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Secondary School Mathematics as Determinant of Academic Performance in University Introductory Physics

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Abstract

The study determined the relationship between performance in secondary school Mathematics and undergraduate students' performance in introductory Physics courses. It also investigated the influence of the performance in Mathematics on undergraduate students' achievement in practical courses and determined the influence of their performances in Mathematics on undergraduate students' attitude to Physics at university level. These were with the view to improving the performance in Physics through the knowledge of Mathematics. The study employed ex-post-facto and survey research design methods. The sample consisted of one hundred and eighty students which were randomly selected from six departments in Faculty of Science, University of Ibadan. The instrument used for data collection is a questionnaire titled; "Undergraduate Students Attitude to Physics Questionnaire" (USAPQ). The reliability of the instrument was found to be 0.71. The data collected were analyzed using correlation coefficient, linear regression and percentage. The result revealed that, there is no significant relationship between performance in secondary school Mathematics and undergraduate students' performance in university introductory Physics. It also showed that there is no significant relationship between the performance of undergraduate students' performance in Mathematics and their performance in practical Physics courses. Finally, it revealed that there is a significant relationship between their performance in Mathematics and their attitude to Physics at university level. The study concluded that, there should be more seminars for teachers on the need to encourage students to improve on their attitude towards Mathematics. The study concluded that, the government should invest more into Physics, Mathematics and science education
Keywords: Mathematics, Academic Performance, Determinant, Physics, Mathematics

1. Introduction

In this scientific Age, the importance of Mathematics cannot be underestimated because it has its limb in virtually all fields of study either Mathematical or non-Mathematical, not to discuss its influence in the Mathematical 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 their institutions. Mathematics is the language of Science and Technology, because it is the tool for solving science subjects like Physics and Chemistry, hence prioritization of Mathematics teaching and learning in the bid for national development is inevitable.

Mathematics is a compulsory subject at basic and secondary levels of education in Nigeria. This is important for the production of science and technological literate citizens who can think critically about complex issues, analyze and adapt to new situations, solve problems of various kinds and communicate their thinking effectively for the economy growth of the nation, this can only be achieved by improving on the science and mathematical process skills starting from the basic level. Ugbebor (2009) supported that Mathematics is an indispensable tool for the transformation of technological development to reality since technology development communicates the idea of growth expansion and improvement in goods and services emanating from practical application of science. In his own opinion, Ojo (1986) described it as a queen of science.

The significance of Mathematics in producing versatile and resourceful graduates that are needed for economic development cannot be over-emphasized. Mathematics is seen as a fundamental subject that is necessary for the understanding of other fields of study such as science, technology, social sciences, medicine, etc. The Science Teachers Association of Nigeria (1992) referred to Mathematics as the central intellectual discipline of the technology societies. The knowledge of science and technology remains superficial without Mathematics. It therefore means that the position of Mathematics in secondary school curriculum in Nigeria is important for scientific development.

Physics on the other hand is one of the basic sciences that touch our lives daily at every point. It involves the study of nature and underlying principles that govern the behaviour of the whole universe and all physical things in it, be it living or non-living. The study of Physics requires a lot of representation like experiments, formulas and calculations, graphs and concepts explanation. Physics is one of the science subjects

taught at the senior secondary school level in Nigeria. It is one of the pre-requisite subjects for the study of science, technology, medical and other applied science courses in institutions of higher learning. Its importance as a discipline cannot be over-emphasized. Physics as a science course of study is perceived generally to be very interesting, vast, mathematical and experimental.

The study of Physics at any level of study requires a good understanding of Mathematics, this is because Mathematics is the tool for solving problems in Physics. The application of Mathematics in solving physical problems through the knowledge of Physics is very essential. Some researchers in their study affirmed that there is strong interrelationship between Physics and Mathematics (Gifford and Harpole, 1986; Hart and Cottle, 1993 and Alters, 1995). However, the performance of a student in Physics might not necessarily be hinged on the knowledge of the students in Mathematics but on other factors. Champagne and Klopfer (1982) and Halloun and Hestenes (1985), found that these correlations did little to explain the actual cause of strong performance and deep conceptual understanding in college Physics. Both Champagne and Klopfer (1982) and Halloun and Hestenes (1985) found that students' pre-conceptions of Physics concepts affected student success in college. Other factors that were found to contribute to students' performance in Physics are teachers' method of teaching (Bello, 2011; Orora, Wachanga & Keraro, 2005, Kibett & Kathuri, 2005). However, the extent at which students' understanding of Mathematics at secondary school can determine their academic performance in the first year Physics courses in Nigeria is yet to be determined, hence this study.

1.1. Objectives of the Study

The specific objectives of the study are to:

i. determine the relationship between undergraduate students' academic achievement introductory Physics course and their academic performance in secondary school Mathematics;
ii. determine the relationship between undergraduate students' academic achievement in practical Physics course and their academic performance in secondary school Mathematics; and
iii. determine the influence of their performance in Mathematics on undergraduate students' attitude to Physics at university level.

1.2 Research Hypotheses

The following research hypotheses were generated to guide the study

i. There is no significant relationship between undergraduate students' academic achievement in secondary school Mathematics (WASCE) and their academic performance in introductory Physics course.
ii. There is no significant relationship between undergraduate students' academic achievement in secondary school Mathematics and their academic performance in practical Physics course.
iii. There is no significant relationship between their academic performance in Mathematics and their attitude to Physics at university level.

2. Methodology

The study employed the use of ex-post-facto and descriptive survey research design. The population comprised all students in the Faculty of Science at the University of Ibadan. The sample consisted of one hundred and eighty undergraduate students who were selected using simple random sampling technique from six departments in the Faculty of Science, University of Ibadan.

2.1 Instrumentation

Three instruments were used to collect data for the study. They are questionnaire titled "Undergraduate Students' Attitude to Physics Questionnaire" (USAPQ); West Africa School Certificate Examination Results of the chosen students in Mathematics; and university introductory Physics Results in Practical and Theory for year one. The instrument which was developed by researchers based on research objectives was given to an expert in the field of test and measurement for face and content validity. The items were administered (trial tested) on the respondents from other university who are different from the respondents who participated in this study. Thus, the content validity was established and Kuder Richardson (KR-20) formula was used to determine the reliability index of the items which was 0.71 for the USAPQ.

2.2 Procedure for Data Collection

Collection of data was done by the researcher. The researcher visited the Head of Department of the chosen departments of the selected students in the university to take permission for the administration of the instrument. Copies of the questionnaire were administered to the students in the six departments of Faculty of Science. The introductory Physics results in practical and theory courses were collected. Data collected were analyzed using correlation coefficient.

3.0 Results

Research Hypothesis One: There is no significant relationship between undergraduate students' performance in secondary school Mathematics and their performance in introductory Physics course.

The result in table 1 above shows the correlation coefficients of the performance of students in Mathematics (WASCE) and their corresponding performance in introductory Physics course result in university. The result indicates that the correlation of the two performances is very low ($r = 0.13$) at $p = 0.05$. This shows that there was a very low correlation between the knowledge of Mathematics in secondary school and the knowledge of Physics in the university introductory course. Therefore the value of 0.13 is not statistically significant. Thus we do not reject the hypothesis that there is no significant relationship that existed between the knowledge of Mathematics in secondary school and the knowledge of introductory Physics course in university.

Research Hypothesis 2: There is no significant relationship between undergraduate students' performance in secondary school Mathematics and their performance in practical Physics course.

The result in table 2 above shows the correlation coefficients of the performance of students in WASCE Mathematics and their corresponding performance in Physics practical course in university. It reveals that the correlation of the two performances is very high ($r = 0.85$) at $p=0.05$. This shows that there is a very high correlation between the knowledge of Mathematics in secondary school and Physics practical course in the first year in university. Therefore, the correlation is statistically significant, and the null hypothesis is therefore rejected that there is no significant relationship between the knowledge of Mathematics in secondary school and the knowledge of Physics practical course in the first year in university. This implies that there is significant relationship between the two variables, this further reveals that secondary school Mathematics is a determinant of introductory practical Physics in university.

Research Hypothesis 3: There is no significant relationship between undergraduate students' performance in Mathematics and their attitude to Physics at university level.

The result in table 3 above shows the correlation coefficient of the performance of students in WASCE Mathematics and their corresponding attitude to Physics course in university. It indicates that the correlation between the two is low ($r = 0.22$) at $p = 0.01$. The result shows that there is a low correlation between the knowledge of Mathematics in secondary school and attitude of undergraduate students to Physics. Since the correlation is not statistically significant, the null hypothesis is accepted that there is no significant relationship between the students' performance in Mathematics and their attitude to Physics at university level.

4 Discussion

The result in table 1 shows clearly that the correlation is not statistically significant, this implies that there is no significant relationship between the performance of secondary school students in final year Mathematics and their performance in introductory Physics. This is in agreement Halloun & Hestenes (1985) who found that high Mathematical competence is not sufficient for high performance in introductory Physics. Therefore, there could be other factors responsible for this difference. Champagne & Klopfer (1982) ascertained that, Mathematics and Physics pretests were the best predictors of college performance, while high school courses in Mathematics and science had statistically significant but minor effects. Also, David (2001) reported that the correlation between Mathematics skill and Physics performance has not been observed to hold consistently, but reported correlation coefficients vary widely and are not statistically significant. He further found that students with higher level of pre instruction Mathematics skill had substantially higher learning gains in the introductory Physics in the university than students with lower level of pre-instruction mathematics. Furthermore, Champagne & Klopfer (1982) found that these correlations did little to explain the actual cause of strong performance and deep conceptual understanding in college Physics. They opined that students preconceptions of Physics concepts affected their success in college Physics significantly, and that performance on specialized conceptual tests to identify these preconceptions was a better predictor of college Physics grades than either high school grades.

Furthermore, the result of findings to research hypothesis two showed that there is high correlation between secondary school Mathematics and students' performance in practical Physics at the university level. Correspondingly, this was supported by Hart & Cottle (1993) who found that high performing introductory college Physics students performed well in high school Mathematics. Hart & Cottle (1993) also reported that students who had good grades in high school Mathematics and had taken Physics in high school performed well in introductory Physics courses in college. On the other hand, Bello (2012) found that effective utilization of Physics laboratory equipment can enhance academic achievement in Physics and opined that Physics laboratory

work helps to simplify the abstractness aspect of Physics thereby increasing the students' performance by learners; Olatunbosun (2008) also found that laboratory adequacy can positively influence the academic performance of students. Therefore, the high academic performance by the students in their Physics practical might not only be as a result of their performance in secondary school Mathematics but could also be as result of the above identified factors

The result of findings to research hypothesis three indicated that there is low correlation between undergraduate students' performance in Mathematics and their attitude to Physics. Bajah (1998) explained that students have negative attitudes to Physics which was caused by misconception about the subject. Physics is considered as the most difficult area in the realm of science, and it traditionally attracts fewer students than Chemistry and Biology. (Rivard & Straw, 2000) also found out that Physics is perceived as a difficult subject for students from secondary school to university and also for adults in graduate education. It is well known that both high school and college students find Physics difficult. On the contrary, Olusola & Rotimi (2012) established that students have high favourable attitudes towards Physics oriented career courses. Also, Abdulkarim & Raburu (2013) postulated that there was a significant difference in the attitude of students towards Physics between the experimental and the control group.

Conclusion

Although, student's performance in an examination is an indication of the student's knowledge at the time of the examination, but is not necessarily related to what the student has learned in the course. Hence, it is necessary to have some measure of student's learning, in contrast to a measure that merely quantifies students' knowledge. One way to provide such a measure is to test students both at the beginning and at or near the end of a course to assess how much they may have learnt. Through this, their learning gain can be measured, which is the quantity that, in principle, is most susceptible to change by actions of the instructor and students during the course. Students' performance in course examination may or may not be correlated with learning gain, and the relationship between performance and learning gain is, at best, an indirect one. This is an important point that needed to be considered by instructors so as to be able to find better ways of assessing students most especially through the three domain of learning. Research is devoid of investigation on the possible relationship of Mathematics and other preparation to students' learning gain in college Physics courses.

The result of this study had revealed that; high Mathematical competence in the secondary school is not sufficient for high performance in introductory Physics at university level. This implies that secondary school Mathematics cannot sufficiently predict undergraduate students' performance in introductory Physics in university. However, the performance of students in Physics could be due to other factors such as lack of self-confidence (Bello, 2012), unavailable and ineffective utilization of laboratory equipment (Bello & Olajide, 2012), inability to solve Physics questions correctly using the appropriate formula and not being able to see the relevance of Physics to the society. Also, effort should be intensified in improving on teaching methodology adopted in teaching Physics. The science teachers should make use of research results through research uptake so that outcome of research in improving teaching/learning process in Physics can be implemented and positive results could be obtained. Furthermore, lecturers and students at higher level of learning should adjust to new roles which may lead to changes of classroom processes which in turn may affect the nature of the relationship between the lecturer - student interpersonal relationship and students' attitudes.

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Table 1: Correlation coefficient showing the relationship between students' performance in Mathematics (WASCE) and undergraduate introductory Physics course

		Grade in Mathematics (WASCE)	Grade in introductory Physics course
Grade in Mathematics (WASCE)	Pearson Correlation	1	.131
	Sig. (2-tailed)		.080
	N	180	180
Grade in introductory Physics course	Pearson Correlation	.131	1
	Sig. (2-tailed)	.080	
	N	180	180

Table 2: Correlation coefficient showing the relationship between students' performance in Mathematics (WASCE) and first year practical Physics course in the university.

		Grade in Mathematics (WASCE)	Grade in first year Physics practical course
Grade in Mathematics (WASCE)	Pearson Correlation	1	.853**
	Sig. (2-tailed)		.000
	N	180	180
Grade in first year Physics practical course	Pearson Correlation	.853**	1
	Sig. (2-tailed)	.000	
	N	180	180

Table 3: Correlation coefficient showing the relationship between secondary school students' performance in Mathematics (WASCE) and their attitude to Physics at university level.

		Grade in Mathematics (WASCE)	Undergraduate students' attitude to Physics
Grade in Mathematics (WASCE)	Pearson Correlation	1	.220**
	Sig. (2-tailed)		.003
	N	180	180
Undergraduate Students' attitude to Physics	Pearson Correlation	.220**	1
	Sig. (2-tailed)	.003	
	N	180	180

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