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Mathematical competence and attitude as predictors of students' performance in secondary school physics

[1]Ademola, K. BADRU & [2]Elizabeth, M. AANU
Department of Science and Technology Education,
Olabisi Onabanjo University, Ago-Iwoye, Nigeria.
e-mail address: badru.ademola@yahoo.com; lizzymosun@yahoo.com

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Abstract

This study examined mathematical competence and attitude as predictors of students' performance in secondary school physics with four hypotheses of the ten stratified schools, a total of 249 secondary school students II offering physics participated the study. 128 (51.41%) of the students were from urban based schools and 121 (48.59%) of the students from rural based schools. Three constructed and validated instruments (MCST, r = 0.78), (SAPQ, r = 0.68) and (PPT, r = 0.74) were employed. Data were analysed using both regression analysis and t-test at P < 0.05. The results revealed that there exists significant relative contributions of mathematical competence and students' attitude to secondary school students' performance in physics ($F_{(1,247)}$ = 35.11 & 16.86). It also revealed significant composite contribution of mathematical competence and attitude on secondary school students' performance in physics ($F_{(2,246)}$ = 30.20). Finally, the finding revealed that school location is significant on secondary school students' performance in physics (t = 13.54). It is therefore, concluded that mathematical competence is a contributory factor in learning physics. Hence, it is recommended that those teaching physics at secondary schools should note that extra work in the mathematics concept needs to be done.

Key words: Mathematical competence, Student attitude, Performance in physics

Introduction

The development of any nation depends largely on the level of its scientific and technological literacy. Physics which is one of the sciences is indispensable, basic and fundamental to technological studies. It is a physical science that involves the study of the physical properties of matter and its interaction with the energy. Physics a study of systematised knowledge produced by careful observation, measurement, and experiment in a view to establishing basic physical laws as well as giving a scientifically reliable explanation of physical phenomena (Charles-Ogan & Okey, 2017). According

to Agommuoh (2014), Oraifo (2005) and Adeyemi (2003), Physics has helped in the development of modern technology through the application of its principles to modern invention, and used in solving diverse problems of humanity and providing solution to natural and artificial problems in the world at large. Physics as a course of study is perceived generally to be very interesting, vast, mathematical and experimental. Physics is one of the pre-requisite subjects for the study of engineering, technology, medicine and other applied science courses in the university. Its study equips graduates with mathematical and information technology skills. That is why Federal Republic of Nigeria (2013) expressed explicitly in the secondary school physics curriculum its objectives as:

i. to provide basic literacy of physics for functional living in the society,
ii. to aid students acquire basic concepts and principles of physics as a preparation for further studies,
iii. to help students acquire essential scientific skills and attitudes as a preparation for the technological applications of physics, and
iv. to stimulate and enhance creativity.

In spite of the laudable objectives and importance of physics other science courses, performance of secondary students in physics in the public examinations such as West African Senior Secondary Certificate Examinations (WASSCE), National Examinations Council (NECO) and Unified Tertiary Matriculation Examinations Board (UTMEB) is not encouraging (Charles-Ogan & Okey, 2017; Isola, 2010). The various factors identified as being responsible included nature of the subject, teacher-related factors, school-related (environmental) factors, or students-related factors. The students related factors are classified as either static or alterable factors (Anderson, 2008; Anigbo. 2016). The static factors are those which the system cannot alter. Such factors are the ages, sexes, socio-economic status, school location and others. The other type, alterable factors as described by Forehand (2010) refer to the context and process factors like classroom behaviours of students, learning materials, attitude towards learning and mathematical competence.

Competence is an abstract construct. It describes the quality of being capable of executing a task. It is the habitual and judicious use of communication, knowledge, technical skills, clinical reasoning, emotions, values and reflection in daily practice for the benefit of the individual and community being served (Epstein & Hundert, 2002). Competence is used as a synonym for performance, skill, or personality trait (Bassellier, Reich & Benbasat, 2001). Not only is competence treated as performance, but it is also used indiscriminately to refer to either the observable performance or the underlying neural functions that support the observable behaviour (Connell, Sheridan & Gardner, 2003). Competence in science refers to the ability and willingness to use the body of

knowledge and methodology employed to explain the natural world, in order to identify questions and to draw evidence-based conclusions (Ntibi & Edoho, 2017). Competence includes an attitude of critical appreciation and curiosity, an interest in ethical issues and respect for both safety and sustainability, in particular as regards scientific and technological progress in relation to oneself, family, community and global issues (Lord & Jones, 2006).

Besides, mathematical competence is the ability to develop and apply mathematical thinking in order to solve a range of problems in everyday situations. Building on a sound mastery of numeracy, the emphasis is on process and activity, as well as knowledge. Mathematical competence then means the ability to understand, judge, do, and use mathematics in a variety of intra- and extra-mathematical contexts and situations, in which mathematics plays or could play a role (Niss & Jensen, 2002). Niss (2003) defined mathematical competence as the ability to handle a particular aspect of general mathematical competence. These competencies include ability to solve problem, reason, apply procedures, represent, connect and communicate. Mathematical competence involves, to different degree, the ability and willingness to use mathematical modes of thought (logical and spatial thinking) and presentation (formulas, models, constructs, graphs, charts (Isola, 2010). It can be explained as insightful readiness to act appropriately in situations which present a particular kind of mathematical challenges.

Furthermore, studies have reported that science students offering physics have difficulties in the understanding of the concepts in physics which demands adequate mathematical competence (Isola, 2010; Akanbi, 2003). Lord and Jones (2006); Osborne, Simon and Collins (2003) maintained that science students offering physics who lacked basic algebra skills performed poorly on mathematical problem-solving tasks in physics due to students' lack of mathematical competence needed, or students do not know how to apply the mathematical skills they have to particularly solve the problems situation in physics. Although, a wide conceptual difference exists between the two subjects (Physics and Mathematics) it is presumed that mathematical competence is required to tackle numerical problems in physics. In addition, WAEC chief examiners report (2015 to 2018) reveal that on the appraised physics questions 2 and 3, it was observed that candidates who sat for the examination had weak performance in the questions related to calculations as shown in Table 1.

Table 1: Observations of Chief Examiners Report in May/June Physics Examinations (Paper 2 & 3)

Year	Observations
2015	Many candidates were unable to: • handle correct Arithmetic processes involving standard notation and conversion of units such as mm to m; cm^2 to m^2etc • effectively handle scale drawing problems • plot graph involving numbers less than unit e.g. 0.001, 0.31 etc • make deduction from graph or draw lines of best fit
2016	Majority of the candidates had in weak ability to: • indicate correct units of measured and calculated values • distinguish graph axes and choose reasonable scales to plot graph • determine components of the velocity of projectile and its maximum height • poor computational skills
2017	Many candidates were unable to: • interpret questions correctly. For example, candidates failed to realize that workability of Pulley system depends on correct fixing of the rope • handle Algebraic Arithmetic processes. For instance, many candidates failed to see the difference between the expressions $\sqrt{n}/_{b}$ and $\sqrt{\frac{n}{b}}$. This led low performance of the subject. • express their calculations to the required answers of decimal points or significant figures • express decimal figures to standard form • plot graph when values were negatives
2018	Majority of the candidates were unable to: • handle correctly, calculations involving express in standard form and lacked knowledge on the applications of velocity – time graph. • properly understand the mathematical relationship of deceleration and acceleration • express calculations to the required numbers of decimal places or significant figures • appropriate values of variables used for plotting of graph, start graph of origin (0,0) when required, determine the slope or intercept • compute and evaluate properly

Source: https://waeconline.org.ng/e-learning/Physics downloaded on 05/02/2020

It is an established fact that mathematics is a contributing factor to the performance of students in physics and chemistry and the control tool of mathematics remains the basic skills underlying all scientific and technological skills (Ogunleye, Awofala & Adekoya, 2014). Mathematics is a subject that is related to other science subjects such as physics and chemistry in areas like number and numeration–fractions, logarithms, indices, algebraic processes – solution of equations, variation, graph, and also in volume.

However, the indispensability of mathematical competence and attitude in the learning of sciences has attracted the attention of science researchers and mathematics educators for a very long time, due to the failure rate in the subjects (Ibrahim, Zakiang & Damio, 2019; Ntibi & Edoho, 2017). According to Mensah, Okyere and Kuranchie (2013), attitude as a concept is concerned with an individual's way of thinking, acting and behaving. It has very serious implications for the learner, the teacher, the immediate social group with which the individual learner relates, and the entire school system. Attitudes are formed as a result of some kind of learning experiences students go through. This is mimicry, which also has a part to play in the teaching and learning situation. Attitude implies favourable, or neutral evaluative reactions towards something or item. In other words, attitude is a way of looking or viewing things or events. Siti, Nursaila and Faridah (2016) opined that attitude is the sum total of a man's instinct and feelings, prejudice or bias, preconceived notions, fears, threats, and convictions about any specified topic. Veloo and Khalid (2015) in a study reported that positive attitude stimulates students to put more efforts and leads to high achievement in that subject while negative attitude towards a certain subject makes learning more difficult.

Furthermore, it has been observed that school location (rural and urban areas) plays a vital role in the students' attitude towards learning. Location here is in terms of whether the place of study or school is sited in rural or urban community. Some studies like Godwin and Okoronka (2015): Alokan (2010) have shown positive influence, others have shown negative influence of school location on the students' learning outcomes or achievement. Ibrahim, Zakiang and Damio (2019) found that location was significant in learning of mathematics and basic science that involve angles, with rural students exhibiting more learning difficulties than their urban counterparts. Ahiaba and Igweonwu (2003) also investigated the influence of school location on the performance of science students in rural and urban schools at the SSC examination and found that mathematics and basic science students in urban schools performed better with superior grades, than their rural counterparts while failure rate was higher in the rural schools. Ibrahim, Zakiang and Damio (2019) reported no difference in academic achievement of students as a result of location. Others such as Nwogu (2010); Ahiaba and Igweonwu (2003) reported that rural students performed better in practical skills in mathematics and basic science than their urban counterparts did. Jia (2013) indicated that there was no difference in performance of students because of location. However, this study is supported by Thorndike's laws of learning (2010), especially laws of readiness and exercise, that student learns when an action tendency is aroused through preparatory adjustment, set of attitudes, and ability to reason or solving problems and manipulate. This implies that the students need to cultivate habit of practice and solve problems involving calculations in Physics. Hence, this study investigated the contribution of mathematical competence and attitude as predictors of secondary school students' performance in physics in Ogun state.

The main objective of the study was to investigate mathematical competence and students' attitude as predictors of their performance in secondary school physics in Ogun state. Specific objectives are to:

i. determine the relative contribution of mathematical competence and attitude to students' performance in physics.
ii. determine the composite contribution of mathematical competence and attitude to students' performance in physics.
iii. determine the difference between the performance of the physics students from urban and rural located schools.

Hypotheses

To achieve the objectives of the study, the following hypotheses were formulated:

1. There is no significant influence of mathematical competence to students' performance in physics.
2. There is no significant influence of attitude towards learning physics to students' performance in physics.
3. There is no significant composite contribution of mathematical competence and attitude towards learning physics to students' performance in physics.
4. There is no significant difference between the mean performance of students from schools in urban and rural location in physics.

Methodology

The research design used for this study was descriptive survey research design type. The population consisted of Senior Secondary School II (SSSII) students offering physics in Ijebu-ode local government area in Ogun state. Ten public Schools were randomly stratified into two groups, based on school location from the thirteen Schools in Ijebu - Ode local government area. That is, five schools each from urban and rural areas. In this study, the schools from urban area were those sited within Ijebu - Ode township while the schools from rural area were those sited outside Ijebu - Ode township. An arm of intact class of students offering physics was used in each selected school, and the sample size was 249 students of which 128 (51.41%) were from urban location and 121 (48.59%) were from rural location.

Instrumentation

Three instruments were employed to measure the variables under investigation. The instruments were constructed and validated by the researchers. They included:

i. *Mathematical Competence Scale Test (MCST):* This was used to measure students' competence in mathematics. It contained twenty-six multiple choice

items with four options (A – D) derived from six topics (number & numeration; algebraic process; trigonometry; bearings & distances; and mensuration) extracted from the senior secondary school II mathematics curriculum. The total score of all the correct items was taken as the index of mathematical competence. The Kuder-Richardson 20 formula was used to determine the reliability index of the instrument and it gave a coefficient value of 0.78.

ii. *Student Attitude towards learning Physics Questionnaire (SAPQ)***:** This a four-point likert type scale having strongly agree, agree, disagree and strongly disagree options. It was designed to identify positive or negative attitude of students towards learning physics in secondary schools. It consists of thirty-two items of which 18 items were positive statements while 14 items were negative statements. The total score for all the items was taken as the index of students' attitude. Items of SAPQ are subjected to Cronbach's Alpha and its coefficient of reliability was 0.68.

iii. *Physics Performance Test (PPT):* It was used to measure students' performance in physics. PPT is a multiple-choice objective test with 30 items on five areas of Secondary School II physics curriculum (mechanics, heat and temperature; light waves; sound waves; and molecular theory of matters). Each item has four options of A to D. The Kuder-Richardson 20 formula was used to determine the reliability index value of the instrument of 0.74.

Data Collection and Analysis Procedure

The researchers collected data for the study with the cooperation of mathematics and physics teachers in the selected schools. The instruments were administered to the students twice to avoid boredom. The MCST and SAPQ were administered on the first visit while the students responded to the PPT on the second visit. The information collected were scored and coded by the researchers for analysis. The multiple regression analysis was employed to analysis hypotheses 1, 2 and 3 and t-test was used to test hypothesis 4.

Results

Ho_1: There is a significant influence of mathematical competence on students' performance in physics.

Table 2. Influence of mathematical competence on students' performance in physics.

Model	R	R Square	Adjusted R Square	F Change	Df1	df2	Sig.
1	0.47	0.22	0.21	35.11	1	248	0.00

Table 2 indicates the simple linear regression calculated to determine the influence of mathematical competence on students' performance in physics. A significant regression equation was found ($F_{(1,248)} = 35.11$, $R^2 = 0.22$, $p < 0.05$). This means that mathematical competence positively significantly influenced students' performance in physics. The table also revealed that mathematical competence accounted for 22% of the total variance in students' performance in physics. Consequently, the hypothesis which states that there is a significant influence of mathematical competence on students' performance in physics is not rejected.

Ho_2: There is a significant influence of attitude towards learning physics to students' performance in physics.

Table 3. Influence of attitude towards learning physics to students' performance in physics.

Model	R	R Square	Adjusted R Square	F Change	df1	df2	Sig.
1	0.28	0.08	0.08	16.86	1	248	0.00

Table 3 indicates the simple linear regression calculated to determine the influence of attitude towards learning physics to students' performance in physics. A significant regression equation was found ($F_{(1,248)} = 16.86.11$, $R^2 = 0.08$, $p < 0.05$). This means that attitude towards learning physics positively significantly influenced students' performance in physics. The table also revealed that attitude towards learning physics accounted for 22% of the total variance in students' performance in physics. Consequently, the hypothesis which states that there is a significant influence of attitude towards learning physics on students' performance in physics is retained.

Ho_3: There is no significant composite contribution of mathematical competence and attitude towards learning physics, to students' performance in physics.

Table 4: Summary of the Multiple Regression Analysis on ma thematical competence and attitude towards Physics on students' performance in Physics

Multiple R = 0.62			Adjusted R^2 = 0.36		
R^2 = 0.39			Standard Error = 13.75		
Analysis of Variance					
Model	**SS**	**Df**	**MS**	**F**	**Sig of F**
Regression	5309.71	2	2654.86	30.20	0.00
Residual	21627.09	246	87.92		
Total	26936.79	248			

Significant F at P = 0.05

Table 4 shows the result of the regression of mathematical competence and students' attitude towards learning physics on the sampled secondary school students' performance in physics. The result also reveals significant outcome ($F_{(2,246)} = 30.20$; $P < 0.05$). This implies that mathematical competence and students' attitude towards learning physics when combined, significantly contributed to the variance in students' performance in physics. The result shows a multiple correlation coefficient of 0.62 and R^2 value of 0.39, thus showing that mathematical competence and students' attitude towards learning Physics jointly accounted for 38.80% of the variance in the dependent variable. As a result, the null hypothesis is rejected. Hence, mathematical competence and students' attitude towards learning physics significantly contributed, when combined, to the prediction of secondary school students' performance in physics. That is, there is significant composite contribution of mathematical competence and students' attitude towards learning physics to secondary school students' performance in physics.

Ho_4: There is no significant difference between the mean performance of students in physics from urban and rural located schools.

Table 5 : D ifference between in the mean performan ce of students in physics from Urban and Rural located schools

Variables	N	Mean	Std Deviation	df	t-calculated	t-critical
Urban Area	128	27.32	4.20	247	13.54	1.96
Rural Area	121	20.19	4.19			

Table 5 shows the result of the difference between the mean performance of students in physics from Urban and Rural locations. It also shows the mean and standard deviation scores of the students that participated according to school location indicating that the sampled urban and rural based students recorded the following: urban (mean = 27.32; standard deviation = 4.20) and rural (mean = 20.19; standard deviation = 4.19). This means that the urban based students performed better than their rural based counterparts in the Figure I. The result also shows that t-calculated value of 13.54 is greater than t-critical value of 1.96. As a result, the null hypothesis is rejected. Thus, there is significant difference between in the mean performance of urban based students and rural-based students in physics. Hence, there is significance difference between the mean performance of students in physics from urban and rural located schools.

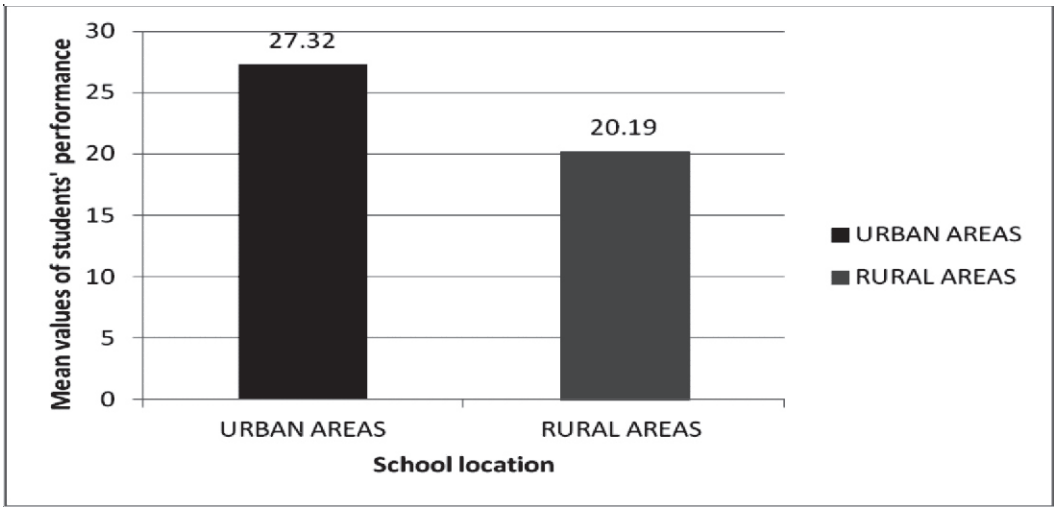

Figure I: **Showing the mean performance of students in physi cs from U rban and Rural based schools**

Discussion

The findings reveal that there was significant relative contribution of mathematical competence to secondary school students' performance in physics. This implies that there was a significant contribution of mathematical competence to the students' performance in physics. This finding is in line with Charles-Ogan and Okey (2017) and Ogunleye, Awofala and Adekoya (2014) which reported that mathematics is a dominant contributing factor to the performance of students in physics. The finding also reported that there was significant relative contribution of students' attitude towards learning physics to secondary school students' performance in physics. The finding is in line with Godwin and Okoronka (2015) and Veloo and Khalid (2015) that a significant relationship exists between students' attitude and their corresponding academic performance in physics. But this outcome negates the findings of Ibrahim, Zakiang and Damio (2019) which reported that attitude towards physics has no relationship with achievement in physics. That is, students achieved good grades in physics without having any positive or favourable learning attitude towards the subject.

Furthermore, the finding shown that there was significant composite contribution of mathematical competence and students' attitude towards learning physics to secondary school students' performance in physics. This outcome is in line with findings of Godwin and Okoronka (2015) and Alokan (2010), that there is significant relationship between location, attitude and academic performance in secondary school physics. Finally, the finding revealed that there was significance difference between the mean performance of students in physics from urban and rural - based schools. The finding is in support of Nwogu (2010); Obe (2004); Ahiaba and Igweonwu (2003) that school location significantly contributed to performance in

mathematics and basic science students. However, studies of Bosede (2010) and Obe (2004) indicated that there is no significant relationship in mathematics and basic science achievement scores of students in urban and rural based schools.

Conclusion

Based on the outcomes of this study, it can be concluded that mathematical competence is a contributory factor in learning physics. It can be a useful tool or a barrier too high to overcome for some of our students. Evidence has shown that students who performed well in physics must have possessed good mathematics background and students with positive attitude can take up the study of physics with confidence. Mathematical competence, attitude towards learning physics and school location have influence on the secondary school students' performance in physics.

Recommendations

It is therefore recommended that those teaching physics at secondary schools should note that mathematical competence and students' attitude are good predictors of students' performance in physics, therefore extra work in the mathematics concept needs to be done. Teachers should encourage students offering physics in solving problems so that they may develop positive attitude towards learning. Lastly, the school authority or curriculum planners should note the contributions of mathematics competence in students' performance in physics in the process of teaching and learning. School location was also found to be a significant factor, it implies that governments have to improve on provision infrastructure in rural areas to reduce migration to urban areas for education and jobs. This will consequently affect the quality of studentship in rural schools.

References

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

Alokan, F. B. (2010). Influence of sex and location on relationship between student problems and academic performance. *The Social Sciences, 5* (4), pp. 340 – 345.

Anderson, U. (2018). *The relevance of mathematics to learning of physics in secondary schools*. Afribary.com: Retrieved May 05, 2020. From https://afribary.com/works/the-relevance-of-mathematics-to-learning-of-physics-in-secondary-schools-1721.

Anigbo, L. C. (2016). Factors affecting students' interest in mathematics in secondary schools in Enugu state. *International Journal of Education and Evaluation, 2* (1), pp. 452-461.

Awofala, A. O. A. (2010). *Impact of personalised instruction on senior secondary school learning outcomes in mathematics word problems: PhD Thesis*. Ibadan: University of Ibadan.

Charles-Ogan, G. Ibibo, & Okey, I. F. (2017). Effects of mathematics knowledge on physics students' performance in electromagnetism. *International Journal of Theoretical and Mathematical Physics,* 7 (4), pp. 61-67.

Chief Examiners' Report, WASSCE (2015-2018). *The West African Examinations Council*, Lagos. *https://waeconline.org.ng/e-learning/Physics Downloaded on 05/02/2020*.

Daniel, K. K.,& Felix, K. (2014). The impact of school environment and peer influence on students' academic performance in Vihige County, Kenya, *International Journal of Humanities and Social Science*, 4 (5), pp. 12-22.

Godwin, B. A., & Okoronka, U. A. (2015). Attitude and academic performance of senior secondary school students in physics in Nigeria. Paper presented at *proceeding of 2nd* International *Conference on Education*, Istanbul, Turkey.

Federal Republic of Nigeria (2013 & 2004). *National Policy on Education,* Nigeria Educational Research and Development Council (NERDC), Abuja:

Ibrahim, N., Zakiang, M. A., & Damio, S. M. (2019). Attitude in learning physics among form four students. *Social and Management Research Journal*, 16 (2.), pp. 7060- 066.

Mensah, J. K., Okyere M., & Kuranchie, A. (2013). Students' attitude towards mathematics and performance: Does the teacher attitude matter? *Journal of Education and Practice,* 4 (3), pp. 133-140.

Mkpanang, J. T. (2005). Enhancing the professional physics teachers' role in lifelong education through professionalization of teaching. *Proceedings of the 46th Annual Conference of the Science Teachers' Association of Nigeria*. pp. 269-273.

Niss, M. (2003). Mathematical competencies and the learning of mathematics: The Danish KOM Project. In A. Gagatsis & S. Papastavridis (Eds.), *Proceedings of the Third Mediterranean Conference on Mathematics Education.* pp. 115–124.

Ntibi, Joseph Effiom-Edem., & Edoho, Emmanuel A. (2017) Influence of school location on students' attitude towards mathematics and basic science. *British Journal of Education,* 5 (10), pp. 76-85.

Obafemi, D. T. A., & Ogunkunle, R. A. (2014). Mathematics abilities of secondary school physics students and performance in sound waves. *International Journal of Research and Development (IJRD)* 1 (1), pp. 111-123.

Ofodu, G. O. (2010). Gender, school location and class level as correlates of reading interest of secondary school students. *Journal of Contemporary Studies,* 2. pp.118-123.

Ogunleye, A., Awofala, A. O. A., Adekoya, E. A (2014). Effect of students' background knowledge of mathematics on senior secondary school students' achievement in physics, *Bulgarian Journal of Science education, 23 (6), pp. 45-51.*

Osborne, J. Simon, S., & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education*, 25. pp. 1049-1079.

Lord, P., & Jones, M. (2006). Pupils' experiences and perspectives of the national curriculum and assessment. *Final report for the research review Slough*, UK: NFER.

Thorndike, E. L. (2010). Thorndike's laws of learning and its educational implications Educational Psychology. Tuesday, October 19, 2010.

Veloo, A., Nor, R., & Khalid, R. (2015). Attitude towards physics and additional mathematics achievement towards physics achievement. *International Education Studies,* 8 (3), pp. 35-43.

Yusuf, S. & Araba, H. (2019). Perceived causes of students' failure in mathematics in Kwara state junior secondary schools: Implication for educational managers. *International Journal of Educational Studies in Mathematics,* 6 (1), pp. 19-33.