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Consonance of General Mathematics and Physics: The Learners' Achievement Symmetry

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Abstract

The consonance and interrelatedness of mathematics and science Perdue in the parlance of scholars. Admittedly over the years, researchers have established mathematical components as germane in learning physics. The symmetry between these two subjects at the senior secondary school level may afford more answers than questions. This Ex post facto research traversed predictively, the consonance between students' General Mathematics ability and their achievement in Physics. A purposive sampling technique was employed in the selection of 857 respondents in this study. Pro forma of students' grade in General mathematics and Physics from West African Senior School Certificate Examinations (WASSCE) elicited data for the study. Pearson's Product Moment Correlation and Multivariate Analysis of Variance tools inferenced four research hypotheses raised and succinctly answered. This study established symmetry in students' General Mathematics ability and students' achievement in Physics. Score levels, gender and school type were also pioneered to influence this prediction.

Introduction

Introduction

The need to effectively transfer and improve the knowledge of science and technology relies on the understanding of various strata of science and technology, and the advancement in its teaching and learning. Abimbola and Omosewo (2006) define science as a body of knowledge, a way of investigating or method, and a way of thinking in pursuit of understanding nature. Science Education may be viewed as learning science by acquiring and developing conceptual and theoretical knowledge through scientific inquiry and problem solving (Obeka, 2011). Physics, Chemistry and Biology are the basic science subjects at secondary school level of education in Nigeria. Physics is a major branch of science, concerned with the laws that govern the structure of the universe, the forms of matter, energy and their interactions. Also, physics is an aspect of science concerned with the structure of matter, energy and their interactions in the fields of mechanics, acoustics, optics, heat, electricity, magnetism, radiation, atomic structure, and nuclear phenomena (Merriam Webster Online Dictionary, 2020). Physics aimed at explaining the behavior of variety of forms of matter and energy using two methods; Observation and experimentation from which construction of models or theories evolve about the universe. The experimentation involves exposing some of these objects to controllable external influence thereby causing changes in their properties. Physics has undoubtedly established its importance over the years. Application of physics and mathematics concepts such as "electricity" and "magnetism" led to the establishment of power industry, radio, television and other means of electronic communication. The application of physics is observable in fabrication, medicine and therapy through the use of x-rays, electro-cardiographs and other anatomical scanning machines (Omosewo, 2005).

Mathematics and physics are indispensable in the development of science and technology. Mathematics is the language of science, an abstract language which explains natural phenomena (Torigoe, 2008). In studying physics, students are faced with explanations in solving of physics problems when relating theoretical models to real world phenomena, especially while using mathematics. The combination of mathematical operations and conceptual reasoning about physical phenomena affords equations the privilege to have a supreme meaning. Thus, an in-depth knowledge of mathematics is required to effectively cope with the rigour in physics (Kuo, Hall, Gupta & Elby, 2013; Uhden, Karam, Pietrocola & Pospiech, 2012).

Instructors of physics may agree that mathematics problem solving tasks in physics are generally a struggle for students. Among physics teachers and instructors, two common interpretations ensue for students' poor achievement on mathematical problem solving in physics. One interpretation is that students lack the requisite mathematical knowledge to solve mathematical problems in physics. An alternative interpretation may be that

students do not know how to apply the mathematical knowledge they have learnt in mathematics classes to the context of physics (Tamuniro, 2004; Badmus, Akanmu and Akanbi, 2015).

Score levels has a long history in academics. It forms the basis upon which students are graded which thereafter cumulates to their achievement. Basically, students are grouped/categorized as high, medium and low scorers having met a certain benchmark based on certain criterion accounting for such student's achievement in prescribed test or examination. In some instances, the high achievers may be those students who scored between 70% - 100% in Achievement Test. The medium achievers may be students who scored between 50% - 69% while low performers may be students who scored between 0% and 49% depending on the rating scale (Aluko, 2008).
Gender differences in the achievements of students in Science, Technology and Mathematics (STM) show a line of difference in favour of male and occasionally female. On the contrary, it has been stated that the female students' attitude towards mathematics is more positive than the male students. Although, women have made great strides in law, medicine and social science professions, very few can be found in graduate programs or professions in mathematics, physics, engineering, or information technology jobs (Eccles, 2007).
Researches have reported diverse views regarding school type, while some reported significant difference regarding achievement, others posited differently. Ariyo and Ibeagha (2011) submitted that school type has both direct and indirect causal linkages on students' achievement in physics. Sharp decline in the academic achievement at various levels of educational system in Nigeria is largely attributed to the poor conditions in educational institutions which are more pronounced in public schools (Jolly, Oyaziwo, Justina, & Afen, 2012)

Statement of the Problem

The unsatisfactory achievement of students in physics is a concern to teachers and scholars alike. The need to improve achievement in physics calls for caution, owing to the fact that areas of weakness of students are already established in reports of the examiners. The Chief Examiners' Reports (CER) is a position document about areas of strength and weaknesses of students in each subject across West-African countries after a general examination. These reports conclude each regional examination by West African Examination Council (WAEC). Analysis of the Chief Examiners' Reports (Physics) affirmed students' inadequacies in Conversion of Units (CER; 2010,2014, 2015, 2017, 2018), Arithmetic problem (CER; 2011, 2014, 2015), Measurement and Computational Skill (CER; 2012, 2013, 2018) and inability to take precise measurement to required accuracy mostly in laboratory based sessions (CER; 2008, 2012, 2017). However, owing to the consistent recurrence of mathematics related concept as area of weakness, this study explored the consonance between students' achievement in general mathematics and physics with a view to establish a symmetry or dissonance.

Research Hypotheses
$H0_1$: no significant consonance exists between students' mathematics ability and their achievement in physics.
$H0_2$: Score level will not significantly influence the consonance between students' mathematics ability and their achievement in physics.
$H0_3$: Gender will not significantly influence the consonance between students' mathematics ability and their achievement in physics.
$H0_4$: School type will not significantly influence the consonance between students' mathematics ability and their achievement in physics.

Methodology
This study was an Ex post facto research of the correlational type. The population were all Senior Secondary School three students (SS 3) in Kwara state, Nigeria. Eight hundred and fifty-seven (857) students were purposively selected in the study to form the sample. The students willing to participate in the study were given a consent form as well as their parents before their participation. The instrument for this study were pro forma of students in West African Senior School Certificate Examination in both General Mathematics and Physics. The instruments were grades of students in Senior School Certificate Examination (SSCE), therefore, Students unwilling to make available the original copy of their result were exempted. No validation or reliability was done since the proforma were standardized examinations across 5 west African countries. Pearson's Product Moment Correlation and Multivariate Analysis of Variance were employed to test the hypothesis raised.

Data Analysis and Results

A total of 857 students participated in the study, 428 students representing (49.9%) were male students, while 429 students representing (50.1%) were female students. Table 1 further revealed that, 531 students representing (62.0%) were from public secondary schools, while 326 students representing (38.0%) were from private schools.

Table 1
Demography of Respondents based on Gender and School Type

Variables	Frequency	Percentage (%)
Gender		
Male	428	49.9
Female	429	50.1
School Type		
Public	531	62.0
Private	326	38.0

H0$_1$: *No significant consonance exists between students' mathematics ability and their achievement in physics.*
From Table 2, the calculated r-value is 0.45 while its calculated significance value is 0.00 and df of 2/855 at alpha level of 0.05. Consequently, null hypothesis 1 was rejected. This means that students' mathematics ability had significantly consonance on their achievement in Physics. This was evident from the calculated significance value (0.00) which was less than 0.05 alpha level (**ρ** < 0.05). Physics achievement had a higher mean score of 64.01 while mean score of 60.83 was observed for students' mathematics ability (Physics Achievement = 64.01 > Students' Mathematics = 60.83).

Table 2
PPMC Analysis of Consonance between the Students' Mathematics and Physics Achievements

Variable	No	Mean	Std	df	Cal.r	Sig.(2-tailed)	Decision
Mathematics	857	60.83	11.41				H_{02}
				855	0.45	0.00	Rejected
Achievement Physics	857	64.01	10.87				

ρ < 0.05

H0$_2$: *Score level will not significantly influence the consonance between students' General Mathematics ability and their achievement in physics.*
In order to test hypothesis 2, participants' WASSCE results in Mathematics and Physics were collated and analyzed based on score level as shown on Table 3. Result on Table 3 shows that score level significantly influence the consonance between students' mathematics ability and their achievement in Physics. This was evident from the F-calculated value of 375.152 and p-value of 0.00 for score level which is less than 0.05 level of significance (0.00 < 0.05). Since the p-value is lower than 0.05 level of significance, the null hypothesis was rejected. This means that score level significantly influenced the consonance between students' General Mathematics ability and their achievement in Physics.

Table 3
Multivariate Analysis of Consonance between Students' General Mathematics Ability and their achievement in Physics Based on Score Level

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.983	24833.643[b]	2.000	853.000	.000
	Wilks' Lambda	.017	24833.643[b]	2.000	853.000	.000
	Hotelling's Trace	58.227	24833.643[b]	2.000	853.000	.000
	Roy's Largest Root	58.227	24833.643[b]	2.000	853.000	.000
Score Level	Pillai's Trace	.739	250.324[b]	4.000	1708.000	.000
	Wilks' Lambda	.283	375.152[b]	4.000	1706.000	.000
	Hotelling's Trace	2.453	522.801[b]	4.000	1704000	.000
	Roy's Largest Root	2.422	1034.225[b]	2.000	854.000	.000

a. Design: Intercept + Score Level. b. Exact statistic. c. Computed using alpha = .05

Table 4 shows where differences were observed. Result in Table 4 shows that score level significantly influence the consonance between students' mathematical ability and their achievement in physics. Also, significant symmetry in score level was observed with respect to physics achievement. This is evident in the F-calculated value of 1017.519 and p-value of .000 for students' mathematical ability and 114.352 and p-value of 0.000 for Physics achievement respectively.

Table 4
Tests of Between-Subjects Effects (Differences)

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Maths	71209.066[a]	2	35604.533	1017.519	.000
	Physics	23543.001[b]	2	11771.500	114.352	.000
Intercept	Maths	1544070.827	1	1544070.827	44126.989	.000
	Physics	1322206.336	1	1322206.336	12844.337	.000
Score Level	Maths	71209.066	2	35604.533	1017.519	.000
	Physics	23543.001	2	11771.500	114.352	.000

H0$_3$: *Gender will not significantly influence the consonance between students' mathematics ability and their achievement in physics.*

Participants' WASSCE results in General Mathematics and Physics were collated and analyzed based on gender as shown in Table 5. Table 5 shows that gender significantly influence the consonance between students' mathematical ability and their achievement in Physics. This is evident with the F-calculated value of 4.469 and p-value of 0.01 for gender which is less than 0.05 level of significance ($0.01 < 0.05$). Since the p-value is lower than 0.05 level of significance, the null hypothesis is rejected. This means that gender significantly influence the consonance between students' mathematical ability and their achievement in Physics.

Table 5
Multivariate Analysis of Gender influence on Students' Mathematical Ability and their achievement in Physics

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.978	18809.262[b]	2.000	854.000	.00
	Wilks' Lambda	.022	18809.262[b]	2.000	854.000	.00
	Hotelling's Trace	44.050	18809.262[b]	2.000	854.000	.00
	Roy's Largest Root	44.050	18809.262[b]	2.000	854.000	.00
Gender	Pillai's Trace	.010	4.469[b]	2.000	854.000	.012
	Wilks' Lambda	.990	4.469[b]	2.000	854.000	.012
	Hotelling's Trace	0.010	4.469[b]	2.000	854.000	.012
	Roy's Largest Root	0.010	4.469[b]	2.000	854.000	.012

a. Design: Intercept + Gender b. Exact statistic c. Computed using alpha = .05

Table 6 shows where differences were observed. Result on Table 6 shows that gender did not significantly influence the prediction between students' mathematical ability. However, significant influence of gender was observed with respect to physics achievement only. This is evident in the F-calculated value of 8.810 and p-value of .095 for students' mathematical ability and 2.795 and p-value of 0.003 for achievement in Physics respectively.

Table 6
Tests of Between-Subjects Effects (Differences)

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Maths	363.09[a]	1	363.09	2.795	.00
	Physics	1031.07[b]	1	1031.07	8.810	.10
Intercept	Maths	3170941.43	1	3170941.42	24404.73	.00
	Physics	3511943.82	1	3511943.81	30008.886	.00
Gender	Maths	363.09	1	363.09	8.810	.10
	Physics	1031.07	1	1031.07	2.795	.10

H0$_4$: *School type will not significantly influence the consonance between students' mathematics ability and their achievement in physics.*

To test hypothesis 4, respondents' WASSCE results in General Mathematics and Physics were collated and analyzed based on school type as shown on Table 7. Result on Table 7 shows that school type significantly influenced the consonance between students' mathematics ability and their achievement in Physics. This is evident from the F-calculated value of 26.981 and p-value of 0.00 for score level which is less than 0.05 level of significance (0.00 < 0.05). Hence, the p-value is lower than 0.05 level of significance, the null hypothesis is hereby rejected. In essence, school type significantly influenced the consonance between students' mathematical ability and their achievement in Physics.

Table 7
Multivariate Analysis of influence School Type on Consonance between Students' General Mathematics Ability and achievement in Physics

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.978	18879.769[b]	2.000	854.000	.000
	Wilks' Lambda	.022	18879.769[b]	2.000	854.000	.000
	Hotelling's Trace	44.215	18879.769[b]	2.000	854.000	.000
	Roy's Largest Root	44. 215	18879.769[b]	2.000	854.000	.000
School Type	Pillai's Trace	.059	26.981[b]	2.000	854.000	.000
	Wilks' Lambda	.941	26.981[b]	2.000	854.000	. 000
	Hotelling's Trace	0.063	26.981[b]	2.000	854.000	.000
	Roy's Largest Root	0.063	26.981[b]	2.000	854.000	. 000

a. Design: Intercept + School Type, b. Exact statistic, c. Computed using alpha = .05

Table 8 shows where difference was observed. Table 8 shows that school type significantly influenced consonance between students' mathematics ability. Also, significant influence of school type was observed with respect to physics achievement. This is evident in the F-calculated value of 49.248 and p-value of .000 for students' mathematical ability and 25.053 and p-value of 0.000 for achievement in Physics.

Table 8
Tests of Between-Subjects Effects (Differences)

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Maths	6070.134[a]	1	6070.134	49.248	.000
	Physics	2877.893[b]	1	2877.893	25.053	.000
Intercept	Maths	3054223.712	1	3054223.712	24779.413	.000
	Physics	3357727.363	1	3357727.363	29230.646	.000
School Type	Maths	6070.134	1	6070.134	49.248	.000
	Physics	2877.893	1	2877.893	25.053	.000

Discussion

It was found in this study that students' ability in general mathematics predicted their achievement in physics. The prediction between these variables were significant, invariably, students with high mathematics ability are high achievers in physics, students with medium and low ability levels in mathematics have corresponding achievement in physics. Researches of Badmus, Akanmu and Akanbi (2015) and Bello and Ariyo (2014), Awodun and Ojo (2013) share the position of this study. This study found that male students outperformed their female colleagues in both mathematics ability and physics achievement. The corresponding hypothesis confirmed significance in the prediction between mathematics ability and achievement in physics in favour of the male students. This finding may be due to the domestic role socially associated to female students as they are expected to cook, wash clothes and dishes which may render them tired and unwilling to study after the tedious shores. This situation may not be applicable to Male. The position of this study is in line with the studies of Awodun and Ojo (2011), however, this finding is contrary to that of Badmus, Akanmu and Akanbi (2015). Hence, study on mathematics ability and achievement in physics based on gender may be said to be inconclusive.

Public schools had higher number of respondents in this study than the private schools. However, private schools had better mean scores in both mathematics ability and achievement in physics. Furthermore, the corresponding hypothesis formulated to test the significance in consonance based on school type confirmed significance in favour of the private schools. It should be noted that the same criteria were employed in the choice of schools with regard to availability of teachers in various subjects, teachers' qualifications and the number of periods for teaching per week. The plausible reasons for the difference in ability and achievement could have emanated from dedication, instructional resources, discipline and school environment which favoured private schools than public schools in this study. The position of this research work is in line with the works of Alimi, Ehinola and Alabi (2012), Olasehinde and Olatoye (2014). Contrarily, Eme (2014) reported no significant difference in the performance of students in Public and Private schools.

Conclusions

There exists a symmetry in Students' General Mathematics ability and their achievement in Physics. Felicitate. Score level significantly influenced the consonance between students' Mathematics ability and their achievement in Physics. This is in favour of the high scorers and Gender significantly influenced the consonance between students' Mathematics ability and their achievement in Physics. This is in favour of the male students.

Recommendations

Physics students are encouraged to take mathematics seriously, and if possible, offer further mathematics for improved achievement in physics. Professional and non-professional bodies like National Teacher Institute (NTI), Nigerian Institute of Physics (NIP), Science Teachers Association of Nigeria (STAN) and Teachers Registration Council of Nigeria (TRCN) in conjunction with state and federal ministries of education should organize seminars and workshops for teachers on how best to incorporate mathematical ability in the teaching of physics for better achievement.

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