Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.4, No.24, 2013

Mathematics Abilities of Physics Students: Implication for the Application and Analysis of Sound Waves

Dr. (Mrs) Deborah T.A. Obafemi [1*] Dr. (Mrs) R.A. Ogunkunle [2]

1. Department of Curriculum Studies and Educational Technology, Faculty of Education, University of Port Harcourt, Uniport P. O. Box 91 Choba, Port Harcourt. Rivers State Nigeria.
2. Center for Teacher Education, Faculty of Education, Department of Curriculum Studies and Educational Technology,University of Port Harcourt, P M B 5323, Port Harcourt.

*E-mail of the corresponding author : deborah.obafemi@uniport.edu.ng

Abstract

The study investigated the effect of mathematics abilities of students on their performance in Sound Waves concept in physics in Ikwerre Local Government Area of Rivers State, Nigeria. A quasi-experimental pretest posttest design comprising of three experimental and one control group was used, each group was taught with a different Instructional method. A purposively selected sample of fifty- five (55) physics students of Senior Secondary 2 (SS2) class was involved in the study. Two instruments- Mathematics Ability Test (MAT) and Physics Performance Test on Sound Waves (PPTSW) with reliability coefficients of 0.97 and 0.85 respectively were used. The performances of the students were considered at the levels of application and analysis of Sound waves. Data collected was analysed using Mean scores and Percentages for the research questions, while 4x3 Multivariate Analysis of Covariance was used to test the hypotheses. Analysis of results showed that there was a significant difference in the effect of mathematics abilities of students on their performances in Sound waves. There was also a significant difference in the effect instructional methods on the performance of the students in Sound waves. The Post hoc analyses showed that the significant difference in the mathematics abilities was credited to students with high mathematics ability while Guided-Discovery method accounted for the significant difference found in instructional methods. The Implications of the findings were discussed and relevant recommendations made thereafter.

Keywords: Mathematics Abilities, Sound Waves, Physics, Instructional methods

1. Introduction

Physics is the study of systematized knowledge produced by careful observation, measurement and experiment which attempts to establish general laws or principles to describe phenomena under study (Ivowi, 1999). It is an interesting and essential subject because it links the principles learnt and the phenomena observed in the classroom with application in every human endeavour. Physics plays a major role in the proper understanding of technological subjects. It is a major contribution to technology through the nature of its discipline and its application in the field of engineering, medicine, manufacturing among others. Physics concepts are however considered difficult and unattractive by many students in secondary Schools (Onwioduokit, 1996; Ivowi, 1999; Angell, Guttersand, Henriksen, & Isnes, 2004). This could be attributed to the mathematical nature of physics where students have to learn and understand numerous theoretical concepts which are rooted in fundamental mathematics (Obafemi, 2005.

Mathematics is commonly referred to as “the language of science” (Redish, 2005). Scientists studying in all field of science interweave equations into their everyday theories. The study of physics benefits from conceptual understanding in mathematics. Physics and mathematics are actually inseparable. Physical sciences cannot do without mathematics (Adesoji, 2008). This is because many of the expressions used in these subjects are lent from mathematics. Students’ understanding of basic mathematical concepts influence greatly how they will cope with higher level materials where the application of these basic mathematical concepts are required especially when solving problems in physics (Study Up, 2009). Thanormsuay (2010) discovered from his study that Science and Engineering students need strong mathematical background to succeed in their fields. Akatugba and Wallace (2009) in the same vein discovered that mathematical issues among others were associated with students’ use of proportional reasoning in physics.

It is however a matter of great concern for researchers like Adegoke (2009) who observed that many students appear to lack the reasoning ability involved in the study of physics, they have problems with the logical-mathematics operations that are demanded in physics learning. Similarly, Brekke (2010) exclaimed “there is an urgent arithmetic crisis in our nation” (America). He lamented that a number of students who come from elementary to high school are deficient in basic mathematics facts such as the result of dividing a number by zero. Study Up (2009) portrayed most students finding Physics interesting, but have trouble with the mathematics used in physics. Most students will concede they understand the concepts of physics, but they do not know how to show mathematically, the hows and whys of physics. This view agrees with the findings of

Obafemi (2005), where 90% of students complained about the cumbersome and rigorous nature of physics concepts in which someone cannot solve a problem without using a formula, almost all the topics have several formulae and someone must be really clever not to interchange one formula for another. Again, Owolabi (2008) discovered that students are deficient in mathematical concepts consequently, they perform poorly in physics. Similarly, Ighomereho (2005) found that students who perform poorly in physics have inadequate background in mathematics.

Chief Examiner's report of West African Examination Council (WAEC, 2006) noted that the marks lost by physics students is as a result of their mathematical mistakes, this contributes to about half of the marks lost in the subject'. Similarly, Ighomereho (2005) and Owolabi (2008) discovered that mistakes made by students while performing arithmetical operations involved in solving physics problems contributed greatly to their poor performance in physics. These stirred the interest of the researchers for this study. Hence could the poor performance of students in physics be linked to the mathematical nature of physics? Could it be due to the mathematics abilities of students? What are the effects of students' mathematics abilities on their performance in Sound waves in physics? This study therefore investigated the effect of mathematics abilities of students on their performance in Sound waves.

1.1: Purpose of the Study

The purpose of this study was to investigate the effect of mathematics abilities of students in the study of Sound waves. Specifically, the objectives of the study were to:

i. Determine the effect of students' mathematics abilities on their application and analysis of Sound waves concept in physics.
ii. Assertain the effect of students' mathematics abilities on their application and analysis of Sound waves, considering the instructional method.

1.2: Research Questions

i. What difference exists among the performances of students with high, average and low mathematics abilities with respect to their application and analysis of Sound waves?.
ii. What difference exists among the performances of students with high, average and low mathematics abilities with respect to their application and analysis of Sound waves considering the instructional methods?.

1.3: Research Hypotheses

The null hypotheses tested in this study include:

iii. There is no significant difference among the performances of students with high, average and low mathematics abilities with respect to their application and analysis of Sound waves.
iv. There is no significant difference among the performances of students with high, average and low mathematics abilities with respect to their application and analysis of Sound waves considering the instructional methods.

2. Methods

For the research, the quasi-experimental, pretest- posttest experimental and control group design was used. There were three experimental groups and one control group. The factors involved in the study were Mathematics ability and Instructional methods. The control group was taught with Lecture method while the three experimental groups which were taught with three other methods (Collaborative learning method, Demonstration method(Teacher-Students) and Guided-discovery method). Purposive sampling was used to select a sample of 55 Senior Secondary 2 (SS2) students for the study. A preliminary study has been done in which Sound Waves and their applications were found to be the one of the most difficult concepts in SS2 physics curriculum. Two instruments namely: Physics Performance Test on Sound Waves (PPTSW) and Mathematics Ability Test (MAT) were developed for the study. The PPTSW was constructed by the researchers to measure the performance of students in Sound waves with respect to understanding, application and analysis. It contained 30 multiple choice objective questions on Sound Waves. The MAT was constructed by the researchers to measure the students' mathematical ability. It contained 26 multiple choice objective questions and 4 essay type mathematics questions based on the mathematical concepts and skills required by the students to understand and solve problems on Sound waves and their applications. The difficulty and discrimination indices of PPTSW were 0.51and 0.45 respectively while the difficulty and discrimination indices of MAT items were 0.59 and 0.46 respectively. The two instruments were validated for content and constructs. Using Kuder- Richardson formula 21, the reliability coefficients of PPTSW and MAT were found to be 0.85 and 0.97 respectively.

The PPTSW and MAT were administered as Pre-test to both the experimental and control groups. The students in one control and three experimental groups were then taught the concept of Sound waves and their applications with four different methods over a period of three weeks. Each of the four schools was taught with one of Lecture Method, Collaborative learning method, Demonstration method, and Guided-discovery respectively.

After each group was taught with the specified instructional method, the PPTSW was administered to them as Post – test, their responses were graded and their scores were obtained. The students' scores in the MAT during pre-test were used to categorize them into high, average and low Mathematics abilities. Based on the data obtained, the research questions were answered using descriptive statistics such as Percentages and Mean scores while the 4x3 Factorial Multivariate Analysis of Covariance was used to test the hypotheses.

3. Results of the study

3.1: Research Question 1

What difference exists among the performances of students with high, average and low mathematics abilities with respect to their application and analysis of Sound waves?

Table 1 indicates that students with High mathematics ability have the highest percentage gains of 61.0% and 133.3% in the application and analysis of Sound waves respectively.

3.2: Research Question 2

What difference exists among the performances of students with high, average and low mathematics abilities with respect to their application and analysis of Sound waves considering the instructional methods?

Table 2 indicates that the students with High mathematics ability taught using Demonstration method have the highest percentage gain of 392.3% in the application of Sound waves while the students with Low mathematics ability taught using Demonstration method have the highest percentage gain of 800.0% in the analysis of Sound waves. The table further shows that in the analysis of Sound waves, students with High mathematics ability have the highest percentage gain in most of the instructional methods used.

3.3: Research Hypothesis 1

There is no significant difference among the performances of students with high, average and low mathematics abilities with respect to application and analysis of Sound waves.

Table 3 shows that Math Ability is not significant since its calculated $F_{2,42}$ value is 0.623 and probability level of 0.05 against the $F_{2,42}$ critical value of 3.15. This shows that there is no significant difference among the performances of students with high, average and low mathematics abilities with respect to application of Sound waves. Table 4 shows that Math Ability is significant since its calculated $F_{2,42}$ value is 5.634 and probability level of 0.05 against the $F_{2,42}$ critical value of 3.15. This shows that there is significant difference among the performances of students with high, average and low mathematics abilities with respect to analysis of Sound waves.

3.4: Research Hypothesis 2

There is no significant difference among the performances of students with high, average and low mathematics abilities with respect to application and analysis of Sound waves considering the instructional methods.

Table 3 shows that Math Ability is not significant since its calculated $F_{2,42}$ value is 0.623 and probability level of 0.05 against the $F_{2,42}$ critical value of 3.15. Method is not significant since its calculated $F_{3,42}$ value is 1.497 and probability level of 0.05 against the $F_{3,42}$ critical value of 2.76. The interaction of Method and Math Ability is also not significant since its calculated $F_{6,42}$ value is 0.781 and probability level of 0.05 against the $F_{6,42}$ critical value of 2.25. There is no significant difference among the performances of students with high, average and low mathematics abilities with respect to application of Sound waves considering the instructional method.

Table 4 shows that Math Ability is significant since its calculated $F_{2,42}$ value is 5.634 and probability level of 0.05 against the $F_{2,42}$ critical value of 3.15. Method is also significant since its calculated $F_{3,42}$ value is 4.030 at degree of freedom of 3,42 and probability level of 0.05 against the $F_{3,42}$ critical value of 2.76. The interaction of Method and Math Ability is however not significant since its calculated $F_{6,42}$ value is 0.944 at degree of freedom of 6,42 and probability level of 0.05 against the $F_{6,42}$ critical value of 2.25. There is no significant difference among the performances of students with high, average and low mathematics abilities with respect to analysis of Sound waves considering the instructional method.

The Post hoc analysis on Table 5 indicates that the students with High mathematics abilities contributed most to the significant difference between the effects of the three levels of mathematics abilities.

The Post hoc analysis on Table 7 indicates that method 3 which is the Guided-discovery method contributed most to the significant difference between the effects of the instructional methods.

4. Discussions

The students with High mathematics ability have the highest percentage gains of 61.0% and 133.3% in the application and analysis of Sound waves respectively. This may be accounted for by their high mathematics skills required at the realms of application and analysis which are higher levels in the Cognitive domain of the Taxonomy of Educational objectives.

Also considering the effect of Mathematics abilities based on the instructional method used, in the analysis of

Sound waves, students with High mathematics ability have the highest percentage gain in most of the instructional methods used. This reinforces the significant difference found among the performances of students with high, average and low mathematics abilities with respect to analysis of Sound waves in favour of students with High mathematics ability, while in the level application, no significant difference was found. This may be also accounted for by their high mathematics skills required at the realm of analysis which is a higher level in the Cognitive domain of the Taxonomy of Educational objectives. This finding agrees with Thanormsuay (2010) who concluded from his study on the mathematical background of Thai Pre-Engineering Students that Science and Engineering students need strong mathematical background to succeed in their fields. It also agrees with Akatugba and Wallace (2009) who discovered that mathematical issues among other issues were associated with students' use of proportional reasoning in physics.

From the Post hoc analysis done, Guided-discovery method contributed most to the significant difference between the effects of the instructional methods in the analysis of Sound waves. However, Demonstration method was also found to be superior to the Collaborative and Lecture methods in enhancing the performance of the students in Sound waves at the application and analysis levels. This finding agrees with Adegoke (2009) who found from his study, that to stimulate students' interest in physics, teacher needs to explain, ask questions, allow students to participate in the teaching-learning activities and clarify issues. It also agrees with Chang, Jones, & Kunnemeyer (2002) who found that students, who were taught physics with the interactive teaching approach promoted their learning interest, introduced them to real life experiences, stimulated their thinking about physics concepts and enhanced their conceptual understanding unlike the students taught with the traditional teaching method.

5. Conclusion and Recommendations

The findings of this study implies that if effort is not made to give physics students a sound background in mathematics, their understanding of physics concepts may be limited and this may hinder their ability to pursue their dream career in Science and Technology. Also, the use of instructional methods that are student-centred, interactive and practical-oriented may enhance the performance of students in physics. Based on the findings of this study, it is recommended that:

1. Sound mathematics background should be ensured for physics students in order to enhance their performance in physics concepts.
2. Interactive and practical-oriented instructional methods like Guided-discovery and Demonstration methods should be preferably used in the teaching of physics concepts.

References

Adegoke, B.A. (2009). Determining factors in secondary school students' choice of physics. *Journal of Science Teachers' Association of Nigeria,* 4(1&2), 75-84.

Adesoji, F. A. (2008). English language and mathematics mock results as prediction of performance in S.S.C.E. physics. *Journal of Social Science,* 17(2), 159-161.

Akatugba, A. H., & Wallace, J. (2009). An interactive perspective on students' proportional reasoning in high school physics in a West African context. *International Journal of Science Education,* 31(11), 1473-1493.

Angell, C., Guttersand, O., Henriksen, E. K. & Isnes, A. (2004). Physics: frightful, but fun, pupils' and teachers' views of physics and physics teaching. *Science Education,* 88(5), 683-706.

Brekke, S. (2010). Urgent mathematics crisis in our nation: Basic mathematics deficits affects student performance in high school physics and chemistry. Teachers.net Gazette 7(8). Retrieved from *http://teachers.net/gazette/ wordpress/categoty/stewart-brekke.*

Chang, W., Jones, A. & Kunnemeyer, R. (2002). Interactive teaching approach in year one university physics in Taiwan: Implementation and evaluation. *Asia-Pacific Forum on Science Learning and Teaching,* 3(1),Article 3.

Ighomereho, P. O. (2005). *Students expressed usage of some mathematical concepts in senior secondary physics.* Unpublished Post Graduate Diploma in Education project, Lagos State University.

Ivowi, U.M.O. (1999). Physics education for technology development In *Akpan, B. (Ed.) Perspectives on education and science teaching: from the eyes of Uduogie Ivowi (*638-643). Abuja: Foremost Educational Services.

Obafemi, D. T. A. (2005). A comparative analysis of attitudes towards physics in the University Demonstration and Unity secondary schools in Rivers State. Unpublished M.Ed Thesis, University of Port Harcourt.

Onwioduokit, F. A. (1996). Difficult concepts in physics as experienced by senior secondary students in Akwa Ibom State Nigeria. *The Researcher, Journal of Nigerian Education Research Reporters' Association,* 1(1), 19- 28.

Owolabi, T. (2008). Students' expressed mathematics errors in solving numerical problems in physics. In Udofia, N (Ed.) *Curriculum development in Science, Technology and Mathematics (STM) Education. Proceedings of the 49th Science Teachers' Association of Nigeria Conference.* 259-261.

Redish, E. F. (2005). Problem solving and the use of mathematics in physics courses. *World view on Physics Education in 2005: Focusing on change Conference Proceedings.* Retrieved from *umdperg.pbworks.com/w/page/34255731/Math-Physics:-References*

Study Up (2009). Mathematics and physics- math's relation to physics. Retrieved from www.studyup.com/articles/careers/graduatecollegeloans.htm

Thanormsuay, S. (2010). Thai pre-engineering students, mathematical background and attitudes toward instruction. *2010* European Applied Business Research *(*EABR*) and European College Teaching & Learning (*ETLC*)* Conference *Proceedings.* Dublin, Ireland.

Wikipedia (2010) *Science*. Retrieved from *http://enwikipedia.org/wiki.science*

Table 1: Gain scores of the application and analysis of Sound waves by students of high, average and low mathematics abilities.

MA	Application				Analysis			
	Pre test $\bar{X}$	Post test $\bar{X}$	Gain	Gain%	Pre test $\bar{X}$	Post test $\bar{X}$	Gain	Gain%
H	4.1	6.6	2.5	61.0	2.7	6.3	3.6	133.3
A	5.2	7.9	2.7	51.9	2.4	4.5	2.1	87.5
L	4.0	6.2	2.2	55.0	1.9	3.7	1.8	94.7

KEY: MA- Mathematics Ability, H-High, A-Average, L-Low.

Table 2: Gain scores of the application and analysis of Sound waves by students of high, average and low mathematics abilities and Instructional methods.

MA		Application				Analysis			
	Inst. Meth.	Pre test $\bar{X}$	Post test $\bar{X}$	Gain	Gain%	Pre test $\bar{X}$	Post test $\bar{X}$	Gain	Gain%
H	CLM	3.3	5.0	1.7	51.5	2.3	6.7	4.4	191.3
	DM	1.3	6.4	5.1	392.3	0.6	3.3	2.7	450.0
	GDM	6.0	8.0	2.0	33.3	3.0	8.0	5.0	166.7
	LM	5.7	7.0	1.3	22.8	5.0	7.0	2.0	40.0
A	CLM	6.0	7.3	1.3	21.7	2.0	5.5	3.5	175.0
	DM	2.5	6.5	4.0	160.0	0.5	2.0	1.5	300.0
	GDM	4.8	9.3	4.5	93.8	3.8	6.0	2.2	57.9
	LM	7.3	8.5	1.2	16.4	3.1	4.3	1.2	38.7
L	CLM	3.6	6.4	2.8	77.8	2.4	3.8	1.4	58.3
	DM	1.0	4.0	3.0	300.0	0.3	2.7	2.4	800.0
	GDM	5.0	8.0	3.0	60.0	2.5	5.0	2.5	100.0
	LM	5.3	6.3	1.0	18.9	2.4	3.3	0.9	37.5

KEY: CLM- Collaborative Method, DM- Demonstration Method,
GDM- Guided-discovery Method, LM- Lecture Method.
MA- Mathematics Ability, H-High, A-Average, L-Low.

Table 3: Summary of 4x3 Analysis of Covariance of students' application of Sound waves classified by mathematical abilities and instructional methods, using Pre-test scores as a covariate.

Dependent Variable: Post-test scores on application

Source of variation	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	137.417[a]	12	11.451	3.182	s
Intercept	87.456	1	87.456	24.305	s
Pre-test	46.166	1	46.166	12.830	s
Main Effect					
Math Ability	4.486	2	2.243	0.623	ns
Method	16.162	3	5.387	1.497	ns
Interactions					
First order					
Math Ability * Method	16.869	6	2.811	0.781	ns
Error	151.129	42	3.598		
Total	2914.000	55			
Corrected Total	288.545	54			

a. R Squared = 0.476 (Adjusted R Squared = 0.327)

Table 4: Summary of 4x3 Analysis of Covariance of students' analysis of Sound waves classified by mathematical abilities and instructional methods and using Pre-test scores as a covariate.

Dependent Variable: Post-test scores on analysis

Source of variation	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	135.837[a]	12	11.320	5.991	s
Intercept	95.019	1	95.019	50.285	s
Pre-test	31.544	1	31.544	16.693	s
Main Effect					
Math Ability	21.293	2	10.646	5.634	s
Method	22.846	3	7.615	4.030	s
Interactions					
First order					
Math Ability * Method	10.703	6	1.784	0.944	ns
Error	79.363	42	1.890		
Total	1280.000	55			
Corrected Total	215.200	54			

a. R Squared = 0.631 (Adjusted R Squared = 0.526)

Table 5: Post hoc analysis of students' analysis of Sound waves based on their mathematics abilities.

Pair-wise Comparisons

Dependent Variable: Post-test scores on analysis

(I) Math Ability	(J) Math Ability	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1.00	2.00	1.531*	0.594	0.014	0.332	2.729
	3.00	1.914*	0.579	0.002	0.746	3.082
2.00	1.00	-1.531*	0.594	0.014	-2.729	-0.332
	3.00	0.383	0.493	0.441	-0.611	1.378
3.00	1.00	-1.914*	0.579	0.002	-3.082	-0.746
	2.00	-0.383	0.493	0.441	-1.378	0.611

Based on estimated marginal means

*. The mean difference is significant at the 0.05 level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Table 6: Post hoc analysis of students' analysis of Sound waves based on the four instructional methods.

Pair wise Comparisons

Dependent Variable: Post test scores on analysis

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1.00	2.00	1.446*	0.678	0.039	0.078	2.814
	3.00	-0.432	0.707	0.544	-1.859	0.994
	4.00	1.246*	0.573	0.035	0.089	2.402
2.00	1.00	-1.446*	0.678	0.039	-2.814	-0.078
	3.00	-1.878*	0.846	0.032	-3.585	-0.172
	4.00	-0.200	0.767	0.795	-1.748	1.347
3.00	1.00	0.432	0.707	0.544	-0.994	1.859
	2.00	1.878*	0.846	0.032	0.172	3.585
	4.00	1.678*	0.662	0.015	0.343	3.013
4.00	1.00	-1.246*	0.573	0.035	-2.402	-0.089
	2.00	0.200	0.767	0.795	-1.347	1.748
	3.00	-1.678*	0.662	0.015	-3.013	-0.343

Based on estimated marginal means

*. The mean difference is significant at the 0.05 level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).