# EFFECT OF POLYA'S PROBLEM SOLVING TECHNIQUE ON THE ACADEMIC ACHIEVEMENT OF SENIOR SECONDARY SCHOOL STUDENT IN PHYSICS

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**Abstract**

This study examined effects of the Polya's problem solving Technique (POPSOT) as observed by Shaibu (1987) in Atadoga (2010) and conventional problem-solving Technique (CONPSOT) on cognitive achievement of physics students. A pre -test post – test quasi experimental design used adopted for the study. The sample comprised of 102 senior secondary two (ss11) physics students drawn from the 6(six) public owned secondary schools in Aguata Education zone, Anambra State, Nigeria. Two research questions and one hypothesis guided the study. The instruments consisted of pre-test (PREPHY) and Post-test (POSTPHY) questionnaire comprising of 20 test items constructed by the searcher. There are two groups of Physics students. One group (experimental group) was taught using Polya's problem solving Technique (POPSOT) while the other group (the control group) was taught using conventional problem-solving technique (CONPSOT) . The instrument was validated, and reliability tested using pears product moment correlation technique. The internal consistency was found to be 0.87. The research questions were answered using mean and standard deviation while the hypothesis was tested using t-test statistics. The t-test used for analysis was because pre-test adopted in this study established homogeneity. The result showed that student taught with Polya's problem solving technique as in Atadoga (2010) performed better than those taught with conventional problem-solving technique. Based in the findings, the researcher recommended that physics students should be taught with Polya's problem solving technique rather than conventional problem-solving technique to enhance their learning of physics.

**Keywords**: Polya's problem; solving technique; academic achievement.

## INTRODUCTION

The development of any nation requires that her citizens should be adequately empowered to be able to contribute their quota meaningfully and appropriately as responsible productive citizens. (Nwankwo and Okafor, 2015). According to them, this empowerment is mostly achieved through creative and relevant science (especially physics) education leading to critical thinking problem solving and being ICT literate.

Physics is one of the science subjects taught at the senior secondary school (SSS) level in Nigeria secondary schools. Nigeria as a developing nation requires physics as regards to technological and scientific development to meet up other developed nation.

Physics is an aspect of science which offers explanation to natural phenomena, existing nature of science and technology (Atadoga, 2010) .

Physics in Henery (2000) as cited by Nwankwo and Okafor (2015) is the national development of experiments , observations and theories to explain the fundamental structure of all we perceive which is crucial for effective living in this jet age of science and technology. Being fundamentally the study of various forms of energy interactions and inter-conversions with matter, Physics is the study of nature of our environment and how different energies of nature can be produced, conserved and changed to another form (Atadoga, 2015).

Atadoga (2015) observed that teaching of physics in secondary school includes the followings:

a. *Learning of the fundamental facts and principles of science*
b. *Development of abilities and skills needed to engage in the processes of science*
c. *Inculcation of positive attitudes about and appreciation of science and consequence of science*

Also, Adenowo (1998) lectured that teaching of physics aimed to achieve the followings:

*(i) Training for careers in science*
*(ii) Training of technical manpower such as research scientists applied scientists and engineers.*

In spite of the important position Physics as a subject occupies in science and technology , few students offer it at senior secondary Examination (SSCE) compared with Biology and chemistry. Even the that opt for its record low achievement at both West African Examination Council (WAEC) and National Examination Council (NECO). (Thornton, 1995, Otuka, 2006 and Atadoga, 2010).

A number of researches (Ogoamaka, 1986; Ali, 1989; Shaibu & Bichi, 2004) emphasized the importance of Problem-Solving Strategies in the teaching-learning process of science. They also observed that teachers' incompetence's in the curriculum is a contributing factor to students' poor performances in science subjects. Students' poor performances in science subjects are attributed to teachers' non-utilization of the necessary techniques in teaching-learning processes (Ali, 1989; Alio and Harbor-Peter 2002).

Many studies, such as Adigun (2016) and Achimugu (2016), were carried out on teaching strategies by the teachers of science subjects, their studies were more on methods of teaching sciences such as inquiry method, demonstration method, lecture method, etc.; but there were no known much research works on Polya's students' problem-solving strategies in selected physics topics such as light, magnetism and atomic physics. Even where studies on problem-solving strategies were carried out, none was on Polya's problem-solving strategy as modified by Shaiba (1987) cited by Atadoga (2009). To the best of the researcher's knowledge, there were no research work on Polya's problem solving strategy as modified by Shaiba (1987) cited by Atadoga (2009) on Senior Secondary Physics in Aguata Local Government Area Anambra state. Atadoga (2009) opined that one might see conventional strategies of problem-solving among

students. He also observed that one of the problems associated with the conventional strategies of problem-solving is that it could not address the issue of poor performance of secondary students' at senior secondary certificate examination(SSCE).

In 1945, George Poly's published a book on 'how to solve' (Polya 1957). He was known as the father of modern problem solving. In his book, he identified four basic principles of problem solving (*https://math.Berkeley.edu-gme/vin/polya.pdf*) which includes:

*Polya's First Principle*: Understand the problem. This seems so obvious that it is often not mentioned, yet physics students are often stymied in their efforts to solve problems simply because they do not understand it fully, or even in part. Polya taught teachers to ask students questions such as:

- *Do you understand all the words used in stating the problem?*
- *What are you asked to find or show?*
- *Can you restate the problem in your own words?*
- *Can you think of a picture or diagram that might help you understand the problem?*
- *Is there enough information to enable you find a solution?*

*Polya's Second Principle*: Devise a plan (translate). This help one come up with a way to solve physics problem. The skill of choosing an appropriate strategy is best learned by solving many physics problems. Setting up an equation in physics, drawing a diagram, using a physics problems, eliminate possibilities, solving a simpler physics problem, using direct reasoning and being ingenious are all ways that you can go about solving problem.

*Polya's Third Principle*: Carry out the plan (Solve). This step is usually easier than devising the plan. In general, all you need is care and patience, given that you have the necessary skills. Persist with the plan that you have chosen. If it continues not to work discard it and choose another. Do not be misled, this is how physics is done , even by professionals.

*Polya's Fourth Principle*: Look back (check and interpret). One may be familiar with the expression 'do not look back'. Polya mentions that much can be gained by taking the time to reflect and look back at what you have done, what worked and what did not work. Doing this will enable you to predict what strategy to be used to solve future problems.

The problem of this study therefore is the effect of Polya's problem-solving model as cited by Atadoga (2010) and Shaibu (1987) on students' Achievement in Physics in Senior Secondary Schools in Aguata Local Government Area.

*Purpose of the Study*

The purpose of the study was to compare the Polya's problem-solving Technique (POPSOT) as cited by Atadoga (2010) in Shaibu (1987) and the conventional problem-solving Technique (CONPOT) in other to find out which techniques is more effective in teaching problem-solving in Physics. Therefore, the study is intended to find out if there is any difference in the Physics achievement of senior SSII Physics students taught using POPSOT and those taught using CONPSOT.

*Research Questions*

1. How has Polya's problem solving techniques affected students' achievement in Physics in Senior Secondary Schools?
2. To what extent has Polya's problem solving techniques affect male and female students' achievement in secondary school physics?

*Hypothesis*

There is no significant difference in the cognitive achievement of SSS Physics students' exposed to Polya's problem solving technique.

## METHODS

This research is designed to study the analysis of possible effects on the students. The pretext post-test quasi experimental design was used. The test items used as pre-test and post-test were constructed by the researchers. There were 20 test items on topics which were related to the area of study taught by their Physics teachers'. One group of the students was taught adopting Polya's problem-solving Techniques. This group is called the experimental group. The second group is the control group. This is the group, taught problem-solving using conventional problem-solving Techniques.

Polya's problem solving Techniques (POPSOT) proposed four phases (Atadogo, 2010):

1. *Understanding a problem*
2. *Devising a plan*
3. *Carrying out a plan*
4. *Looking back*

In this study, phases 1-3 are adopted. According to Atadoga (2010), the phases are predictive statements of an expert solving problems. These are as follows:

- *Getting acquainted with the problem*
- *Disembodying the key information from the statement.*
- *Forming a global overview of the problem*

1. *Understanding the Problem* means becoming familiar with the problem, being able to interpret the problem in one's own words, etc.
2. *Devising a Plan*: This phase talks about the followings:
   - Breaking the problem statement into smaller, relevant subunits memory.
   - Selection and refinement of key information.
3. *Carrying out a Plan*: This phase consists of the followings:

- Functional awareness of information recalled and obtained from the problem statement.
- Organizing and applying information to reach a solution.

In this paper, the conventional solving techniques and strategies to problem solving (CONPSOT) are the current techniques adopted in the teaching of Physics subject in schools. They are the strategies of teaching problem solving at senior secondary school level. These strategies include lecture, laboratory/practical method, demonstration method and discussion method. The CONPSOT does not lay much emphasis on steps taken to arrive at solution to problems as does POPSOT.

The target population for the study comprised of 250 savior secondary sectors II (SSII) Physics students in Aguata Education zone. The choice of SSII physics student was for the fact that they were chosen to do the subject in external examinations (such as WAEC and NECO) they have also covered most of the physics topics in their curriculum. A sample size of 102 SSII physics students was drawn from six secondary schools through simple random procedure and intact classes were used.

There are two groups (experimental and control groups) which were not located in the area to avoid interference between the two groups. The three schools used as experimental groups were located in Aguata North of Aguata Education zone while the other three school were located in Aguata south of the same zone. The distance between the two groups for the study is about 11km apart. The researcher for the purpose of this study trained two physics teachers. They were trained to assist in the conduct of the study with the researcher as the trainer. The teachers were graduate physics teachers who had 10 years teaching experience. The training lasted for 3 contact hours per day. The training covered POPSOT and CONPSOT, the use of lesson plans that are based in two techniques and general conduct of the study.

One of the Physics teachers taught the experimental group with the prepared notes on Polya's problem solving techniques while the other one taught the control groups with notes on the conventional problem-solving technique. Both the experimental and control groups' notes were proposed by the researcher. During the trial testing of the notes, the researcher was present to make corrections and ensure effective mastering of the techniques. The teachings were done at the same day. The teaching lasted for two months. Even during the pilot study, the researcher was present to supervise the teachings. Both experimental and control groups were taught the same content and using the same contact hours.

The pre-test (PREPHY) was administered before commencement of teaching and the prost-test (POSTPHY) was administered immediately after two weeks teaching period. Both PREPHY and POSTPHY were the same in contents except that the items were reshuffled after use.

The test items and the marking scheme were validated by five. Physics educators from Nnamdi Azikiwe University and Chukwuemeka Odumagwu Ojukwu University who here above 10 years teaching experiences. There were 20 multiple choice test items of four options in mechanics, wares and electricity areas of Physics at SSS level. Out of these four options, one option was correct while the remaining three served as distractors. The scoring is based on 100 percent (i.e. 5 marks for each items). This was done by the teachers who did the teaching with the researcher. By the use of Pearson's correlation method ( r) the test-retest stability co-efficient of the instrument was computed and found to be 0.89.

*Data Analysis*

The data generated from the respondents were analyzed by testing the hypothesis using t-test statistics. The t- test statistics is used because the two groups are drawn from the same sample. Hence, it is the comparison of mean of two samples from the same population. Also, the t- test statistics is used, because the study is to establish a cause and effect relationship in view to determining the superiority of one mean over other (i.e. POPSOT and CONPSOT). The pretest scores of POPSOT and CONSOT groups were first tested for significant difference (Table 1). This gave the grounds to assume that the two groups were homogeneous as there was no statically difference between their means (see Table I). However, the research questions were answered using means and standard. Immediately after two weeks teaching period. Both PREPHY and POSTPHY were the same in contents except that the items were reshuffled afterwards.

*Validation of the instruments*

The test items and the marking scheme wear validated by five physics conductors who here above 10 years teaching experiences. There were 20 multiple choice test items of four options in mechanics, waves and electricity areas of physics of SSS level. Out of these four options only one option was correct while the remaining three served as distracters. The summing is based on 100 percept (i.e. 5 marks for each item.) This was done by the teachers who did the teaching with the researcher. By the test use of Pearson's correlation method ® , the test retest stability coefficient of the instrument was computed and found to be 0.89. The data generated from the respondent were analyzed by testing the hypothesis using t-test statistics. The t-test statistics is used because the two groups are drawn from the same sample. Hence, it is the comparison of mean of two samples from the same population. Also, the t-test is used because the study is to establish a cause and effect relationship in view to determining the superiority of one mean over other (i.e. POPSOT and CONPSOT)

The pretest scores of POPSOT and CONPSOT groups were tested for significant difference (Table 1). They gave the grounds to assume that the two groups were homogeneous as there was no statistical difference between their means (see table 1). However, the research questions were answered using mean and standard variation.

## RESULTS

*Research Question 1*

How has Polya's problem solving techniques affected students' achievement in Physics in Senior Secondary Schools.

***Table 1***. *Comparison of mean scores of Physics Students' achievement on POSOT and CONPSOT Group*

| Source of variable | N | $XT_1$ | $XT_2$ | GX | REMARK |
|---|---|---|---|---|---|
| POPSOT | 102 | 48.95 | 61.21 | 12.36 | More effective |
| CONPSOT | 102 | 50.33 | 50.90 | 0.57 | |

From table 1, it can be seen that the mean score of students on the POPSOT group is 61.21 and the Gem mean score is 12.36. Also, the mean score of CONPSOT group is 50.90 and the Gem mean score is 0.57. Since the mean score of the physics students on the Polya's Problem Solving Technique (POPSOT) is greater than the mean score of convention problem solving Technique (CONPSOT), this signifies an increase in the average performance of the students on the POPSOT. Hence, the Polya's problem solving techniques is more effective than the conventional teaching techniques.

*Research Question 2*

To what extent has Polya's problem solving technique affected male and female student's achievement in Secondary School Physics?

***Table 2***. *Comparison of mean scores of male and female Physics students using Polya's solving technique*

| **Source of variable** | **N** | **X** | **S.D** |
|---|---|---|---|
| Male | 49 | 54.63 | 20.55 |
| Female | 53 | 56.90 | 17.58 |

From Table 2, it can be observed that the average score of the male students taught using Polya's problem solving technique is 54.63 and the average score of the female students taught using Polya's problem solving technique is 56.90 since the difference between the effects of the Polya's problem solving techniques on the male Physics students and female Physics students is not far apart, it can be concluded that the effects of the Polya's problem solving technique on the male student and female Physics students are equal.

*Hypothesis*

There is no significant difference in the cognitive achievement of SSS students exposed to Polya's problem solving technique as modified by Shaubu (1987) as in Atadoga (2010) .

***Table 3***. *T-tests for equality of means on Pre-Achievement scores of the experimental (Popsot) and control (Consot) groups*

| Group | **N** | **X** | **SD** | **t-stat** | **t-crit** | **P-value** | **REMARK** |
|---|---|---|---|---|---|---|---|
| POPSOT | 102 | 48.95 | 17.68 | 1.0208 | 1.98.37 | 0.3098 | N.S* |
| CONPSOT | 102 | 51.33 | 15.33 | | | | |

*NS* = Not significant at P = 0.05*

From Table 3, the comparison of the two means scores to Polya's solving technique as mollified by Shaibu (1987) and as cited by Atadoga (2010) , and the convention problem solving technique groups gave t-value of 0.86 which is not significant at P= 0.05. Therefore, there is no significant difference in this pre-achievement mean scores of POPSOT and CONPSOT groups. The result enables the researcher to further proceed on the post-test as the treatment was given to the samples (i.e. the physics students). The analysis was done using arithmetic mean (X), standard deviate and t-test at P = 0.05 alpha level.

***Table 4***. *T-tests for equality of means on Post-Achievement scores of the experimental and control groups*

| Group | **N** | **X** | **SD** | **t-stat** | **t-crit** | **P-value** | **REMARK** |
|---|---|---|---|---|---|---|---|
| POPSOT | 102 | 61.2 | 18.24 | 3.8820 | 1.9837 | 0.0002 | S* |
| CONPSOT | 102 | 50.90 | 18.60 | | | | |

*S*= Significant at P = 0.05*

The results in Table 4 show t-value of 3.8820 and ap-value of 0.0002 which is less than the and -value of 0.05. There is a statistically significant difference in physics achievement of senior Secondary School Students (SSS) taught using POPSOT and those taught using CONPSOT

## DISCUSSION

The Polya's problem solving technique has impacted more positively to the students' performance in Physics (Table 1) than conventional method. The effect of Polya's problem solving technique on the male and female Physics are equal.

In the post-test, the t-value of 3.8820 is statically significant (Table 2). Also, by comparison, the mean score of Polya's problem solving techniques which is 61.21 show better performance of physics students than conventional problem-solving techniques which is 50.90 (Table 1).

Hence, the Polya's problem solving techniques has impacted more on the student than the conventional teaching techniques. These results agree with Burrow and Okey (1979) Alio and Harbor-peters (2000), Martins and Oyebanje (2000), Atadoga (2010) who found in their studies that learners exposed to well-structured learning activities perform better than those who were not exposed to well-structured learners activities.

The Polya's problem solving techniques (POPSOT) in Atadoga (2010) assists the problem solvers (e.g. students) to see the solutions to problem has been in phase or steps which is not explicit in the conventional techniques to problem solving (CONPSOT)

The POPSOT has some implications in the teaching and learning of physics which too many people who find the subject difficult to understand perceived it as abstract. For anyone to

have a good understanding of a concept or topic or anything, one needs to interact with it. The POPSOT affords learners and or problem solvers the opportunities of getting to the root(s) of a given problem or task. This is made possible because the first phase of POPSOT as in Atadogo (2010) explicitly leads problem solvers (e.g. students) into getting acquainted with the problem disembodying the key information from the statement and then forming a global overview of the program. When appropriate key information to a problem is obtained it is a positive step to solution(s) of problem(s). The first phase of POPSOT requires the use of more than one sense organ by the problem solvers (e.g. students) in their search of positive approved result in positive solutions problems.

Hence, the teaching and learning of Physics should appeal to more than one sense organs (eyes, ears, nose, tongue and skin) should involve in the teaching and learning of Physics. Hence, more emphasis should be placed on physics practical classes than theory classes. In other words, both practical and theory classes should be balanced.

POPSOT as in Atadoga (2010), implies that those approaches to solving problems in Physics through any devise should break the problem statement(s) into smaller relevant subunits memory. This when properly accomplished would assist the selecting and streaming key information which are lead-ways to carry out action plan to solving correctly given problems. Therefore, questions in Physics should always carry subsets (e.g. question 1a, b, c, &d)

Furthermore, the POPSOT as in Atadoga (2010) places Physics teachers as facilitators and guides to the Physics learners (students). In carrying out a plan as in POPSOT, the Physics teachers should guide Physics students to discover for themselves functional and relevant information that lead to expected solution. Therefore, the POPSOT as in Atadoga (2010) emphasizes more phase (or steps) to problem solution than solution itself. Hence, students should be taught logical steps to solving problems and orderly arrangement of works. When this techniques is well learned or taught, Physics learners (or students) would develop positive and logical arrangement of steps that enhances positive solutions to problems since they could distinguish between relevant information and irrelevant information in the problem statements, break the problem statement into smaller relevant subunits and finally, organize and apply the key-relevant information to reach solutions of given or identified problems, the Physics students exposed to POPSOT would perform better than their counterparts exposed to CONPSOT (Table 4). Students who are well groomed using POPSOT are likely to develop self-confidence, independent learning and problem-solving attitude.

## CONCLUSION

Based on the findings in this study, it can be concluded that Polya's problem solving technique as cited by Atadoga (2010) spells out steps of approaches to given physics problems, enhances better performance of students than the conventional physics problems solving technique. The result in this study points to the fact Polya's problem solving technique enhances better performance among students than conventional problem-solving technique. Physics students are well groomed using POPSOT are thereby developing in them self-confidence, independent learning and problem-solving attitude. The Physics students cease to perceive physics as being abstract in nature.

## RECOMMENDATIONS

On the basis of the findings, the following recommendations are put forward. As much as possible physics teachers should use Polya's problem solving technique to teach Physics. Physics students, Physics teachers and will-be Physics teachers should be taught and trained in line with Polya's problem solving technique. Physics teachers should show commitments to their teaching job by ensuring that they use Polya's problem solving technique in teaching in their schools.

Physics teachers should expose to seminars and workshops on Polya's problem solving technique as modified by Shaibu (1987) and cited by Atadoga (2010) by the ministry of Education, government and school authorities to learn the steps involved in teaching Physics students and also act as facilitators in the classroom. Physics teachers and students if properly trained on Polya's technique in solving Physics problem should be able to select and streamline key information which are lead-ways to carrying out action plan to solving correctly physics given problems. Therefore, questions in Physics should always carry subsets such as question one: 1a, b, c &d.

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