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Performance and Retention of Secondary School Students in Algebraic Processes Using MATLAB in Obio-Akpor Local Government Area, Rivers State

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Abstract
The study looked at how well secondary school students in Obio-Akpor, Rivers State, performed and retained algebra lessons using the MATLAB computing package. It used a quasi-experimental design with 160 students (80 boys and 80 girls) out of a population of 8,587. The students were chosen randomly. Four research questions and four hypotheses were tested at a 0.05 significance level. The tools used were the Algebraic Process Achievement Test (APAT) and the Algebraic Process Retention Test (APRT), which were validated and found reliable with a KR-21 coefficient of 0.83. The results showed that students taught with MATLAB did better and retained more than those taught with traditional methods. The study recommends that math teachers use MATLAB to improve students' performance and retention in algebra. The study also added to the existing knowledge on this topic.

Keywords: MATLAB, Technology, Software, Academic Performance, Retention

Introduction

MATLAB is a high-performance language used extensively in technical and mathematical computing, developed by Cleve Moler at the University of New Mexico in the late 1970s (Mustafy & Rahman, 2024). It is widely utilized across various fields, including education, research, and industry. The name MATLAB stands for MATrix LABoratory, emphasizing its strength in linear algebra, solving algebraic and differential equations, numerical integration, and producing 2D and 3D graphics. MATLAB's interactive nature enhances the learning experience by allowing students to analyze, synthesize, organize, and evaluate content, thereby constructing their own knowledge (Ponce-Ortega et al., 2024). According to Gagniuc (2024), MATLAB facilitates data analysis, algorithm development, and model creation, improving efficiency, resource management, and creative thinking skills. Thus, MATLAB is a valuable digital tool in mathematics education, enhancing student performance. The significance of mathematics in the national curriculum highlights its crucial role in societal development, relying on effective mathematics education programs with modern instructional materials, digital tools, and qualified teachers. The school curriculum covers topics such as Numbers, Algebra, Measurement, Geometry, Trigonometry, Statistics, and Probability (Okeke et al., 2022a). This study focuses on algebraic processes, a branch of mathematics originating from Arabian traditions. Algebra extends arithmetic by introducing variables and encourages critical thinking. Despite its importance, reports show students often perform poorly in Algebra (WAEC Chief's Examiner Report, 2021). Algebra is essential at both primary and secondary levels, forming the basis for other areas of mathematics. It is included in nearly all classes of the National Mathematics Curriculum, but many students struggle to understand it. Algebra involves solving and graphing different types of equations, including linear, simultaneous linear, and quadratic equations.

Algebraic processes are important in the SSII mathematics curriculum and appear in standard examinations like WAEC and NECO. However, students often avoid these topics and perform poorly when they attempt them. Onyeka and Arokoyu (2018) found that from 2010 to 2015, students' performance in Nigeria's West Africa Certificate Examination (WAEC) was consistently poor, with less than half achieving a passing grade. Several reasons for this poor performance include math anxiety, negative attitudes toward math, harsh teaching methods, student laziness, poor foundational knowledge, overcrowded classes, and lack of materials (Sarfo et al., 2022; Egara et al., 2022; Evans et al., 2019; Jameel & Ali, 2016; Osakwe et al., 2023a; Mosimege & Egara, 2022).

One major issue is the teachers' inability to choose appropriate teaching methods and lack of knowledge about technological innovations in teaching algebra. Conventional teaching methods are mostly teacher-centred, which limits students' critical thinking, problem-solving, and decision-making skills. Incorporating technology can create a more engaging, student-centred environment that enhances motivation and interest. Using computers in mathematics education increases attention and curiosity in the classroom. It allows teachers to demonstrate physical phenomena in a three-dimensional form, making learning more tangible. Technologies and software like Mathematica, MATHCAD, SPSS, PYTHON, OCTAVE, MATLAB, and MAPLE are essential in modern mathematics education. Software-supported educational products enhance student engagement and performance (Charles-Ogan, 2015). Academic performance reflects students' learning, knowledge gained, and skills developed. Retention is crucial for long-term learning, referring to the ability to remember and use information over time (Andriotis, 2018). Performance in mathematics lasts only if students retain what they have learned. Studies have shown that mathematics software positively impacts students' academic performance and retention. For instance, Jose Sherwin (2016) found that students using mathematical software performed better in algebra than those using conventional methods. Emaikwu et al. (2015) reported that GeoGebra improved senior secondary students' interest and achievement in statistics. Williams et al. (2017) observed that GeoGebra enhanced SSS3 students' performance in mathematics in Rivers State. Gimba et al. (2015) discovered that computer simulation instructional packages improved retention in arithmetic progression among senior secondary students. Enikanolaye (2021) demonstrated that multimedia instructional strategies enhanced performance and retention in mathematics. Despite these findings, public examination results in algebra remain unsatisfactory, prompting further investigation into using MATLAB computing packages to improve performance and retention in Obio/Akpor, Rivers State.

Statement of the Problem

Technology has significantly impacted education, including mathematics teaching and learning. Despite advancements, poor student performance and retention in mathematics remain major concerns. Research suggests that ineffective teaching methods may contribute to these issues. Challenges in algebra, such as difficulties with factoring, solving equations, and understanding abstract concepts, further complicate learning.

Other factors affecting algebra performance include inadequate qualified teachers, lack of facilities, and outdated instructional methods. To address these problems, researchers advocate using innovative software like MATLAB. Traditional methods are insufficient in today's rapidly changing technological landscape. This study aims to investigate how using MATLAB as a computing package can improve students' performance and retention in algebra in Obio-Akpor Local Government Area, Rivers State.

Aim and Objectives

The aim of this study was to investigate how well secondary school students perform and retain algebraic processes using the MATLAB computing package in Rivers State. Specifically, the objectives of this study are:

1. Determine the mean performance of students taught the algebraic process with MATLAB and those taught with the discussion method.
2. Determine the mean retention scores of students taught the algebraic process with MATLAB and those taught with the discussion method.

Research Questions

The study addressed the following research questions:

1. What is the mean performance score of students taught the algebraic process with MATLAB and those taught with the discussion method?
2. What is the mean retention score of students taught the algebraic process with MATLAB and those taught with the discussion method?

Hypotheses

The following null hypotheses were tested at a 0.05 significance level

1. There is no significant difference between the mean performance of students taught the algebraic process with MATLAB and those taught with the discussion method.
2. There is no significant difference between the mean retention of students taught the algebraic process with MATLAB and those taught with the discussion method.

Methodology

This study used a quasi-experimental design with non-equivalent pre-test and post-test groups. The researcher chose this design to control for internal validity threats, such as initial group differences and selection bias, since the subjects were not randomly assigned to groups. Instead, intact classes were assigned to the experimental and control groups. The design is shown below:

Table 1: Nonrandomized Control Group, Pre-test–Post-test Design

E = Y1 X Y2

C = Y1 - Y2

E =experimental group

C =control group

$\mathbf{Y_1}$ = pre-test for both control and experimental group

$\mathbf{Y_2}$ =post-test for both control and experimental group

X = treatment (taught with MATLAB)

— = no treatment (Taught with Discussion method)

---- = intact class

The study included all Senior Secondary Two (SS II) students in Obio-Akpor Local Government Area, Rivers State. According to the Rivers State Schools Board, there are 8,587 SS II students in the schools. The sample for this study included 160 SS II students from four schools in Obio-Akpor. There were 80 males and 80 females. The researcher randomly selected two classes from each school, making a total of four classes. Only SS II students were chosen. Two schools were assigned to the experimental group and two to the control group using simple random sampling.

Table 1: Sample Distribution of the selected schools according to Gender

S/N	Schools	Male	Female	Total
1	A	17	23	40
2	B	18	22	40

The data was collected using the Algebraic Process Performance Test (APPT) and the Algebraic Process Retention Test (APAT), both developed by the researchers. The test included 20 multiple-choice questions on algebraic processes, with 9 higher-order and 11 lower-order questions. The same test was used for the pre-test, post-test, and retention test. For the retention test, the researcher adjusted the numbering and switched the options to minimize the impact of the post-test on the retention test. The researchers had experts in measurement and evaluation, and mathematics education review the test items for content and face validity. These experts checked the clarity and suitability of the test items, restructured any poorly formulated items, and removed any ambiguous or double-barreled statements. This process allowed the researcher to add new items that were initially missing. The experts also ensured that the test items covered the content to be taught, matched the lesson objectives, and were appropriate for the student's level. The researchers conducted a trial test of the Algebraic Process Performance Test (APPT) and Algebraic Process Retention Test (APRT) with 20 students from a school not included in the main study. The internal consistency of the tests was calculated using the Kuder-Richardson formula (K-R 21), resulting in coefficients of 0.86 and 0.83, respectively. This formula was chosen because the tests were designed by the researchers. The data were analyzed using mean, standard deviation, and ANCOVA. Mean and standard deviation were used for the research questions, and ANCOVA was used to test the hypotheses at a 0.05 significance level.

Results

Research Question 1: What is the mean performance score of students taught the algebraic process with MATLAB and those taught with the discussion method?

Table 2: Mean, standard deviation and gain scores of students taught the algebraic process using MATLAB and those taught using the discussion method

		Pre- test		Post – test		
Method	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean Gain**
MATLAB	80	7.60	2.69	17.68	1.34	10.07
Discussion	80	7.90	2.24	17.20	1.10	9.30

Table 2 indicates that students taught with MATLAB had a mean gain of 10.07 while those taught using the discussion method had a mean gain of 9.30. This implies that MATLAB improves students' performance in the algebraic process compared to the discussion method.

Research Question 2: What is the mean retention score of students taught the algebraic process with MATLAB and those taught with the discussion method?

Table 3: Mean, standard deviation and mean gain scores of students' retention taught algebraic process using MATLAB and those taught using the discussion method.

		Post- test		Retention test		
Method	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean Gain**
MATLAB	80	17.68	1.33	14.66	2.67	3.01
Conventional	80	17.20	1.10	14.34	2.70	2.86

Table 3 shows that students taught with MATLAB had a mean gain of 3.01 while those taught using the discussion method had a mean gain of 2.86. This implies that student taught algebraic processes using MATLAB retain more than their counterparts taught with the discussion method.

Hypothesis 1: There is no significant difference between the mean performance of students taught the algebraic process with MATLAB and those taught with the discussion method.

Table 4 shows a significant difference in mean performance scores between students taught algebra using MATLAB and those taught using the discussion method ($F(1, 157) = 5.929$; $p < 0.05$; partial eta square = 0.036), leading to the rejection of the hypothesis.

Table 4: summary of ANCOVA of students' performance based on methods

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9.060[a]	2	4.530	3.009	.052	.037
Intercept	4494.162	1	4494.162	2985.770	.000	.950
Pre-test	.035	1	.035	.023	.880	.000
Methods	**8.924**	**1**	**8.924**	**5.929**	**.016**	**.036**
Error	236.315	157	1.505			
Total	48896.000	160				
Corrected Total	245.375	159				

Hypothesis 3: There is no significant difference between the mean retention of students taught the algebraic process with MATLAB and those taught with the discussion method.

Table 5: Summary of ANCOVA of students' retention based on methods

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	109.607[a]	2	54.804	9.270	.000	.106
Intercept	504.946	1	504.946	85.415	.000	.352
Post-test	96.951	1	96.951	16.400	.000	.095
Methods	**28.943**	**1**	**28.943**	**4.896**	**.028**	**.030**
Error	928.136	157	5.912			
Total	34129.000	160				
Corrected Total	1037.744	159				

Table 5 shows that students who were taught with MATLAB retained significantly more information than those taught using the discussion method ($F(1, 157) = 4.896$; $P < 0.05$; partial eta square = 0.030), leading to the rejection of the hypothesis.

Discussion

The data in Table 2 showed that students taught using MATLAB had higher gain scores compared to those taught using conventional methods. Analysis of covariance was used to test Hypothesis 1 in Table 4, revealing a statistically significant difference between the effects of MATLAB and discussion methods on students' performance in Algebra, confirming that MATLAB is more effective. This finding aligns with Jose (2016) and Charlse-Ogan et al. (2017), who found that using mathematical software improves students' performance in algebra more than discussion methods. The effectiveness of MATLAB is likely due to its interactive nature, which increases students' interest and engagement in learning algebra. Also Working with MATLAB encourages students to develop critical thinking and problem-solving skills. They learn to approach problems methodically and explore different solutions, which enhances their overall mathematical abilities. Additionally, Table 3 showed that students taught with MATLAB had higher mean scores than those taught using discussion methods in retention, and this difference was significant in Table 5, suggesting that students taught with MATLAB retained more information. This result is consistent with Enikanolaye (2021), who reported that multimedia instructional strategies improve retention. It also agrees with Gimba et al. (2015), who found that students taught arithmetic progression through computer-simulated instruction retained concepts better than those taught using conventional methods. MATLAB's interactive capabilities enable students to see visual representations of algebraic problems and solutions. This interaction can make abstract concepts more concrete and easier to grasp, leading to better understanding and retention.

The data presented in Table 2 showed that the students taught MATLAB performed better with gain scores of 10.07. While students taught with the conventional method had a gain of 9.30. At the same time, Analysis of covariance was used to test hypothesis 1, Table 4, at the $F(1.157) = 5.929$, $p<0.05$ and confidence level of .05. There was a statistically significant difference between the main effect of MATLAB and discussion method on students' performance in Algebra confirming that the difference between the main effect of MATLAB and discussion method was statistically significant. The implication of this finding is that MATLAB as a computing package is more effective than the discussion method in enhancing students' performance in Algebra. The findings showed that MATLAB as a computing package has a positive effect on students' performance. This finding of this study is similar to the findings of Jose (2016) and Charles-Ogan, Williams and Adesope (2017) who found that the utilization of mathematical software in teaching algebra improved students' performance in the algebraic process than students taught algebra using the discussion method. A possible explanation for the effectiveness of the use of MATLAB on students' performance is attributed to the fact that the application of MATLAB could provide such properties as interaction. As such, the students participated actively and worked interactively with the MATLAB programme, thereby, increasing their interest and awareness in learning algebra.

Results from Table 3, students who were taught with MATLAB have a higher mean score than students who were taught algebra using the discussion method. Table 5 showed the difference is significant at $F(1,157) = 4.896$ and $p<0.05$. This indicated that students who were taught MATLAB retained more than students who were taught with the discussion method. This outcome could be because students who are taught using MATLAB have seen the algebra problem solved on the MATLAB interface and could figure out any question asked through the

imagination of the seen algebra problem solved on the interface. This result agrees with Enikanolaye (2021) who reported that multimedia instructional strategy improves and stimulates students' retention level thus, multimedia instructional package helps to concretize the learning of mathematics and makes learning more effective. The study is also in consonance with Gimba et al. (2015) who revealed that students taught arithmetic progression through computer simulated instructional package retained the concept learnt more than their counterparts taught using conventional lecture method.

Conclusion

Based on the study's results, the following conclusions were made: MATLAB significantly improves students' performance in Algebra compared to the discussion method. Students taught with MATLAB also retained more information than those taught with the discussion method. This shows that MATLAB is more effective for both performance and retention in Algebra.

Recommendations

Based on the findings, the following recommendations are made:

1. Mathematics teachers should use MATLAB as a teaching strategy to enhance performance and retention in Algebra.
2. Teachers should attend workshops and seminars to learn how to use MATLAB and other mathematical software in teaching.
3. Schools should provide MATLAB and other mathematical software so all students can use them.
4. Parents should be encouraged to buy computers for students to use at home, helping them practice what they learn in school and stay engaged.

References

Andriotis, N. (2018). Make your eLearning stick: 8 tips & techniques for learning retention. Retrieved from https://www.talentlms.com/blog/8-tips-techniques-learning-retention/)

Charles-Ogan, G. (2015). Utilization of Matlab as a technological tool for teaching and learning mathematics in Schools. *International Journal of Mathematics and Statistics Studies, 3*(5), 10 -24

Chief Examiner's Report, (2021).The West African Examination Council. S. S. C. E. May/June

Egara, F. O., Eseadi C., & Nzeadibe, A. C. (2022). Effect of computer simulation on secondary school students' interest in algebra. *Education and Information Technologies, 27,* 5457-5469. https://doi.org/10.1007/s10639-021-10821-8

Emaikwu, S.O., Iji, C.O. &Abari, M.T. (2015).Effect of Geogebra on Senior Secondary School Students' Interest and Achievement on Statistics in Makurdi Local Government Area of Benue state, Nigeria.*IOSR Journal of Mathematics, 11*(3), 14 – 21

Enikanolaye, A. J. (2021). Effects of Multimedia Instructional Strategy on Senior School Students' Performance and Retention in Mathematics. *Anatolian Journal of Education*, *6*(2), 193-206.

Evans, G. U. F., Ekpofia, C. A., & Thompson, M. E. (2019). The influence of primary school background on students' achievement in junior secondary school mathematics in Akwa. IOSR *Journal of Research & Method in Education, 9*(1), 1-7.

Gagniuc, P. A. (2024). MATLAB specific. In *coding Examples from Simple to Complex: Applications in MATLAB®* (pp. 251-270). Cham: Springer Nature Switzerland

Gimba, R. W., Falode, O. C., & Bashir, A. U. (2015). Effect of computer simulation instructional package on senior secondary school mathematics students' retention in arithmetic progression in Lavun Local Government area of Niger State, Nigeria. The African Symposium.

Jameel, H. T., & Ali, H. H. (2016). Causes of poor performance in mathematics from teachers, parents and student's perspective. *American Scientific Research Journal for Engineering, Technology, and Sciences, 15*(1), 122-136.

Jose Sherwin O. S (2016). Mathematical Software Utilization: Effect on Students' Achievement in Algebra. *International Conference on Research in Social Sciences, Humanities and Education (SSHE-2016)* May 20-21, 2016 Cebu (Philippines).

Mosimege, M. D. & Egara, F. O. (2022). perception and perspective of teachers towards the usage of ethnomathematics approach in mathematics teaching and learning. *Multicultural Education, 8*(3), 288-298. https://mc-caddogap.com/wpcontent/uploads/paper-31-of-vol-8-issue-3.pdf

Mustafy, T., & Rahman, M. T. U. (2024). MATLAB. In *statistics and data analysis for engineers and scientists* (pp. 37-80). Springer Nature Singapore

Okeke, M. A., Aneshie-Otakpa, V. O., Orga, C., Egara, F. O., Ubebe, S. A., & Inweregbuh, O. C. (2022a). Effect of google classroom on secondary school students' engagement and achievement in mathematics. *African Journal of Science, Technology and Mathematics Education*, *8*(1), 411-417.

Onyeka, E. C., & Arokoyu, A. A. (2018). Trends in students' performance in senior school certificate examination (SSCE) in mathematics between 2010 and 2015: Implication for sustainable development. *International Journal of Applied Research*, 4(9), 99-102.

Osakwe, I. J., Egara, F. O., Inweregbuh, O. C., Nzeadibe, A. C., & Emefo, C. N. (2023a). Interaction pattern approach: An approach for enhancing students' retention in geometric construction. International Electronic Journal of Mathematics Education, 18(1), em0720. https://doi.org/10.29333/iejme/12596

Ponce-Ortega, J. M., Ochoa-Barragán, R., & Ramírez-Márquez, C. (2024). Optimization Using the Software MATLAB. In *Optimization of Chemical Processes: A Sustainable Perspective* (pp. 439-463). Cham: Springer Nature Switzerland.

Sarfo,J. O., García-Santillán, A., Adusei, A., Violetta S. M., Marina, D., Olena, S., Donyeh, P. S., Somayeh, Z., Reza, N., Violeta, E., Sadia, M., Farzana, A., Najma, I. M., Edward, W. A., Hattaphan, W., Egara, F. O., Arun, T., Josephine, C., Uzma, A., Mohammed, S. H., Mai, H., & Zahir, V. (2022). Psychometric properties of anxiety towards mathematics scale using samples from four continents. European Journal of Contemporary Education 11(2), 504-514. https://doi.org/10.13187 /ejced.2022.2.504

Williams, C., Charles-Ogan, G., & Adesope, R. Y. (2017). The GeoGebra interactive software and senior secondary school three (SSS3) students' interest and achievement in mathematics. *International Journal of Mathematics and Statistics Studies*, *5*(1), 1-8.