at secondary school level. This will remove the difficulty of application of mathematics in physics. It will help the students to transfer concepts, ideas and procedures learned in mathematics to a new and unanticipated situation in Physics.

6. Conclusion

Based on the results of this study, the six mathematics skills proved potent at predicting Physics student academic performance in Physics at senior secondary. It can be concluded that students who do well in mathematics are expected to do well in Physics class.

7. Recommendations

Based on the findings of this study, the following recommendations were made: adequate mathematics Education should be given to the prospective physics student; there should be collaboration between mathematics and physics curricula; and the government should invest more into mathematics and science education since science is the bedrock of technology and without technology a country can not be said to have advanced or developed.

References

[1] O.A. Asikhia,, "Students' and Teachers' Perception of the causes of poor Academic performance in Ogun State Secondary Schools (Nigeria): Implications for Counseling for National Development". *European Journal of Social Sciences*. 13(2), 2010, 229.

[2] Ekiti State Ministry of Education and Technology. Summary of Past enrolments and SSCE WAEC results. Planning, Research and Statistics Department, Ado-Ekiti, Nigeria. 2013.

[3] Oyedeji Samson Oyelola " Mathematics Skills as predictors of science achievement in Junior Secondary Schools." World J Young Researchers 2011. (4): 60.(2011.

[4] F. Ornek, W.R.W. Robinson, and M.P. Hangan,. "What makes Physics Difficult?" . *International Journal of Environmental and science Education*, 3(1), 30-34. 2008.

[5] E. Torigoe, "What kind of Math matter? A study of the Relationship between mathematical Ability and success in Physics. Unpublished doctoral dissertation". University of Illinois at Urbana-Champaign, Urbana. 2008.

[6] P.H. Liu, and S.Y. Liu,. "A Cross-subject investigation of Collage Students' Epistemological Beliefs of Physics and Mathematics". *The Asia- Pacific Education Researcher*, 20(2). 2011.

[7] B. Bektashi, "The relationships between spatial Ability, Logical Thinking, Mathematics performance and kinematics Graph interpretation skills of 12th Grade Physics students". Unpublished Doctoral Dissertation, The Ohio State University, Ohio. 2006.

[8] M. Mubark,. "Mathematics Thinking and Mathematics achievement of students in the year 11 scientific stream in JORDAN". Unpublished Phd Thesis, the University of Newcastle, Australia. 2005.

[9] Yeo Kee Jiar "Mathematics Thinking and Physics achievement of Secondary school students". . 2013. Online. Retrieved on 4/05/2013.