Effects of Knowledge of Mathematics on Student's Performance in Physics in Senior Secondary Schools in Ekiti State, Nigeria

Adebisi O. AWODUN
Department of Science Education, Bamidele Olumilua University of Education, Science and Technology, Ikere-Ekiti, Ekiti State, Nigeria.

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ABSTRACT: *This study examined the effects of knowledge of mathematics on student's performance in physics in senior secondary schools in Ekiti State, Nigeria. Three hypotheses were formulated to guide the study. The sample size for this study consisted of Forty (40) secondary school physics students from two public schools were randomly selected in Ikere Local Government Area of Ekiti State. Self-Structured Test was used for data collection. The Pearson Correlation statistical and t-test tools were used to test all the hypotheses at 0.05 level of significance. The results revealed that knowledge in Mathematics helps to provide a basic foundation for study of physics. Thereby, allows learners to have better understanding of physics contents and improve their procedural knowledge to inter-relate various symbols during solving of physics problems. Student's mathematics knowledge should be lay more emphasis on because it helps in others aspect of sciences, students demonstrate conceptual understanding when they provide evidence that they can recognize, it also helps to develop their procedural and problem solving skills. Students absent during Mathematics class might lack knowledge which can leave lasting impact on them. In line with the findings of the study, appropriate recommendations were made.*

Key Words: *Knowledge, Mathematics, Physics, Students' Performance, Senior Secondary schools.*

Introduction

Science has been regarded as the bed rock on which modern day technological breakthrough is built. Nowadays countries all over the world especially the developing ones like Nigeria, are striving hard to develop technologically and scientifically, since the world is turning scientific and all proper functioning of lives depend greatly on science. Science is a dynamic human activity concerned with understanding the workings of our world. This understanding helps man to know more about the universe. Without the application of science, it would have been difficult for man to explore the other planets of the universe. Science comprises the basic disciplines such as physics, chemistry, biology and mathematics. Many investigations have shown that secondary school students are exhibiting dwindling interest in science (Ogunleye, 2002). Besides, physics as one of the science subjects remains one of the most difficult subjects in the school curriculum according to the Nigeria Educational Research and Development Council (NERDC) (Isola, 2010). Studies have revealed that the academic performance of Nigerian students in ordinary level physics was generally and consistently poor over the years. Physics is an important science subject that makes immense academic demands on the students in its learning.

Academic performance has been described as the scholastic standing of a student at a given moment. This scholastic standing could be explained in terms of the grades obtained in a course or groups of courses. Mallory (2004), commented on this scholastic standing and argued that performance is a measure of output and that the main outputs in education are expressed in terms of learning, that is, changes in knowledge, skills and attitudes of individuals as a result of their experiences within the school's system. Academic performance is regarded as a student's performance in an examination as being depended on his cumulative grade point average (Cambridge University Reporter, 2003). Student's success is generally judged by examination performance. On the other hands, poor academic performance according to Aremu (2000), is a performance that is adjudged by the examinee and some other significant as falling below an expected standard. The interpretation of this expected standard is better appreciated from the perpetual cognitive ability of the evaluator of the performance.

The factors affecting the academic performance of students in senior secondary physics include; students background and classroom environment, nature of the subject, teacher variable and students variables. These student variables include student's attitude towards physics, student's interest in physics, gender inequality, student's study habit and student'smathematics knowledge according to Akanbi (2003), Asikhia (2010), Akinola (2006), and Macmillan (2012).

Student's knowledge of mathematics can be classified into three categories; conceptual understanding, procedural knowledge, and problem solving (National Assessment of Educational Progress, 2003). Students demonstrate conceptual understanding when they provide evidence that they can recognize, label and generate examples of concepts, use and interrelate models, diagrams, manipulative and varied representation of concepts; identify and apply principles, know and apply facts and definitions; compare and contrast, and integrate related concepts and principles; recognize, interpret and apply the signs, symbols and terms used to represent concepts, conceptual understanding reflects a student's ability to reason in settings involving the careful application of concepts definition, relations or representations of either.

Students demonstrate procedural knowledge when they select and apply appropriate procedures correctly; verify the correctness of a procedure using concrete models or symbolic methods; or extend or modify procedures to deal with factors inherent in problem settings. Procedural knowledge encompasses the abilities to read and produce graphs and tables, execute geometric constructions, and perform non computational skills such as rounding and ordering. Procedural knowledge is often reflected in a student's ability to connect an algorithmic process with a given problem situation, to employ that algorithm correctly, and to communicate the results of the algorithm in the context of the problem setting.

Problem solving in mathematics is demonstrated by students when they recognize and formulate problems, determine the consistency of the data; use strategies, data, models; generate, extend and modify procedures; use reasoning in new settings; and judge the reasonableness and correctness of solutions. Problem solving situations require students to connect all their mathematical knowledge of concepts, procedures, reasoning, and communication skills to solve problems.

Mathematics forms a strong foundation for the study of physics. Mathematics serves as a symbolic expression in physics to show the structure of relationship between different factors (Terigue, 2005). Similarly, Jia (2013) asserts that symbolic expression allows learners to have a better understanding of physics contents and improve their procedural knowledge to inter-relate various symbols during solving of physics problems.

Physics is one of the science subjects taught at the senior secondary level of Nigerian educational system. Its importance as a discipline cannot be overemphasized especially in the area of science and technology. Almost all aspect 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 technology, medical and other applied sciences courses in the university. Physics as a science course is perceived generally to be very interesting, vast, mathematical and experimental. In spite of the enormous role that physics provides for national development, physics results in most certified examinations like the West African Senior School Certificate Examination (WASSCE) and National Examination Council (NECO) have not been satisfactory. In a situation where the students will be blamed for the poor performance, emphasis is only placed on the student's cognitive or intellectual ability. Little or no attention is given to the fact that the student's mathematical ability can affect their performance in physics. Based on this assertion, this study intends to find out the impact of good knowledge of mathematics on students performance in physics.

A lot of studies in the past indicate a poor performance of students in physics, however, other studies also shows prospect in teaching of physics in secondary schools looking at avenue or prospect that may offer hope to those who take interest in the study and teaching of physics (Van, 1991).

In this regard, teaching of physics, is typically used to demonstrate physical phenomena, to present derivations; and to show examples of how to solve problems, the first of these uses of the lecture is an important factor in teaching physics, and is often neglected by teachers who feel compelled to "cover more materials" or who regard the demonstrations as a distraction. Good lecture demonstrations are having the strength of being memorable. As such the lecture method, even though considered as one of the ancient teaching methods must not be neglected or abuse so as not to deprive students to learn the most important concept in physics (Heller, 1992).

Thus, the lecture-demonstrator becomes a big element in the teaching of physics. Moreover, it is also stressed that the use of lecture in the presentation of derivations is ineffective. Far and away, however, the least effective use of lecture time is for presenting the solutions to physics problems. The essential difficulty here is that physics problems-solving is a skill that has to be learned by repeated practice. In learning skills, it can be useful to first watch an expert exercise that skill, by that is by no means the most important part of the learning process. The lecture method with active learning is meritorious in the teaching of physics. This technique has several merits according to Freeman (2002). First the students have something constructive to do during the lecture; it is a sure-fire cure for the torpor that grips student's midway through a conventional lecture. Second, students are forced to discuss physics with their peers and to defend their ideas. Third, students get immediate feedback as to whether or not they understand a concept that has been presented in class, and any points of confusion can be corrected at an early stage in the students; apprehension of the concept. Last, the instructor can learn a great deal about her or his students' understanding of the material. Thus a workbook is the best way for students to learn physics as they are given ample time to do the exercise on it (Freeman (2002).

In the same source McDermott (1996) also offers physics teachers that for the discussion sections of the actual process, two strategies offer helps: Teaching problem solving and cooperative learning. This is intended to "principally be a forum in which students gain insight into problem solving techniques by observing the discussion leader, by practicing solving problem and by discussions with other students" in cooperative groups, students are given opportunities for "context-rich" problem these problems that are too difficult and challenging for students to work on their own. In order to solve such problems, cooperative groups of students can be organized; Freeman (2001) describes the strategy as a big prospect in teaching of physics in secondary school level.

Furthermore, Cheng (2004) opined that a creative activity in the teaching of physics is another prospect. In his study, Cheng contends that based on the students evaluation, they find creative activities as a contributing factor to their physics learning. They said their learning is consistent with the nature of most creative activities. Most students felt that these activities makes them think more, and think wider which enhances their creativity and also promote better physics learning. This can be achieved through the adoption of multiple learning objectives in physics, i.e. both cognitive and effective learning objectives.

Nevertheless, Van (2002) opined that necessity of a substantial teacher re-training is another prospect in teaching of physics in secondary school level, he observed that the teacher's evaluation results in most secondary schools in Nigeria shows that teachers do not have confidence in designing, conducting and accessing the teaching techniques and creative activities that are suitable for students and physics curricula. Due to the non-creative background of the teachers, as such substantial re-training of physics teachers is necessary even though these creative activities are rather simple. The results also suggest that teachers feel more comfortable to try-out these creative activities outside classroom.

However, Roger(2003) opined that formulation of a set of learning objectives, strategies, and activities for fostering creativity in physics is a big prospect in the teaching and learning of physics in secondary schools. A comprehensive set of learning objectives, strategies, and activities for fostering creativity in physics, and shed light on creative learning of other subjects must be accomplished to sustain the success of physics teaching. It demonstrates symmetrically to teachers and educators how learning activities suitable to their own contexts can be developed. It highlights that researchers should not only look for instructional methods that have idea learning outcomes, but also develop some simple and practical ones that can be widely-accepted and implemented.

In conclusion, Okoh (2004) opined that the prospect of teaching and learning physics at secondary school level is low sequel to myriad of problems confronting the teaching and learning of physics. Ranging from inadequate curriculum and inconsistency in government policies on education, to the problem of unqualified teachers and ill motivated teachers.

Learning physics in secondary school level help students to gain skills useful and proficient of solving problems and to have he ability to solve challenges by thinking creatively. Learning physics gives students grounding in advance mathematics. The practical skills gained through planning experiments will be appreciated by students in future (Okoh, 2004).

Similarly, Cheng (2004) opined that is about observation, understanding and predication of natural systems. As such learning physics at secondary school level will help students develop a range of skills that can be applied in many areas, both scientific and non-technical. These skills includes

- *Problem-solving:* studying physics give students a pragmatic and analytical approach to problem-solving.
- *Reasoning:* The course involves using reasoning skill to construct logic arguments, applying analytical skills and grasp complex problems.
- *Numeracy*: A physics degree gives you skills in using mathematics to find solution to scientific problems
- *Practical skills*: The learning of physics help students to obtain practical skills by planning, executing and reporting experiments, using technical equipment and paying attention to details

- *Information and communication technology (ICT):* Learning of physics exposes student to specialize in software packages and some programming.
- *Communication*: Studying physics in secondary school level give students skills to communicate complex ideas and use technical languages correctly

However, Van (2001) opined that learning or studying physics at secondary school level will enable students to gain valuable experience by applying the subject knowledge in a working context. He further opined that other skilled develop from learning physics in secondary school includes: independent working; teamwork; organizational and time management considering the skills developed from learning of physics in secondary school and its importance to the technological development of the society at large one will evidently conclude that there is a great prospect in learning of physics as such it is worth the trouble arising from complexity in learning the subject.

Nevertheless, Okoh (2004) opined that physics is a pre-requisite to studying course such as engineering, medical sciences, applied science and other professional science and technological course in the institutions of higher learning as such students who learn the subject properly will definitely make the required grades to study one of these courses and would consequently have a brighter future. There is a great prospect in learning physics in the secondary school regardless of the poor performance in the subject.

Several studies have indicated that students have a negative perception about physics in secondary school level this owns to their behavior that the subject is complex and difficult to assimilate; as such most students in secondary school resist studying physics and do not choose it as a subject in their senior class (Cheng, 2004).

As such Okoh (2004) opined that as a result of the negative attitude of students in the past, their performance had significantly declined in the period of five years. Furthermore, he opined that it is sad to note that student's attitudes and performance had obviously deteriorated in the last five years.

However, Thorndike (2006) opined that there is a need to emphasize and encourage positive attitude among the students in any learning area. They said that the more positive are the attitudes, the more positive are the students' actions in all activities. The students who have positive attitudes in their subject are also positive and take their serious. Even though the students are more incline into subject that can easily be assimilated and prefer a more simple method in learning physics, they need more positive attitude the more because the subject is dealing with activities that could improve and enhance their awareness on phenomenal changes in the surroundings and by fostering positive attitudes, they will be able to develop and improve their performance as a whole.

In Nigeria, students' poor performance in physics have been attributed to poor teaching methods, unqualified and inexperienced teachers, poor student attitude toward physics, poor learning environment and gender effect (Ogunleye, 2000; Jegede et al., 2002; Owolabi, 2004). In spite of all the advantages derived and the recognition given to physics as one of the core science subjects and as a pivot upon which technological and economic development rest, there are wider gaps between curriculum planner intention, the implementers, that is, physics classroom teachers and what goes on in the classroom. This has led to the negative perception of students that physics is a difficult school subject. More often than not the interrelatedness of mathematics and physics is not always emphasized in physics teaching. What students already know about the content is one of the strongest indicators of how well they will learn new information relative to the content.

Commonly, researchers and theorists refer to what a person already knows about a topic as "background knowledge." Numerous studies have confirmed the relationship between background knowledge and student achievement (Nagy et al., 2007; Dochy et al., 2009; Tobias, 2004). In these studies the reported average correlation between a person's background knowledge of a given topic and the extent to which that person learns new information on that topic is .66. Prior research has attempted to measure the impact of high school physics courses on students' success in undergraduate physics (Hart & Cottle, 2003; Alters, 1995). These American studies generally found that students who performed well in high school mathematics and physics subjects also did well in undergraduate physics.

However, Tai & Sadler (2001) point out that these conclusions were reached by examining only a few variables and forming simple correlations. Studies of students' Background knowledge in science and mathematics began in the 1970s and have since produced a voluminous literature (Dochy et al., 1999). Interest in prior knowledge began with the careful documentation of common errors made by students in solving physics and mathematics problems. Analysis of interviews with these students reveals that the errors are not random slips, but rather derive from underlying concepts. The learner will formulate existing physics structures only if new information or experiences are connected to knowledge already in memory. It is evident that it is from experiences that students develop a cognitive structure which may be valid, invalid or incomplete (Dresel et al., 1998).

Prior knowledge is defined as a multidimensional and hierarchical entity that is dynamic in nature and consists of different types of knowledge and skills (Dochy, 1992; Hailikari et al., 2007). Prior knowledge has long been considered the most important factor influencing learning and student achievement (Dochy & McDowell, 1997; De Corte, 1990; Dresel et al., 1998; Tobias, 1994).The amount and quality of prior knowledge positively influence both knowledge acquisition and the capacity to apply higher-order cognitive problem-solving skills (Dochy & McDowell, 1997; De Corte, 1990; Dresel et al., 1998; Tobias, 1994) irrespective of gender. World-wide gender has often been a variable of interest in most research works in Education and in this study it was included as a moderator variable of interest because past studies in Nigeria had indicated gender as one of the most important variables in science/mathematics education (Abakpa & Iji, 2011; Abiam & Odok, 2006) with inconclusive report findings (Abakpa & Iji, 2011; Akinsola & Awofala, 2009). Reported findings in gender had been mixed with some claiming that males performed better on achievement measure in mathematics and science than their female counterparts (Awofala, 2011a; Awofala, 2010; Ogunneye, 2003; Akinsola & Awofala, 2009) while others (Abakpa & Iji, 2011; Ogunleye & Babajide, 2011; Arigbabu & Mji, 2004; Agommuoh & Nzewi, 2003) observed no significant effect of gender on students' achievement in science and mathematics thus concluding that gender differences in achievement/performance might be disappearing.

Research Hypotheses

$H_0$1: There is no significant relationship between mathematics knowledge and the performance of senior secondary school physics students in Nigeria.

$H_0$2: There is no significant difference in the performance of physics students with high mathematics knowledge based on gender.

$H_0$3: There is no significant difference between students in physics based on variation in mathematics knowledge

Research Methodology

The study employed quasi- experimental research design. The study will split the students into two groups; viz group 1 and group 2. One group consists of students with fair knowledge of mathematics while group 2 consists of students with sound knowledge of mathematics.

The population of the study consists of two groups of students; group 1 will contain 20 students and group 2 about 20 students of some selected secondary schools in Ikere local government area making it a total of 40 students from the two schools.

The study consists of 20 students which are divided into a group of 20 students, one subject were taught; group 1 the performance of students with fair mathematics knowledge was recorded while group 2 the performance of students with sound mathematics knowledge were also recorded which serves as the data for the analysis.

The instrument for this study was the score sheet constructed by the researcher; the sheet contains two groups namely group 1 and group 2 to take down the performance scores of student on the two performances from the groups which are the sound mathematics knowledge and fair mathematics knowledge

The instrument was subjected to validity and reliability mechanism.

The score sheet were given to the various supervisors during this period of learning to take down the scores of students based on performance for the subjects under consideration using the method of demonstration.

The data was analyzed using SPSS to test for the performance difference of the two groups under the same methods of learning (good mathematics knowledge and fair mathematics knowledge). The Pearson Correlation and t-test statistical tools were used to test all the hypotheses at 0.05 level of significance.

Results and Discussion

Hypothesis 1

$H_0$1: There is no significant relationship between mathematics knowledge and the performance of senior secondary school physics students in Nigeria.

Table 1
Correlations

		Group 1 (demonstration method)	Group 2 (demonstration method)
Group 1 (sound mathematics knowledge)	Pearson Correlation	1	-.432
	Sig. (2-tailed)		.089
	N	30	30
Group 2 (fair mathematics knowledge)	Pearson Correlation	-.432	1
	Sig. (2-tailed)	.089	
	N	30	30

Level of significance (α=0.05)

From table 1 above, since the value of "r" tabulated is greater than "r" calculated, accept the alternative hypothesis (H_1) and reject the null hypothesis (H_0) and conclude that there is no significant relationship between mathematics knowledge and the performance of senior secondary school physics students in Nigeria

Hypothesis 2
H_{02}: There is no significant difference in the performance of physics students with high mathematics knowledge based on gender.

Table 2
Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	GENDER OF THE RESPONDENTS - Group 1 (sound mathematics knowledge)	-57.548	19.433	3.163	-54.822	-34.532	-16.693	29	.000
Pair 2	GENDER OF THE RESPONDENTS - Group 2 (fair mathematics knowledge)	-82.022	16.996	2.718	-73.673	-66.312	-34.231	29	.000

Level of significance (α=0.05)

Since the p-value (0.000) is less than the level of significance (0.05), we reject the null hypothesis and accept the alternative hypothesis thereby concluding that there is significant difference in the performance of physics students with high mathematics knowledge based on gender

Hypothesis 3
H_{03}: There is no significant difference between students in physics based on variation in mathematics knowledge

Table 3
Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Group 1 (sound mathematics knowledge) - Group 2 (fair mathematics knowledge)	-27.422	25.267	5.884	-42.154	-15.213	-6.312	29	.000

Level of significance (α=0.05)

Since the p-value (0.000) is less than the level of significance (0.05), we reject the null hypothesis and accept the alternative hypothesis thereby concluding that there is significant difference (27.422) between students in physics based on variation in mathematics knowledge

Conclusion

Based on the findings, physics should not be taught in isolation but in conjunction with mathematics and better still further mathematics which seems to have more connections with school physics The teaching of prerequisite mathematics concepts in physics before physics teaching made students more confident in learning physics thereby improving achievement in physics.

The teaching of prerequisite mathematics concepts in physics assisted physics teachers through diagnostic testing to ascertain the students' level of preparedness before the teaching of physics. The teaching of prerequisite mathematics concepts in physics could be adopted as a viable strategy for strengthening the students' cognition in physics thereby lessening the general perception that physics is a difficult school subject

Recommendations

The study recommends that:

- Physics teachers should endeavour to teach prerequisite mathematics concepts in physics before engaging in real physics teaching as this will allow for meaningful understanding and integration of mathematics concepts embedded in physics contents; The state government should make all effort to recruit qualified and experienced teachers to teach Physics in all the public schools in the state;
- There should be an increased instructional supervision in Physics and Mathematics education in the state. This should be undertaken by knowledgeable supervisors in the subjects. Where the personnel are not available, knowledgeable supervisors could be engaged on consultancy;
- Since it is revealed that mathematics has positive influence on the achievement of students in physics, it is therefore recommended that all science students should be mandated to take further mathematics for at least the first two years of the Senior Secondary School;
- Mathematics and physics teachers should endeavour to make the teaching and learning of mathematics and physics interesting to the students.

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