IN PHYSICS AMONG SENIOR SECONDARY SCHOOL STUDENTS IN OSUN STATE, NIGERIA

Omiwale, Julius Babajide
Department of Science Education,
Osun State University, Ipetu-Ijesha Campus,
Osun State, Nigeria.

Abstract

This study examined the prior knowledge students have in physics as it affects their achievement in the subject. An ex-post facto research design was adopted for the study. A sample of three hundred and two (302) students was drawn from nine schools out of a total population of fourteen thousand, three hundred and twenty two (14,322) senior secondary school II students, using stratified random sampling technique. Two instruments: Test of Students' Prior Knowledge in Physics (TSPKP) and Test of Achievement in Physics (TAP) with reliability indices of 0.82 and 0.87 respectively, were used for the study. The results of the study revealed that there was significant relationship between students' prior knowledge and achievement in physics (r =0.11, p=0.05). It is recommended that more commitment be given to examining students' prior knowledge before new concepts are taught so that the teacher may be equipped with better understanding of existing scheme of knowledge in which the new learning is to be accommodated.

Keywords: Prior knowledge, achievement, physics, secondary school,

Introduction

Science and technology have proven to be the lifeline for human survival in the modern day world. The realization of science and technology as the basis for socio-economic and political development has made nations of the world to continuously harness their natural endowment for technological development. The level of scientific and technological development seems to be the most important yardstick for determining which countries qualify to be regarded as 'superpowers'. Through science and technology, there have been tremendous achievements in the areas of medicine, engineering, architecture, astronomy, space technology, energy, and communication.

According to Abimbola (2001), science is generally defined as a body of knowledge, a way of investigating or method, and a way of thinking in the pursuit of an understanding of nature. Ekpeyong (2004) defined science as the study of the fundamental laws of nature. Science has developed over the years, from Thales philosophy of the 6th century BC to the Plato and Aristotle logical philosophies of the 4th century BC. During the Hellenistic age, Archimedes, the mathematician and inventor, laid the foundations of mechanics and hydrostatics, Theophrastus, the philosopher and scientist became the founder of Botany, Hipparchus, the astronomer developed Trigonometry, and Herophilus and Erasistratus, the anatomists and physicians based anatomy and physiology on dissection (Microsoft Encarta Encyclopedia, 2001). Over time, the knowledge of science has grown and broadened to a level that necessitates the division of this area of knowledge into various branches. An important area of science that emerged from this division is physics.

Adeniran (2009) defined physics as a major science that deals with the fundamental constituents of the universe, the forces they exert on one another, and the effects of these forces. It provides the theory behind technology and serves as the foundation of many theoretical and applied knowledge. Physics as a subject provides a basic foundation for many other aspects of knowledge like medicine, engineering, astronomy, and communication.

In spite of the importance of physics to technological development, it appears that all is not well with students' enrolment and achievement in the subject at the secondary school level in Nigeria. Studies have shown that physics has a relatively low population index at the secondary school level in Nigeria. (Fasemore, 1970; Adejumobi, 1976; Bamigbala, 2006). Ho and Boo (2007) discussed that in many countries, there has been a decline in the number of students wishing to continue with physics. The West African Examinations Council (WAEC)'s statistics indicate a continuous decline in

enrolment for school certificate physics examination in Nigeria. For example, there was a serious decline between 2004 and 2005, and another decline between 2006 and 2007 (table 1). It is also very clear that out of the three science subjects of Physics, Chemistry and Biology, Physics recorded the least entry each year. There are also empirical evidences that Nigerian senior secondary school students perform below expectation in physics in their school certificate examinations. Nneji (1998) showed that the performance of students in the West African Senior School Certificate Examination (WASSCE) in science between 1988 and 1992 was poor. The average performance showed that 8.27% of the students had credit while 31.2% had passes.

Table 1: Nigerian candidates' enrolment and performance in the May/June West African Senior School Certificate Examination (WASSCE) conducted by the West African Examinations Council (WAEC) between 2004 and 2008

Subjects	Year	Total entry	% pass at credit level (A1 to C6)
Biology	2004	1005553	42.22
	2005	1005894	29.68
	2006	1051557	35.74
	2007	1092556	35.61
	2008	1259965	33.94
	2009	1340206	28.59
Chemistry	2004	313332	49.44
	2005	327503	37.86
	2006	349936	50.94
	2007	355452	50.52
	2008	418423	44.44
	2009	468546	43.69
Physics	2004	305444	46.90
	2005	143352	31.76
	2006	151819	46.89
	2007	135215	36.05
	2008	142248	39.87
	2009	465636	47.83

Source: Research division, West African Examinations Council, Yaba, Lagos.

Even dating back to the 1990's, the performance of secondary school students in Mathematics has been poor. Ali (1990), Okebukola (1997), Nneji (1998), Ogunleye (2000) and Umeh (2002) were all of the opinion that students' performances in the science subjects were poor. From 2004 to 2008, the percentage pass at credit level recorded in physics were 46.9%, 31.76%, 46.89%, 36.05%, and 39.87% respectively (Table 1).In the area of gender, Bamigbala (2006), found that the participation and performance of girls in sciences especially physics was low compared to that of their male counterparts. Reasons advanced for the poor performance of students in physics include: inadequately qualified teachers, inadequate motivation for students, students' poor mathematical background, poor methods of teaching, all of which result in poor problem-solving ability. Specifically, a report of the Science Teachers Association of Nigeria (STAN) workshop on physics held at Osogbo in 2004 stated that students perform poorly in physics due to lack of proper teaching, and poor exposure of students to practicals.

Prior knowledge is defined as a collection of related and interrelated conceptions, which provide an indication of the scientific knowledge as well as non-scientific knowledge possessed by students (Hewson & Hewson, 1983). Science educators have studied the content of students' ideas in an African setting about many physical phenomena and have succeeded in demonstrating that students do not come into science classes with minds *tabula rasa*. Students bring with them ideas, beliefs, and values about the causes and mechanisms of natural phenomena, which they have formulated based on their socio-cultural environment including previous educational experiences (Gunstone,

1988; Cobern, 1991, Onwu, 2000). Some of these ideas are incorrect or over-simplistic, others are quite correct. The incorrect ideas are the non-scientific prior knowledge which are rooted in the students' (commonsense) beliefs while the correct ideas are scientific prior knowledge.

Novak (1987) stated that ideas and explanations that children generate from a complex framework for thinking about the world are frequently different from the views of scientists. These differences he referred to as 'misconceptions' or alternative framework. According to Chiappetta and Koballa (2006), learners come to formal science instruction with a diverse set of alternative conceptions about natural objects and events. The alternative conceptions that learners bring to formal science instruction cut across age, ability, gender, and cultural boundaries. Alternative conceptions are tenacious and resistant to extinction by conventional teaching strategies and they have their origins in diverse sets of personal experiences including direct observations and perceptions, peer culture and language, and in teachers' explanations and instructional materials. Teachers often subscribe to the same alternative conceptions as their students. Learners' prior knowledge interacts with knowledge presented in formal instruction, resulting in a diverse set of unintended learning outcomes. They finally asserted that instructional approaches that facilitate conceptual change can be effective classroom tools.

There has been a significant amount of research efforts by science educators on misconceptions of science concepts about natural phenomena, from primary to tertiary levels of learning. Mankilik (2006) investigated the effects of demonstration and guided discovery methods in correcting misconceptions in physics among remedial students of the University of Jos. Two researcher designed instruments: Physics Misconception Test (PMT) and Physics Achievement Test (PAT) were used as treatment test instruments for data collection. Finding of the study showed that: remedial students in the University of Jos held misconceptions of physics concepts in geometric optics and electricity. The researcher however, recommended that teachers of physics in the Remedial Studies Department should teach Physics concepts using guided discovery method.

Stein, Larrabee and Barman (2008) in a study of common beliefs and misconceptions in physical science, made use of Science Belief Test (SBT), an online instrument comprising of 47 statements that required true or false responses. The target topics in chemistry, physics, biology, earth science and astronomy were designed to assess pre-service elementary teachers' beliefs about general science content. A total of 305 respondents were involved in the study. The result revealed three categories of responses i.e. (1) correct explanation (2) incorrect explanation (3) guess or un-interpretable. According to Weld (2004), some typical alternative conceptions in Physics, expressed by students are as follows:

(i) If no force is being applied, either objects are at rest or, if moving, they are slowing down.
(ii) An object moves in the direction of the force applied to it.
(iii) Heat makes things rise.
(iv) Heat and cold are material substances that can be transferred from one thing to another.
(v) Light brightens objects so that they can be seen.
(vi) Eyes play an active role in reaching out to intercept images.
(vii) Gas molecules are not in constant motion.
(viii) Heating and cooling play no role in particle motion.
(ix) The orbit of the earth is highly elliptical (related to change of seasons).
(x) The earth is flat.

The major thrust of this research was to investigate the relationship between prior knowledge and achievement in physics among secondary school students in Osun State, Nigeria. In this regard, a combination of the new philosophy of science (Khun, 1962) and Constructivism provide the theoretical framework for the study. The new philosophers of science assert that knowledge, beliefs and theories we hold determine to a great extent what we perceive. The effect of this according to Smith (1980) is that the knowledge of science given to students depends on what the teacher

believes, knows and does, as well as what the teacher does not believe, does not know, and does not do. Constructivism posits that facts, theories and concepts that are external realities must fit into students' experience before they can become students' proper conceptions (Von Glasersfeld, 1989). Since misconceptions and alternative conceptions are embedded within learners' prior knowledge, the implication of these two theories therefore is that, for any meaningful learning to take place, teachers must device teaching strategies that will replace misconceptions with correct conceptions in the thinking of the learners.

The Physics content chosen for this study is 'mechanics'. This is because mechanics is more than just one of the domains of physics. Mechanics defines the main tools in physics and presents the most universal law of nature, the Newton's law of gravitation which is applicable to all masses (Galili, 1995). This is why it always opens any physics curriculum. The major concepts the study focused on are Motion and Conservation Principles with particular reference to Newton's Laws of Motion and their prerequisite concepts.

This study is partly justified by the dearth of current studies on the effects of prior knowledge on Nigerian students' performance in science, especially in physics. However, a few studies have been conducted in the area of students' prior knowledge in the past. Ivowi and Oludotun (1987) investigated sources of non-scientific conceptions in Physics. Analysis of their data revealed the most prevalent sources of prior knowledge that are non-scientific to be textbooks, personal intuition, experience, and teachers. Adeniyi (1985) investigated misconceptions related to some concepts held by some secondary school students. He identified non-scientific knowledge in such areas of ecology like population, ecosystem, community, and pyramid of energy. Abimbola (1984) investigated the prior knowledge related to human respiration held by selected Nigerian secondary students. He identified many non-scientific conceptions both before and after instruction. These he traced to instruction, students' culture including their mother tongue and the Nigerian climate. This study therefore examined students' prior knowledge in relation to their achievement in physics at the senior secondary school level.

This study sought to find out how ideas, beliefs, and values about the causes and mechanisms of natural phenomena (prior knowledge), which students have formulated based on their socio-cultural environment affect their understanding of physics concepts.

Research Hypotheses

The following hypotheses were generated and tested for the study at 0.05 alpha level.

1. There is no significant relationship between students' scores in Test of Students' Prior Knowledge in Physics (TSPKP) and their scores in the Test of Achievement in Physics (TAP).
2. There is no significant relationship between male students' scores in Test of Students' Prior Knowledge in Physics (TSPKP) and their scores in the Test of Achievement in Physics (TAP).
3. There is no significant relationship between female students' scores in Test of Students' Prior Knowledge in Physics (TSPKP) and their scores in the Test of Achievement in Physics (TAP).

Methodology

This study adopted the ex-post facto research design since the effects of the independent variable on the dependent variable are already in existence. There was therefore no manipulation of any independent variable.

Sample

The sample for this study comprised of three hundred and two (302) senior secondary school class two (SS II) students selected from a total population of fourteen thousand, three hundred and twenty two students (14,322). From this population, nine intact physics classes were purposively selected from twelve schools out of thirty nine schools in four local government areas of Osun State. The sample consisted of one hundred and seventy males and one hundred and thirty two females. They have an average age of 16.7 years.

Instrument

Two instruments: Test of Students' Prior Knowledge in Physics (TSPKP), and Test of Achievement in Physics (TAP) were used for the study. The TSPKP was set primarily to find out ideas, beliefs, and values about the causes and mechanisms of natural phenomena, which students have formulated based on their socio-cultural environment including previous educational experiences, which of course can influence their understanding of physics concepts but are not themselves directly based on physics content. It contained twenty-five multiple choice objective items with one correct (scientific knowledge) option as the key and four other incorrect but plausible (non-scientific knowledge) options as distracters. For every option chosen, students are to indicate the first source of knowledge from a list of five identified sources. The instrument was developed by the researcher with ideas from previous studies. The TAP contained fifty objective items that required students' possession of adequate understanding of concepts of the selected topics in physics and good problem solving ability, for them to do well in the concept. The questions were adopted from past West African Senior School Certificate Examination (WASSCE) papers and the National Examination Council NECO Senior School Certificate Examination physics papers. Basically, this study sought to find out how those ideas brought into the classroom, as reflected on students' response to the TSPKP affects their understanding of physics concepts as reflected on their performance in the TAP.

The instruments were validated by one expert in the Department of Physics, and two experts in the Faculty of Education, Obafemi Awolowo University, Ile-Ife. In addition, the TSPKP was further validated by two experienced secondary school physics teachers in the School of Science, Ile-Ife. The reliability of the instruments were determined using test re-test method of two weeks interval, and the scores generated in the two administrations were correlated using Pearson Product Moment Correlation Coefficient to obtain reliability indices of 0.82 and 0.87 respectively.

Data Collection

The study lasted for six weeks covering a period of training the research assistants, the field testing, the restructuring of the instruments and the administration of the instruments for the main study. The main study was carried out in nine intact classes in nine secondary schools in Irepodun, Osogbo and Olorunda Local Government Areas of Osun State. The regular physics teachers in these schools also served as research personnel for the administration of the instruments. The Local Inspectors of Education also assisted as research monitoring officers. A coordination meeting of the researcher with eighteen research assistants and three monitoring officers was held before the main study was conducted. The two instruments TSPKP and TAP were administered the same day in two sessions as Paper I and Paper II respectively.

Data Analysis

In testing the three hypotheses, students' scores in the TSPKP and TAP were collated in each case of hypotheses 1, 2 and 3, and the Pearson Product Moment Correlation Coefficient formula was employed to find out the correlation between the two sets of scores.

Results and Discussion

The results of the analysis of the data obtained for each of the hypotheses are presented as follows:

Hypothesis 1: There is no significant relationship between students' scores in Test of Students' Prior Knowledge in Physics (TSPKP) and their scores in the Test of Achievement in Physics (TAP).
The summary of the results obtained in respect of hypothesis 1 are presented in table 2.

Table 2: Summary of pearson product-moment correlation between students' scores in the TSPKP, and TAP

Group	N	Mean	S.D	r	P
TSPKP scores	302	10.1589	2.21	0.113	0.05
TAP scores	302	20. 4901	5.61		

P=0.05

The result presented on table 1 shows a positive correlation between the scores of students in the Test of Students' Prior Knowledge in Physics (TSPKP) and their scores in the Test of Achievement in Physics (TAP). The correlation coefficient obtained is significant at 0.05 level of significance. (N= 302, r = 0.113, p = 0.05). On the basis of this significance, the null hypothesis of non-significant relationship between students' scores in TSPKP and TAP was rejected.

In addition to the above quantitative analysis, qualitative analysis of students' explanations of thoughts in their solutions to the objective test in the TSPKP revealed some of their specific understandings that informed their choice of answers in the objective test. The analysis revealed a lot of misconceptions due to lack of prior knowledge and this impacted negatively on their overall performance in the TSPKP. The misconceptions were widespread and common to majority of the students. For example, most of the students believed that a body moves with uniform velocity only when it has zero velocity. They also believed that a toy car could be caused to move horizontally due to a downward force. They held a misconception that two bodies moving at constant speeds in separate parallel tracks have the same speed when they are at the same position. They used the term power and energy interchangeably, and misconceived the concept of complete oscillation. It was also evident in their responses that they had a poor understanding of the concept of gravitation.

Hypothesis 2: There is no significant relationship between male students' scores in Test of Students' Prior Knowledge in Physics (TSPKP) and their scores in the Test of Achievement in Physics (TAP).

The summary of the results obtained in respect of hypothesis 2 are presented in table 3.

Table 3: Summary of pearson product-moment correlation between male students' scores in the TSPKP, and TAP

Group	N	Mean	S.D	r	P
Male TSPKP scores	170	10.22	2.44	0.202	0.008
Male TAP scores	170	21.34	5.84		

P<0.05

The result presented in table 3 indicates a positive correlation between the scores of male students in the Test of Students' Prior Knowledge in Physics (TSPKP) and their scores in the Test of Achievement in Physics (TAP). The correlation was found to be significant at 0.05 level of significance (N = 170, r = 0.202, p<0.05). Therefore the null hypothesis earlier generated was rejected. Thus, there was significant relationship between male students' scores in Test of Students' Prior Knowledge in Physics (TSPKP) and their scores in the Test of Achievement in Physics (TAP).

Hypothesis 3: There is no significant relationship between female students' scores in Test of Students' Prior Knowledge in Physics (TSPKP) and their scores in the Test of Achievement in Physics (TAP).

The summary of the results obtained in respect of hypothesis 3 are presented in table 4.

Table 4: Summary of pearson product-moment correlation between female students in the TSPKP, and TAP

Group		Mean	S.D	r	P
Female TSPKP scores	132	10.08	1.89	-0.067	0.445
Female TAP scores	132	19.40	5.11		

P>0.05

The result presented on table 4 represents a negative correlation between the scores of female students in the Test of Students' Prior Knowledge in Physics (TSPKP) and their scores in the Test of Achievement in Physics (TAP) which is not significant at 0.05 level of significance ($N = 132$, $r = 0.067$, $p > 0.05$). The null hypothesis was therefore not rejected. The relationship observed suggests an inverse proportionality between the scores of prior knowledge in physics and scores of achievement in physics among female students.

Discussion

Based on the results, there was significant relationship between the scores of all the students combined together in the TSPKP and the TAP. This finding is in line with those Hestenes and Wells (1992) who reported that a good student's score on the Force Concept Inventory (FCI) similar to the TSPKP in this study could contribute to a good score in the Baseline Test, an indication of students' performance in physics. Similarly, Helm (1980), and Ivowi (1981) found out that students held some prior non-scientific knowledge called misconceptions, in physics among secondary school students in South Africa and Nigeria respectively. These prior non-scientific knowledge in physics do not depend on the type of school students attend, given the same educational facilities in the schools. Ivowi (1981) further revealed that the correlation between prior knowledge in physics remains positive and significant for male students but there was an inverse relationship though not significant for females. Such findings have been reported by Helm (1980) who reported that the prior-knowledge exhibited by males and females may call attention to a general mismatch between students' intellectual development and the demands made upon them by the content of the physics course.

Hestenes, Wells and Swackhammer (1992) also discovered that some students indicate false responses by choosing correct options using prior non-scientific knowledge. Also, Henderson (2002) reported that some low scores on prior knowledge test had corresponding high scores in performance, indicating a possible inverse relationship.

Conclusion and Recommendations

The conclusion from this study is that the more the prior knowledge students possess in physics, the better their achievement in physics may be. It is arecommended that more commitment be given to examining students' prior knowledge before new concepts are taught for the teacher to be equipped with better understanding of the existing scheme of knowledge in which the new learning is to be accommodated.

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