

Influence of Mathematical Language Ability and Parental Supports on Students' Academic Achievement in Secondary School Sciences (Physics, Chemistry and Biology) in Ogun State, Nigeria

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Abstract

The development of any nation depends on its scientific and technological prowess which when pivoted on sound mathematical foundation helps acquisition of functional skills for productive contribution to society. However, students have difficulty in applying mathematical knowledge to science learning. This study investigated the influence of Mathematical Language Ability (MLA) and Students' Parental Supports (SPS) on achievement in senior school science subjects in Ogun State. It adopted a survey research type with two research questions raised and six hypotheses formulated. Seven hundred and twenty students were randomly selected from six out of eleven public senior secondary schools purposively selected in Ijebu Ode Local Government Area, Ogun State. Three test instruments: Mathematical Language Ability Test ($r = 0.85$), Students' Parental Supports Questionnaire ($r = 0.75$) and Students' Achievement Test ($r = 0.78$) were used for data collection. Data analysis using regression analysis revealed a significant influence of MLA on students' achievement in the core science subjects. Similarly, the result indicated significant influence of SPS on achievement in science subjects. It is recommended that science teachers should be familiar with the language of mathematics since many of the science concepts involve the use of numbers, symbols, signs and mathematical expression for problem-solving.

Keywords: Mathematical language ability, students' parental supports, academic achievement in science subjects.

Влияние математических знаний и поддержки родителей на успеваемость учащихся по естествознанию (физика, химия и биология) в средней школе в штате Огун, Нигерия

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Аннотация

Развитие нации зависит от её научно-технического прогресса, который опирается на прочную математическую основу и способствует формированию функциональных навыков членов общества. Однако в изучении естественных наук учащиеся редко применяют математические знания. Данное исследование направлено на изучение того, как математические знания (MLA) влияют на освоение школьниками естественнонаучных знаний и какую роль при этом играет поддержка родителей. При планировании исследования авторы сформулировали два исследовательских вопроса и выдвинули шесть гипотез. Объем выборки составил семьсот двадцать учащихся, отобранных случайным образом, из шести средних школ в районе местного самоуправления Иджебу-Одэ, штат Огун. В качестве инструментов для сбора данных были использованы следующие опросники: Mathematical Language Ability Test ($r = 0.85$), Students' Parental Supports Questionnaire ($r = 0.75$) и Students' Achievement Test ($r = 0.78$). Проведенный регрессионный анализ показал значительное влияние математических знаний на академическую успеваемость по физике, химии и биологии. Результаты также показали значительное влияние родительской поддержки на успеваемость по учебным предметам естественных наук. Эти данные позволяют сделать вывод о том, что преподаватели естественнонаучных дисциплин должны быть знакомы с языком математики, поскольку числа, символы, знаки и математические выражения используются ими для решения естественнонаучных задач.

Ключевые слова: математические знания, поддержка родителей, академическая успеваемость по естествознанию.

Introduction

Mathematics is the bedrock for the scientific and technological development of a nation. It strongly influences the understanding of science subjects because several concepts in science require mathematical skills for understanding. Mathematics plays a vital role in building a strong foundation for the advancement of science and technology (International Commission on Mathematics Instruction, 2008; Mberia & Nwagi, 2018). Sazhin cited in Nakakoji and Wilson (2018) sees mathematics as the bedrock of science and engineering and the best language for describing physical and chemical laws. Mathematics has an underlying language which facilitates learners effective understanding. This is a system of communication with a set of symbols, conventions or special characters represented by mathematical structure. It has grammar, syntax, vocabulary, word order, synonyms, negations, conventions, idioms, abbreviation, sentence structure and paragraph structure associated with it (Napipi, *et al.*, 2017). The language helps students

to learn mathematics through effortless reading, writing and discussion of mathematical concepts (Powell, Driver, Robert, & Fall, 2017).

Studies and reports have shown that students are not doing well in science due to lack of their understanding of mathematical language. The Association for Science Education (2016) observed that students are not mastering concepts in science because they lack mathematical skills capable of enhancing their effective learning. In Nigeria, the West African Examinations Council (WAEC), a body commissioned to conduct examinations in the English-speaking West African countries reported that students are not performing well in core science subjects of physics, chemistry and biology because of their lack of mathematical skills. For instance, the WAEC Chief Examiners' Report (2017 & 2018) for Physics pointed out that students had no proper understanding of the mathematical relationship and were unable to handle algebraic arithmetic expressions. They were also unable to recall and apply the correct formula to solve problems.

The WAEC Chief Examiners' Report (2017; 2018) for Chemistry indicated that students were unable to express answers to three significant figures and inconsistently reading burettes to two decimal places. They were also unable to calculate the mass concentration of solutions. Lack of students' mathematical skills was also reported by the WAEC Chief Examiners' Report (2017; 2018) for Biology. The report indicated that students were deficient in their understanding of mathematical concepts and thus unable to apply the skills to solve problems in genetics. They also found it difficult to compute the magnification of biological diagrams. As demonstrated by Hewitt-Brundshaw (2012), students experience challenges using the registers of mathematics and science and there is a need to develop learners' proficiency in these areas if they must do well in both subjects. This means that mathematics language needs to be understood if scientific problems that require the application of mathematics are to be solved effectively.

There is a paucity of studies on the influence of mathematical language on students' performance in the core science subjects especially in biology and physics. Meanwhile, the study by Udofia and Etuk (2014) found that science and mathematics language ability had a significant effect on students' achievement in chemistry. In the study, the researchers merged science and mathematics language as one language to determine the influence on students' performance in chemistry alone. This is different from the present study which determined how mathematical language ability influenced the core science subjects of physics, chemistry and biology. From another standpoint, Wanjiru (2015) explored the influence of mathematical vocabulary instruction on students' achievement. The finding indicated a positive association between mathematical vocabulary instruction and students' performance in mathematics. The finding revealed a statistically significant difference between students' performance in mathematics for the group taught mathematics vocabulary using the Frayer model and those taught using the conventional method.

Empirical evidence from Mbugua (2012) which determined how mathematical language influenced students' achievement in mathematics in Kenya revealed a high correlation between achievement in mathematics and mathematics language learning. The study also reported that students made mistakes when solving problems in mathematics due to poor knowledge of the mathematical language. The researcher concluded that mathematical language played a pivotal role in understanding and achievement in mathematics. In a related study, Mulwa (2014) explored the proficiency of students in using mathematical terminology and related concepts. The study, which adopted a descriptive survey design, showed that students had difficulties using mathematical terms and related concepts which culminated to inadequate grasp of the language of mathematics, and that this affected their learning performance in the subject. Gabriel

(2019) examined students' knowledge of mathematical structure among senior secondary (SS 2) students in connection with their academic performance in mathematics. Although the study reported a significant relationship between students' knowledge of the mathematical structure and academic performance, the mathematical structure was only limited to set theory.

The studies of Mbugua (2012), Wanjiru (2015) on mathematical language and that of Gabriel (2019) which determined the influence of mathematics structure were also in mathematics. They are different from the focus of this study which was to determine the influence of mathematical language ability on students' performance in core science subjects of physics, chemistry and biology.

Apart from mathematical language ability, parental support has also been reported to influence students' performance. Parental involvement in school is a key factor in students' academic achievement (Lara & Saracostti, 2019). It entails the time, emotional, financial and other resources committed by the parents and other members of the family towards the academic achievement of the children. This means that educational processes extend beyond the school settings to individual students' homes. Several studies have reported the links between parental support and academic achievement. Shukla, Tombari, Toland and Danner (2015) conducted a study to determine whether student-perceived at-home parental support for learning is associated with students' personal goal orientations and persistence in mathematics in the classroom. The result revealed that at-home parental support for learning is significantly positively associated with students' achievement in mathematics. The study by Okolo (2014) which explored the influence of parental support on academic achievement of secondary school students in the Udi educational zone of Enugu State, Nigeria also reported that parental support had a significant influence on academic achievement of secondary school students. A similar trend was reported by the studies of Chohan and Khan (2010) and Hassan (2016) which found that parents' contribution to their children's education had a consistent and positive effect on academic achievement. Oyedare, Ogunjimi and Durojaiye (2016) who examined parental involvement as determinants of students' academic performance in Agricultural Science in some selected secondary schools in Oyo State, also reported that parental involvement significantly influenced students' academic performance.

From the foregoing, it is evident that mathematical language ability and parental support influence students' academic achievement. However, there is a dearth of studies on the influence of mathematical language ability and parental support on the academic achievement of students in science subjects (physics, chemistry and biology). This is the gap this study intends to fill. Hence, this study examined the influence of mathematical language ability (MLA) and Parental Support (PS) on the performance in secondary school students in science subjects.

Objectives of the study

The main objective of the study was to investigate the influence (impact) of mathematical language ability and parental support on students' academic achievement in each of the senior secondary school science subjects of physics, chemistry and biology).

Specific objectives were to:

1. Determine the influence of mathematical language ability on students' academic achievement in each of the senior secondary school science subjects of physics, chemistry and biology.
2. Determine the influence of students' parental support on academic achievement in each of the senior secondary school science subjects of physics, chemistry and biology.

Research Questions

The study was guided by the following research questions:

1. Will the mathematics language ability (MLA) significantly influence students' academic achievement in each of the senior secondary school science subjects of physics, chemistry and biology?
2. Will the students' parental support (SPS) significantly influence their academic achievement in each of the senior secondary school science subjects of physics, chemistry and biology?

Hypotheses

To answer the research questions, six hypotheses were formulated such that hypotheses 1, 2, 3 addressed the first research question 1; hypotheses 4, 5, 6 addressed research question 2:

- 1) There is a significant influence of MLA on students' academic achievement in senior secondary school physics.
- 2) There is a significant influence of MLA on students' academic achievement in senior secondary school chemistry.
- 3) There is a significant influence of MLA on students' academic achievement in senior secondary school biology.
- 4) There is a significant influence of SPS on students' academic achievement in senior secondary school physics.
- 5) There is a significant influence of SPS on students' academic achievement in senior secondary school chemistry.
- 7) There is a significant influence of SPS on students' academic achievement in senior secondary school biology.

Method

The study adopted a correlational survey research design, where Mathematics Language Ability and Parental Support were the independent variables and Achievement in Sciences (physics, chemistry and biology) was the dependent variable.

A sample of 720 students was drawn through random sampling technique from six out of eleven public senior secondary schools in Ijebu Ode Local Government Area, Ogun State. One hundred and twenty (120) students were randomly selected from the Senior Secondary II classes of the selected schools. A purposive sampling technique was used to select Ijebu Ode Local Government Area out of the twenty Local Government Areas in Ogun State. The same technique was used to select Senior Secondary II (SS2) because they did not have the pressure of external examinations which might have affected their participation in the study. They also had adequate entry behaviours to attend to the tests and the questionnaire items.

The three instruments used for data collection were developed and validated by the researchers. They are Mathematical Language Ability Test (MLAT), Students Parental Support Questionnaire (SPSQ) and Sciences Achievement Test (SAT). The Mathematical Language Ability Test (MLAT) was constructed to determine the mathematical language ability of the students. It was a multiple-choice objective test with 30 items. Each item had four options (A to D). These items were derived from the past senior secondary school objective questions conducted by West African Examinations Council (WAEC) and National Examinations Council (NECO) in Nigeria. Lawshe's method was used to establish the content validity and the value obtained was 0.77. The item difficulty values, π is such that $0.40 < \pi < 0.82$. The test reliability method was used to establish the reliability of the instrument and it yielded coefficient reliability values of 0.85.

Meanwhile, the Students' Parental Support Questionnaire (SPSQ) was to measure students' perception of the parental support of their learning at home. It contained ten items of a four point Likert scale ranging from All of the support, Some of the support, Fair support to No support. Lawshe's method was also used to establish the content validity and yielded a coefficient of 0.71. Items in SPSQ were analyzed using Cronbach Alpha with a reliability coefficient of 0.75. The Sciences Achievement Test (SAT) was constructed and validated to determine the students' performance in the sciences subjects of physics, chemistry, and biology. This was a multiple-choice objective test with 30 items such that students' mathematical language abilities in the three subjects were tested using ten items each. Each item had four options (A to D) and was derived from the past senior secondary school objective questions conducted by WAEC and NECO. The validity of the SAT was obtained by subjecting it to the critique of experts in test construction and secondary school science teachers. Their suggestions were used to modify the test before final production. The reliability of the test was obtained by administering the test on 30 students from schools that would not participate in the study but share similar characteristics, twice at the interval of two weeks. A test-retest reliability coefficient of 0.78 was obtained.

Data Collection

The researchers obtained permission from the heads of the selected schools with the assurance of being ethical in the conduct of the research. The science teachers of the selected schools were also contacted to seek their supports for the successful conduct of the study. With the assistance of the science teachers, the students were reached and assured that the data collected from them would be handled with the utmost confidentiality and only for research purpose. The three instruments were administered to the students and researchers waited to collect the answer sheets and completed questionnaires after all the students finished.

Data Analysis

The data analysis involved the use of multiple regression analysis to determine the influence of mathematical language ability and parental support on students' achievement in science subjects of physics, chemistry and biology. The hypotheses generated were tested at 0.05 level of significance.

Results

This section presents the results obtained from data analysis based on the testing of formulated hypotheses. The analyses based on the formulated hypotheses are used to answer the research questions (see above).

Hypothesis 1: There is a significant influence of MLA on students' academic achievement in senior secondary school Physics.

Table 1. Influence of MLA on students' academic achievement in senior school physics

Model	R	R Square	Adjusted R Square	R Square Change	F Change	df1	df2	Sig.
1	0.345	0.13	0.13	0.13	109.39	1	718	0.00

A simple linear regression was calculated to determine the influence of MLA on students' achievement in Physics. A significant regression equation was found ($F_{(1,718)} = 109.39$, $R^2 = 0.13$, $p < 0.05$). This means that mathematical language ability

positively significantly influenced students' academic achievement in physics. The table also revealed that MLA accounted for 13% of the total variance in students' academic achievement in physics. Consequently, the hypothesis which states that there is a significant influence of MLA on students' achievement in senior secondary school physics is supported.

Hypothesis 2: There is a significant influence of MLA on students' academic achievement in senior secondary school chemistry.

Table 2. Influence of MLA on students' academic achievement senior school Chemistry

Model	R	R Square	Adjusted R Square	R Square Change	F Change	df1	df2	Sig.
	0.40	0.16	0.16	0.16	136.31	1	718	0.000

Table 2 shows the simple linear regression calculated to determine the influence of MLA on students' achievement in chemistry. A significant regression equation was found ($F_{(1,718)} = 136.31$, $R^2 = 0.16$, $p < 0.05$). This revealed that MLA positively significantly influenced the students' academic achievement in chemistry. Evidence from the table also proved that MLA accounted for 16% of the total variance in students' academic achievement in chemistry. Thus, the hypothesis which states that there is a significant influence of MLA on students' academic achievement in senior secondary school Chemistry is supported.

Hypothesis 3: There is a significant influence of MLA on students' academic achievement in senior secondary school biology.

Table 3. Influence of MLA on students' academic achievement in senior school Biology

Model	R	R Square	Adjusted R Square	R Square Change	F Change	df1	df2	Sig.
1	0.30	0.09	0.09	0.09	72.46	1	718	0.000

Table 3 shows the simple linear regression calculated to determine the influence of MLA on students' achievement in biology. A significant regression equation was found ($F_{(1,718)} = 72.46$, $R^2 = 0.09$, $p < 0.05$) indicating that MLA significantly positively influenced students' academic achievement in biology. It is also obvious from the data in table 3 that MLA accounted for 9% of the total variance in the students' academic achievement in biology. So, the hypothesis which states that there is a significant influence of MLA on students' achievement in senior secondary school Biology is supported.

Since Hypotheses 1, 2, and 3 indicated significant influence of mathematical language ability on students' achievement in physics, chemistry and biology, it can be concluded that mathematical language ability (MLA) significantly influenced students' academic achievement thus answering research question 1

Hypothesis 4: There is a significant influence of SPS on students' achievement in senior secondary school Physics.

Table 4. Influence of SPS on students' achievement in senior school Physics

Model	R	R Square	Adjusted R Square	R Square Change	F Change	df1	df2	Sig.
1	0.37	0.14	0.14	0.14	114.13	1	718	0.000

Table 4 shows the simple linear regression calculated to determine the influence of SPS on students' achievement in physics. A significant regression equation was found ($F_{(1,718)} = 114.13, R^2 = 0.14, p < 0.05$). This means that SPS significantly positively influenced students' academic achievement in Physics. Also, SPS accounted for 14% of the total variance in the students' academic achievement in physics. Hence, the hypothesis which states that there is a significant influence of students' parental support (SPS) on academic achievement in senior secondary school Physics is supported.

Hypothesis 5: There is a significant influence of SPS on achievement in senior secondary school chemistry.

Table 5. Influence of SPS on students' achievement in senior secondary school chemistry

Model	R	R Square	Adjusted R Square	R Square Change	F Change	df1	df2	Sig.
1	0.31	0.10	0.10	0.10	77.31	1	718	0.000

Table 5 shows the simple linear regression calculated to determine the influence of SPS on students' achievement in chemistry. A significant regression equation was found ($F_{(1,718)} = 77.81, R^2 = 0.10, p < 0.05$), meaning that SPS significantly positively influenced students' academic achievement in chemistry. Data from the table also revealed that SPS accounted for 10% of the total variance in the students' academic achievement in chemistry, thus supporting the hypothesis which states that there is a significant influence of SPS on students' achievement in senior secondary school chemistry.

Hypothesis 6: There is a significant influence of SPS on students' achievement in biology

Table 6. Influence of parental support on students' achievement in senior secondary biology

Model	R	R Square	Adjusted R Square	R Square Change	F Change	df1	df2	Sig.
1	0.38	0.15	0.15	0.15	122.90	1	718	0.000

Table 6 shows the simple linear regression calculated to determine the influence of SPS on students' achievement in biology. A significant regression equation was found ($F_{(1,718)} = 122.90, R^2 = 0.15, p < 0.05$), indicating that SPS significantly positively influence students' academic achievement in biology. The SPS also accounted for 15% of the total variance in the students' academic achievement in biology. Therefore, the hypothesis which states that there is a significant influence of parental support (SPS) on students' academic achievement in senior secondary school Biology is supported.

Since Hypotheses 4, 5, and 6 indicated significant influence of students' parental support on students' achievement in physics, chemistry and biology, it can then be concluded that students' parental support (SPS) significantly influenced students' achievement in these subjects thus answering research question 2.

Discussion of findings

This study found mathematical language ability significantly positively influenced students' achievement in physics, chemistry and biology. This may be attributed to the students' use of their mathematical language abilities to solve problems in these subjects. Wikinson (2015) maintains that knowledge and use of mathematics vocabulary provide the basis for students to perform well in areas requiring an application of mathematics

and it becomes problematic when the relationship between the words and symbols are not properly understood. This finding is in line with that of Udofia and Etuk (2014) who reported that science and mathematics language ability had a significant effect on students' achievement in chemistry. However, it disagrees with the finding of Nakakoji and Wilson (2018) that students were unable to transfer their mathematical skills to the learning of Biology.

Further, the finding of this study indicated significant influence of parental support on students' achievement in these three subjects. The significant outcome could be attributed to the efforts of parents and other family members towards improving their children learning. This outcome is in line with the report of Hassan (2016) that parents' contribution to their children education is capable of improving their learning in schools. It also echoes the finding of Oyedare *et al.* (2016) that parental involvement significantly influenced students' academic performance in agricultural science.

Conclusion

This study examined the influence of mathematical language ability and parental support on students' academic achievement in science subjects of Physics, Chemistry and Biology in Ogun State. The finding revealed that mathematical language ability significantly influenced students' achievement in these subjects and also found that students' parental support significantly influenced their achievements.

Based on the results of this study, it is concluded that mathematical language ability, as well as parental support, significantly influence students' achievement in physics, chemistry and biology. Thus, students who do well in mathematics and have good parental supports are expected to do well in these subjects in senior secondary school.

Recommendations

Based on the findings, it is recommended that mathematics and science teachers in the senior secondary schools should collaborate to rearrange or design the related curriculum contents of the Mathematics and Physics so that they can be treated simultaneously. This will help the students to transfer the concepts, procedures and ability that have been learnt in mathematics to basic sciences. It is also important that chemistry and biology teachers liaise with mathematics teachers when teaching mathematical concepts in the subject areas to enable students to see the connection between the subjects i.e. mathematics-chemistry relationship and mathematics-biology relationship. "Unifying mathematical ideas" should also be employed. This means that the major mathematical themes that are relevant in several different strands of the science subjects should be brought together for lesson planning and teaching.

There is a need for science teachers to be familiar with the language of mathematics since many of the science concepts involve the use of numbers, symbols, signs and mathematical expression for problem-solving. Science teachers should always endeavour to teach the learners' the connection between mathematics language and science learning. The efforts are necessary to help them improve their problem-solving ability for learning improvement in core science subjects.

The study also recommended that parents should maintain and improve the forms of support given to their children. These include looking through assignments and offering assistance when necessary, purchasing necessary learning materials in soft and hard copies and giving them enough time to engage in learning activities. These are to ensure that the learners have a conducive learning environment to improve their achievement in science subjects.

Conflict of Interest

The authors declare that there is no conflict of interest in this research.

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