# EFFECT OF MAYER'S PROBLEM SOLVING STRATEGY ON SENIOR SECONDARY STUDENTS' RETENTION IN GEOMETRY

**[1] DASO PETER OJIMBA,**
**[2] ZALMON IBAAN GOGO**
**[3] OTIKOR MARK ANDERSON**

[1&2] DEPARTMENT OF MATHEMATICS/STATISTICS, FACULTY OF NATURAL AND APPLIED SCIENCES, IGNATIUS AJURU UNIVERSITY OF EDUCATION, RUMUOLUMENI, PORT HARCOURT, NIGERIA

[3] POST GRADUATE SCHOOL, IGNATIUS AJURU UNIVERSITY OF EDUCATION, RUMUOLUMENI, PORT HARCOURT, NIGERIA

## Abstract

*This study determined the effect of Mayer's problem solving strategy on senior secondary students' retention in geometry. The pretest-posttest-post-posttest quasi-experimental non-randomized control group research design was used. Purposive sampling technique was used to select a sample of 95 students from two intact classes used for the study. Geometry Retention Test (GRT) was the instrument used for data collection. Kuder-Richardson (K-R 21) method was used to obtain the reliabilities of GRT as 0.88. The experimental group was taught using Mayer's Problem Solving Strategy (MPSS) while the control group was taught using Deductive Learning Strategy (DLS). Mean and standard deviation were used to answer the two research questions while Analysis of Covariance (ANCOVA) was used to test the two null hypotheses formulated. Findings of the study indicated that there was significant difference between the retention levels of students taught geometry using MPPS and those taught with DLS in favour of the MPSS group. Mayer's problem solving strategy was found to bridge gender gap in the retention of students in geometry. The study recommended that Mayer's problem solving strategy be utilized for Mathematics instruction by teachers to enhance students' retention and promote gender equity.*

***Keywords:*** *Effect, Mayer, problem solving, strategy, retention, geometry*

---

**Introduction**

Mathematical knowledge is an indispensable tool for the scientific, economic and technological development of any nation. In recognition of this vital position of Mathematics in national development, the Federal Republic of Nigeria made Mathematics a compulsory cross-cutting subject in senior secondary education (Federal Republic of Nigeria, 2014). Unfortunately, Mathematics teaching and learning at the senior secondary education level has not been effective due to the utilization of passive, teachers-centred and conventional instructional strategies in lesson delivery. The performance of students in Mathematics in annually conducted external examinations in Nigeria has not been encouraging.

Mathematics performance is a measure of learner's cognitive development in Mathematics after instruction (Zalmon, 2021). Literature is replete with reports of abysmal performance of students in Mathematics resulting from ineffective instructional deliveries (Charles-Ogan, 2014; Olaleye and Olosunde, 2012; Zalmon & Wonu, 2017). Ezeugo and Agwagah (2000) as cited in Galadima and Okogbenin (2012), reported that despite the importance and usefulness of Mathematics in Nigeria's educational system, development of the individual and the nation at large through study of science and technology, the student's performance in Mathematics both in internal and external Examinations has continued to deteriorate year by year. This poor performance of students in Mathematics is directly related to their perception of difficulty in certain content areas and of the curriculum. According to Umoinyang and Ekwueme (2005), both male and female students have equal preference for

algebraic processes, statistics and probability without any preference for plane geometry and mensuration. Zalmon, Efet and Ogunsola (2019) revealed that students perceived 33% of the senior secondary education Mathematics curriculum content difficult to learn, with content difficulty perceived in geometry and introductory calculus. This poor performance and perceived learning difficulty of students in Mathematics and particularly geometry can be averted and the improvement sustained with conscious utilization of students-centred and active learning strategy such as Mayer's problem solving strategy.

Mathematics problem solving has long been seen as an important aspect of Mathematics, the teaching of Mathematics and the learning of Mathematics (Liljedahl, Santos-Trigo, Malaspina & Bruder, 2016). According to Liljedahl, *et al.* (2016), mathematical problem solving has infused Mathematics curricula around the world with calls for the teaching of problem solving. Problem solving is a dominant activity in Mathematics and the ability to solve problems is the goal in Mathematics learning (Odogwu, 2015). A problem is an obstacle, an impediment, a difficulty, a challenge or any situation that invites resolution and the resolution of a problem is the problem solving (Polya, 1963 as cited in Odogwu, 2015). Mayer and Wittrock (2006) as cited in Odogwu (2015) defined problem solving as a cognitive process directed at achieving a goal when no solution is obvious to the problem solver.

Meanwhile, problem solving strategies are teaching and learning strategies which comprises of identifying and choosing Mathematical problems which grow out of the experiences of individual students, placing these problems before the students and guiding them in their solutions (Obodo, 2004). According to Zalmon (2021), the problem solving strategy involves the process of problem identification, analysis and solution. The general stages of problem solving are problem identification, planning, implementation and evaluation which requires the problem solver to identify the problem first, then devise a solution plan, implement the plan and finally evaluate or check the results in the original problem; interpreting the solution in terms of the original problem. Zalmon (2021) identified the following types of problem solving strategies: Polya (1957), Schoenfeld (1985), Dewey (1933), Mayer (1992), Krulick and Rudnick (1989), Cindy (1999) (as cited in Zalmon, 2021), Mason, Burton and Stacey (1982), Perkins (2000), Özalkan (2010), Kolawole (2013), Ekwueme (2013), Bransford and Stein (1984), and Zalmon (2021). However, this study is interested in investigating the effects of Mayer's problem solving strategy on senior secondary students' retention in geometry. The independent variables of the study are Mayer's problem solving strategy and the conventional deductive learning strategy. The dependent variable of this study is retention of students while gender is the moderating variable.

Mayer (1992) as cited in Hsiao, *et al.* (2018) designed four problem solving steps which include: problem translation, problem integration, solution planning and monitoring and solution execution. In problem translation, students extract geometric concepts from the textual description of the problem using linguistic and semantic knowledge. Problem integration: students need to integrate the problems concept with an illustration from the information provided by the problem. At the stage of solution planning and monitoring, students develop a plan to solve the problem and monitor the solution according to their understanding of the problem. The final step is solution execution; students finally execute the solution to get the answer (Hsiao, *et al*., 2018). Deductive learning strategy refers to the method of learning from general to particular (Zalmon, 2021). Deductive learning is opposed to inductive learning in which a general law is derived from the study of particular objects or specific processes. In deductive method or strategy, the students are told the formula to solve a problem, then a few examples are solved by the teacher for the students, then, the students apply the formula to solve some problems and commit it to memory for future use (Odogwu, 2015).

Retention is the act of absorbing, holding, or continuing to hold or have facts or things learned (Nneji, 2013). Retention is a measure of performance with respect to time (Zalmon, 2021). While performance is the measure of the extent to which instructional objectives are achieved by the learners after instruction, retention is the ability to remember what has been taught after some time intervals (Zalmon, 2021). The choice of the Mayer's problem solving strategy for this study is premised on few research studies investigating the effectiveness of the strategy on the retention of students in geometry. Mayer's problem solving steps are also few.

**Statement of the Problem**

Students perceived geometry content difficult to learn which has contributed to their poor performance in Mathematics in both internal and external examinations. Students avoid or haphazardly attempts geometry questions due to its high difficulty level. This high difficulty level of geometrical concepts as perceived by students could be attributed to the use of ineffective instructional practices and strategies. Ineffective instructional strategies are conventional instructional strategies that do not promote learning and retention. Therefore, this study shall investigate the effectiveness of Mayer's problem solving strategy in improving the retention abilities of senior secondary students in geometry.

**Aim and Objectives of the Study**

The aim of the study is to determine the effect of Mayer's problem solving strategy on the senior secondary students' retention in geometry in Obio-Akpor local government area of Rivers State. Objectives of the study are to:

1. investigate the difference in the retention level of students taught geometry using Mayer's problem solving strategy and those taught with deductive learning strategy.
2. find out the difference in the retention level of the male and the female students taught with Mayer's problem solving strategy.

**Research Questions**

The study answered the following questions:

1. What is the difference in the retention level of students taught geometry using Mayer's problem solving strategy and those taught with deductive learning strategy?
2. What is the difference in the retention level of the male and the female students taught geometry with Mayer's problem solving strategy?

**Hypotheses**

The following hypotheses were tested at 0.05 level of significance to guide the study:

1. There is no significant difference in the retention level of students taught geometry using Mayer's problem solving strategy and those taught with deductive learning strategy.
2. There is no significant difference in the retention level of the male and the female students taught geometry with Mayer's problem solving strategy.

**Methodology**

**Research Design**

The study adopted the quasi-experimental non-randomized control group research design of the pretest, posttest and post-posttest type. The design is illustrated below:

E: $O_1$ $X_1$ $O_2$ $O_3$
C: $O_4$ $X_0$ $O_5$ $O_6$

Where:

E = Experimental group
C = Control group
$O_1$ = Pretest for E
$O_2$ = Posttest for E
$O_3$ = Post-posttest for E
$O_4$ = Pretest for C
$O_5$ = Posttest for C
$O_6$ = Post-posttest for C
$X_1$ = Treatment (Mayer's problem solving strategy)
$X_0$ = Control (Deductive learning strategy).

**Study Area**

The study was carried out in Obio-Akpor local government area of Rivers State.

**Population of the Study**

The population of the study consisted of 36,232 (male, 15,363; female, 20,869) senior secondary students from the 21 public senior secondary schools in Obio-Akpor local government area of Rivers State (Rivers State Senior Secondary Schools Board, 2021).

**Sample and Sampling Techniques**

A sample of 95 Senior Secondary Class three (SSC3) students was used for the study. Two out of the twenty-one schools in Obio-Akpor local government area were randomly assigned to treatment and control groups. Purposive sampling technique was then used to select the sample of 95 students from two intact classes used for the study. The experimental group was taught geometry using Mayer's problem solving strategy while students in the control group were taught geometry using deductive learning strategy.

**Instrument for Data Collection**

Geometry Retention Test (GRT) was used for data collection. GRT consisted of 20 multiple-choice objective test items each with a total score of 100 and four options labeled A to D. Each correct option earned 5 marks

with zero (0) for any wrong option. GRT was administered to students as pretest (before treatment), posttest (after treatment) and post-posttest (two weeks after treatment). The data obtained were used for analyses.

**Validity of the Instrument**
Three experts in Mathematics Education teacher validated the instrument. The experts established the face and content validities of the instruments.

**Reliability of the Instruments**
Kuder-Richardson (K-R 21) method was used to obtain the reliability of GRT as 0.88.

**Method of Data Collection**
After obtaining due permission to conduct the research in the two schools, the instruments were administered as pretest (before treatment) posttest (after treatment) and post-posttest (two weeks after treatment). The data obtained were analyzed using appropriate statistics.

**Methods of Data Analysis**
Mean and standard deviation were used to answer the two research questions while Analysis of Covariance (ANCOVA) was used to test the two null hypotheses at 0.05 level of significance. ANCOVA was considered appropriate in testing the hypotheses because it takes care of the initial retention difference in the subjects of the study due to non-randomization of sample selected.

**Results**

**Research question one:** What is the difference in the retention level of students taught geometry using Mayer's problem solving strategy and those taught with deductive learning strategy?

**Table 1: Mean and standard deviation on the retention level of students taught geometry using Mayer's Problem Solving Strategy (MPSS) and those taught with Deductive Learning Strategy (DLS)**

| | | Posttest | | Post-Posttest | | Retention | | Difference | |
|---|---|---|---|---|---|---|---|---|---|
| **Strategy** | **n** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| **MPSS** | 38 | 54.26 | 11.82 | 56.16 | 13.78 | 1.90 | 1.96 | 12.64 | 12.27 |
| **DLS** | 57 | 47.04 | 3.31 | 36.30 | 17.54 | -10.74 | 14.23 | | |

Table 1 showed that the difference in the retention level of students taught geometry using Mayer's problem solving strategy and those taught with deductive learning strategy is 12.64, SD=12.27 in favour of the group taught with Mayer's problem solving strategy.

**Research question two:** What is the difference in the retention level of the male and the female students taught geometry with Mayer's problem solving strategy?

**Table 2: Mean and standard deviation on the retention level of the male and the female students taught geometry using Mayer's problem solving strategy**

| | | Posttest | | Post-Posttest | | Retention | | Difference | |
|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **n** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| **Male** | 15 | 58.00 | 10.34 | 57.20 | 13.56 | -0.80 | 3.12 | 4.45 | 1.24 |
| **Female** | 23 | 51.83 | 12.30 | 55.48 | 14.18 | 3.65 | 1.88 | | |

Table 2 showed that the difference in the retention level of the male and the female students taught geometry with Mayer's problem solving strategy is 4.45, SD=1.24 in favour of the female students.

**$H_{01}$:** There is no significant difference in the retention level of students taught geometry using Mayer's problem solving strategy and those taught with deductive learning strategy.

**Table 3: Summary of ANCOVA on the difference between the retention level of students taught geometry using Mayer's problem solving strategy and those taught with deductive learning strategy**

Dependent Variable: Retention

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 9376.89[a] | 2 | 4688.44 | 18.08 | 0.00 |
| Intercept | 2419.34 | 1 | 2419.34 | 9.33 | 0.00 |
| Group | 6122.27 | 1 | 6122.27 | 23.60 | 0.00 |
| Posttest | 384.44 | 1 | 384.44 | 1.48 | 0.23 |
| Error | 23862.54 | 92 | 259.38 | | |
| Total | 219189.00 | 95 | | | |
| Corrected Total | 33239.43 | 94 | | | |

a. R Squared = .282 (Adjusted R Squared = .266)

Table 3 showed that there is a significant difference in the retention level of students taught geometry using Mayer's problem solving strategy and those taught with deductive learning strategy ($F\ 1, 92 = 23.60$, $p<.05$). The null hypothesis one was rejected at 0.05 alpha level and the alternate hypothesis accepted.

**$H_{02}$:** There is no significant difference in the retention level of the male and the female students taught geometry with Mayer's problem solving strategy.

**Table 4: Summary of ANCOVA on the difference between the retention level of the male and the female students taught geometry with Mayer's problem solving strategy**

**Dependent Variable: Retention**

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 105.05[a] | 2 | 52.53 | 0.27 | 0.77 |
| Intercept | 3731.17 | 1 | 3731.17 | 18.87 | 0.00 |
| Gender | 7.42 | 1 | 7.42 | 0.04 | 0.85 |
| Posttest | 78.14 | 1 | 78.14 | 0.40 | 0.53 |
| Error | 6922.00 | 35 | 197.77 | | |
| Total | 126868.00 | 38 | | | |
| Corrected Total | 7027.05 | 37 | | | |

a. R Squared = .015 (Adjusted R Squared = -.041)

Table 4 showed that there is no significant difference in the retention level of the male and the female students taught geometry with Mayer's problem solving strategy ($F\ 1, 35 = 0.04$, $p>.05$). The null hypothesis two was accepted at 0.05 alpha level and the alternate hypothesis rejected.

**Discussion of Findings**

**Examining the difference between the retention levels of students taught calculus using experiential learning strategy and problem solving strategy**

Table 1 showed that the students taught geometry using Mayer's problem solving strategy had higher retention than those taught with deductive learning strategy. Table 3 showed that there is a significant difference between the retention level of students taught geometry using Mayer's problem solving strategy and those taught with deductive learning strategy. Similar result was obtained by Zalmon and Charles-Ogan (2021), who revealed that there was significant difference in the retention mean scores of students taught calculus using Polya's problem solving strategy and those taught with deductive learning strategy in favour of the Polya's problem solving strategy group. Nneji (2013) also revealed that students taught algebra with problem solving strategy significantly achieved higher and retained more than those taught with expository method.

**Ascertaining the difference between the retention levels of the male and the female students taught calculus using experiential learning strategy**

Table 2 showed that the difference in the retention level of the male and the female students taught geometry with Mayer's problem solving strategy is small but in favour of the female students. Table 4 showed that there is

no significant difference in the retention level of the male and the female students taught geometry with Mayer's problem solving strategy. Zalmon and Charles-Ogan (2021) also found out that there is no significant difference between the retention mean scores of the female and the male students taught calculus using of Polya's problem solving strategy. Alake (2015) posited that the problem solving strategy enhances both the male and the female students' retention in Mathematics.

**Conclusion**

This study determined the effect of Mayer's problem solving strategy on senior secondary school students' retention in geometry and found out that students taught geometry with Mayer's problem solving strategy significantly retained more than their colleagues in the group taught with deductive learning strategy. Mayer's problem solving strategy was found to bridge gender gap in students Mathematics retention level.

**Recommendations**

The study recommended that:

1. Teachers should teach geometry with Mayer's problem solving strategy to improve the retention levels of students.
2. Teachers should adopt Mayer's problem solving strategy to promote gender equity in geometry retention levels of the students.

**References**


Alake, E. (2015). *Efficacy of laboratory instructional strategy on students' geometry performance retention and attitude among junior secondary schools, of Kaduna State, Nigeria.* Unpublished MEd Dissertation, Ahmadu Bello University, Zaria. http://Kubanni.abu.ng/jspui/bitstream/123456789/7722/I/EFFICAC

Bransford, J. & Stein, B (1984). *The ideal problem solver: A guide for improving thinking, learning and creativity.* W.H.

Charles-Ogan, G. (2014). Metacognitive strategy and senior secondary school Mathematics students' misconceptions in Rivers State Nigeria. *Abacus: The Journal of the Mathematical Association of Nigeria,* 39(1), 234-246.

Dewey, J. (1933). *How we think.* D.C. Heath and Company.

Ekwueme, C. O. (2013). *Mathematics teaching and learning in schools.* Radiant Ventures Nig. Ltd.

Ezeuogo, U. C. & Agwagah, U. N. V. (2000). Effect of concept mapping on students' achievement in algebra: Implication for secondary Mathematics education in 21st century. *Abacus: The Journal of the Mathematical Association of Nigeria, 25(1),* 10-17.

Federal Republic of Nigeria (2014). *National policy on education,* (6th ed.). NERDC Press.

Galadima, I. & Okogbenin, A. A. (2012). The effect of mathematical games on academic performance and attitude of senior secondary students towards Mathematics in selected schools in Sokoto State. *Abacus: The Journal of the Mathematical Association of Nigeria, 37(1),* 30-37.

Hsiao, H., Lin, C., Chen, J., & Peng, Y. (2018). The influence of a Mathematics problem – solving training system on first – year middle school students. *EURASIA Journal of Mathematics, Science and Technology, Education, 14(1),* 77 – 98.

Kolawole, E.B. (2013). Kolawole's problem-solving method (KPS): A panacea to mathematical and life's problems. *Standard Journal of Education and Essay, 1(8),* 13-14. http://www.standardresearchjournals.org/journals/SJERE/pdf/2013/December/ Kolawole.pdf

Krulick, S. & Rudnick, J. A. (1989). *Problem solving: A handbook for senior high school teachers.* Allyn and Bacon.

Liljedahl, P., Santos–Trigo, M., Malaspina, U., & Bruder, R. (2016). *Problem solving in Mathematics Education*. Springer. Com/content/pdf/ 10.1008% 2F97 8 -3-319-40730-2pdf

Mason, J., Burton, L., & Stacey, K. (1982). *Thinking mathematically.* Pearson Prentice Hall.

Mayer, R. E. & Wittrock, (ni) (2006). Cognition and cognitive process in problem solving. *Journal of the American psychological Association, 7(1),*124-135.

Mayer, R. E. (1992). *Thinking, problem solving, cognition.* WH Freeman/Times Books/Henry: Holt & Co.

Nneji, S. O. (2013). Effect of Polya George's problem solving strategy on students' achievement and retention in algebra. *Journal of Educational and Social Research, 3(6),* 41-48.

Obodo, G. C. (2004). *Principles and practice of Mathematics Education in Nigeria.* Academic Forum.

Odogwu, H. N. (2015). *A comprehensive guide for teaching Mathematics in secondary school*. Sibon Books Limited.

Olaleye, O. O. & Olosunde, G. R. (2012). A path analysis of some psycho-social variables as determinates of achievement of female students in senior secondary school Mathematics. *Abacus: The Journal of the Mathematical Association of Nigeria, 37(1),* 19-29.

Özalkan, B. E. (2010). *The effects of problem solving on the topic of functions on problem solving performance, attitude toward problem solving and Mathematics.* Unpublished Thesis, Middle East Technical University. http://www.citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.633.6482&rep=rep1&type=pdf

Perkins, D. (2000). *Archimedes bathtub: The art of breakthrough thinking.* W. W. Norton and Company.

Polya, G. (1957). *How to solve it: A new aspect of mathematical method (2nd ed.)*. Doubleday Anchor Books.

Schoenfeld, A. H. (1985). *Mathematical problem solving.* Academic Press Inc. http://www. Pdfrive.com/mathematical-problem-solving-a34337130.html

Umoinyang, I. E. & Ekwueme, C. O. (2005). Gender differences in Mathematics learning factors among secondary schools students in Calabar, Cross River State in U. Nzewi (Ed). *Science Technology and Mathematics (STM) Education and professionalism (224-228), proceedings of the 46th Annual Conference of the Science Teachers Association of Nigeria: Heiman.*

Zalmon, I. G. & Charles-Ogan, G. I. (2021). Polya's problem solving strategy and students' retention in calculus. *Journal of Education and Training Technology, 10(1),* 123-139.

Zalmon, I. G. & Wonu, N. (2017). Comparative analysis of student Mathematics achievement in West African senior secondary certificate examination in Nigeria. *European Journal of Research and Reflection in Educational Sciences, 5(1),* 24-31.

Zalmon, I. G. (2021). *Effects of Polya's and Schoenfeld's problem solving strategy on secondary students' performance and retention in Mathematics in Obio- Akpor, Rivers State.* Unpublished Ph.D Thesis, University of Port Harcourt.

Zalmon, I. G., Efet, D. E. & Ogunsola, A. O. (2017). Diagnosis and remediation of student content difficulty in the senior secondary education Mathematics curriculum. *International Journal of Science, Technology, Engineering, Mathematics and Science Education, 2(1),* 90-109.