e-2795-3272
p-2795-3264





10.5281/zenodo.6849377 Vol. 05 Issue 01 Jan - 2022 Manuscript ID: #0514

# PROBLEM SOLVING INSTRUCTIONAL STRATEGY (PSIS) AND SENIOR SECONDARY SCHOOL STUDENTS' ACADEMIC ACHIEVEMENTS IN QUADRATIC EQUATION IN ENUGU STATE, NIGERIA

**Ezeanyi, Benson Chukwunonso *(Ph.D)***
*Department of Science Education.*
**Ezeanyi, Helen Chinwe**
*Depart. Early Childhood and Primary Education Faculty of Education Nnamdi Azikiwe University Awka, Anambra state, Nigeria.*

***Corresponding author:*** *Benson Chukwunonso Ezeanyi
***Email***: freedom4ben10@gmail.com

## ABSTRACT

*The study investigated the effects of Problem Solving Instructional Strategy (PSIS) on senior secondary school students' academic achievements in Mathematics. The design of the study was quasi experimental which adopted pre-test post-test non equivalent control group design. The sample consisted of 94 (48 males and 46 females) senior secondary one (SS1) students drawn through multi stage sampling technique. Three research questions and three hypotheses guided the study. Quadratic Equation Achievement Test (QEAT) was used as instrument for data collection while lesson plan on problem solving instructional strategy developed by the researcher was used for experimental treatment. The instruments were face and content validated by three experts and also trial tested. The item analysis was conducted on QEAT in order to fully standardize the instrument. The reliability of QEAT was established using Kuder Richardson formula 20 (KR-20) which yielded reliability coefficient of 0.94 considered high enough for the study. The data collected from the field were analyzed using descriptive and inferential statistics. Mean, standard deviation was used to answer the research questions while t- test was used to test the hypotheses at 0.05 alpha levels. The results indicated among others that the PSIS have significant effect on students' achievement scores in quadratic equations; gender and school location has significant effect on students' achievement scores in quadratic equations. Based on the findings of the study, it was therefore recommended among others that Mathematics teachers should employ the use of problem solving instructional strategy in mathematics classroom so that teaching and learning of mathematics will be student centred.*

## KEYWORDS

*Problem solving, Instructional strategy, Quadratic equations and Achievements.*

## INTRODUCTION

Science is both a body of knowledge and a process. Processes of science involve observation, classification, measurement, inference, prediction, experimentation, hypothesising, humility, honesty and curiosity. In school, science may sometimes look like a collection of isolated and static facts listed in a textbook, but that is only a small part of it. Most importantly, science is a process of discovery that allows linking isolated facts into coherent and comprehensive understanding of the natural world (Okoli, 2020). Okoli further stressed that science is a way of discovering what is in the universe and how those things work today, how they work in the past and how they are likely to work in the future.

Science is very important in everyday life because there is no one aspect of daily living that science has not made easier, faster or safer. Science results in technology that people rely on for health, communication and transportation. Scientific knowledge helps people understand the world from a cellular to a universal level. Science makes everyday life easier than it has ever been; for instance, the scientific discovery of a method for harnessing electric energy changed peoples' lives forever. Electric light benefits people every day in inventions such as traffic lights, refrigerators and communications devices. Science is the reason for the quick pace of modern life. A journey that took weeks on foot or horseback was shortened to a few days travel by the use of steam-powered locomotives followed by personal automobiles. Science is subdivided into various teaching subjects especially in Nigeria, one of which is Mathematics.

Mathematics is the science of numbers and shapes. Mathematics is not only considered as an important subject in all the levels of education but also regarded as the father and queen of all science subjects. It is a practical subject used to solve personal and social problems. It deals with the counting and measuring of numbers. According to Birgan (2019), Mathematics deals with logical reasoning and quantitative calculations. Mathematics is a body of knowledge essential for the attainment of scientific and technological development of any nation (Anaduaka & Okafor, 2021). The authors further maintained that the knowledge of Mathematics promotes the habit of accuracy, logical, systemic and orderly arrangement of facts in the affairs of an individual. The importance of Mathematics does not only lie in its contribution to scientific and technological development but also in its utility in the day to day interactions at the market place, transportations, business of all sorts by both literate and illiterate members of the society (Ezeanyi, 2021).

Mathematics has so many branches which include arithmetic, algebra, geometry, calculus, statics topology, mathematical modelling. Algebra which is a branch of mathematics concerned with the study of rules of operations which include polynomials, equations and algebraic structures. Quadratic equation is an aspect of algebra which is a second-degree sentence whose standard form is $ax^2 + bx + c=0$, where a, b, c are real numbers and $a \neq 0$. The importance of quadratic equation to man cannot be overemphasised because it is used to construct the Holland Tunnel under the Hudson River in New York, radar dishes, reflectors or spotlights, components of microphones and cables of suspension bridges which have the shapes of parabolas. Ekwueme (2018) stipulated that profit and cost functions in business equilibrium, point and Laffer curve in economics, blood velocity and pollution in life sciences and population growth in the social sciences are all models of quadratic functions.

Despite the importance of quadratic equations in the development of science, there is still persistence poor achievement of student in this area. Kieran (2018) posited that quadratic equations are so important in the society but studies showed that teaching and learning of quadratic equations are quite scarce in algebra education research. Havi (2017) stated that West African Examination Council is worried about the persistent errors in solving quadratic equation among the students. Reports from Examination bodies like WAEC stated that over 65% of the candidates for the examination performed poorly in quadratic equation questions between 2016 and 2021. The body stated that the few students who attempted solving quadratic equation questions had difficulties in identifying constants when the coefficient of $X^2$ is not unity and as well as difficulties in finding the factors of the equation.

Ahmad (2017) indicated that the factoring techniques in solving quadratic equations are problematic for students especially, when the leading coefficient or constant in the quadratic has many pairs of possible factors. Studies has also shown the reasons for the students' under achievements in quadratic equations which according to Clements (2020) are related to lack of instrumental and crude teaching strategy. Thomas (2021) reported that students' difficulties in quadratic equations are related to poor understanding of graphical and symbolic solution of quadratic equations. Taylor (2019) admitted that students simply memorize the procedures and formulas to solve quadratic equations due to lack of understanding the concept of quadratic equations.

Having identified the importance and difficulties encountered while solving quadratic equations, methods of improving students' achievements in mathematics and quadratic equation in particular will be the key strategy to address the issue of poor achievement of students in mathematics. No wonder Gore and Morgan (2017) emphasized that innovative teaching method that provide positive mathematical learning experiences will enhance students' achievements in mathematics. This means that mathematics teachers should show concern on the ways students should learn mathematics effectively with utmost interest and better achievement. Hence effort now is to use Problem solving instructional strategy in solving quadratic equations.

Ezeanyi and Okigbo (2019) defined instructional strategy as a strategy by which a teacher delivers his/her subject content to the learners based on predetermined instructional objectives in order to promote learning. Teaching strategy is a general plan which includes all the parts of the teaching situation; namely: teaching methods, teaching aids and evaluation strategy. Norman (2021) posited that teaching strategies involve the use of all instructional materials, facilities and other resources available to an educator in order to meet the instructional needs of all learners and enable learners' progress from dependent to independent learners. There are different instructional strategies employed in science education particularly in Mathematics in Nigerian secondary schools. For any instructional strategy to bring good result in the present age, it should be a strategy that promotes maximum social interaction.

The traditional teaching strategy usually employed by secondary school teachers is filled with too much talking and writing which makes students fear and have sort of phobia towards learning mathematics. The traditional teaching strategy is an instructional setting where teachers mainly use textbooks and solve problems on the chalkboard without actively engaging the students in the course of solving mathematical problems. While teachers are active students are mainly passive and copy solutions provided by their teacher without responsibility for their own learning. This kind of teaching approach creates an idea in the mind of pupils that mathematics is a difficult subject and

cannot perform better in the subject. Correspondingly, Ayhan (2018) averred that, the passivity of students in this teaching approach also makes Mathematics even more complicated as students cannot analyze questions and answer questions on their own.

Problem- solving instructional strategy (PSIS) is a student's centred instructional method which exposes the students to new ideas and concepts. Here, students work actively and independently on problems that the teacher presented to them. Ali and khan (2020) in their study, see PSIS as one in which the students turn from passive listeners or information receivers to active, free self learners and problems solvers. Besides, Tarooq (2019) stated that "problems" are difficulties that tend to appear to the attainment of goal. However, this study adopted problem-solving approach guideline of Polya's (2018) heuristics of problem-solving approach which involve; (1) Understand the problem (2) Devise a plan (3) Carry out the plan (4) Look back ( checking or feedback).

Adeyanju (2020) carried out a study titled "effect of problem solving approach on academic achievement of students in Mathematics at the secondary level ". Treatment of the planned problem-solving approach used the guidance of Joshua (2016) and Abiodun (2020) heuristics of problem-solving approach. The experimental group outscored the control group significantly on the post test. In addition, Folake and Ibidiran (2021) carried out a study on the effect of problem-solving instructional strategy and numerical ability on students' learning outcomes in mathematics. The seven steps mathematics problem-solving model suggested by Frazer (2017) and Birgan (2019) was adopted for the study. The Numerical Ability Test (NAT) was the instrument for the study. Analysis of covariance was used to analyze the data at probability level of 0.05. The result showed that there was significant difference in the academic performance of those students exposed to problem-solving instructional strategy and those in the control group.

Gender issue has become has become the talk of today's forum. Gender is a specially instructed phenomenon that is brought about as society ascribes different roles, duties, behaviours and mannerisms to the two sexes, (Ezeanyi and Okigbo, 2021). Gimba (2017) agreed that bias is very prevalent in Africa and particularly Nigeria. He argued that in Nigeria, harder task are assign to males while females are given the relatively easy and less demanding tasks. Also Ebisine (2017) reported that gender has no effect on student achievement in science while Montague (2018) found that female subjects were significantly better than their male counterparts. The consensus among science educators is that some instructional strategies are gender bias while some are gender friendly. However, the degree of gender related differences in learning vary from one method of instruction to the other as well as the concepts being learnt. Therefore, this study is aimed to find the impact of problem solving instructional strategy on achievement among male and female of SSI mathematics students.

School location refers to the particular place, in relation to other areas in the physical environment (rural or urban), where the school is sited (Odili, 2016). In Nigeria, rural life is uniform, homogenous and less complex than that of urban centers, with cultural diversity, which often is suspected to affect students' academic performance. This is because urban centers are better favored with respect to distribution of social amenities such as pipe borne water, electricity, healthcare facilities while the rural areas are less favored. This is also true in the distribution of educational facilities and teachers. These prevailing conditions imply that learning opportunities in Nigerian schools differ from school to school. It would appear therefore that students in Nigerian urban schools have more educational

opportunities than their counterparts in rural schools. While some studies (Opoh and Akai, 2017; Ruel and Bastiaans, 2018) have shown positive influence, others (Njoku & Sunday, 2020) have shown negative influence of school location on the students' learning outcome or achievement.

## Statement of the Problem

Students' poor achievement in mathematics has been a source of worry to teachers, guidance counsellors, parents, academician and the society at large. It has become a collective concern to observe that senior secondary students perform poorly in mathematics examinations especially at SSCE. As a result, the researcher deemed it necessary to investigate the effect of Problem solving instructional strategy (PSIS) on senior secondary school students in Quadratic equation aspect of Mathematics against the conventional methods.

## Purpose of the study

The main purpose of this study is to examine the effect of problem solving instructional strategy on student's achievement in quadratic equations. Specifically the study sought to:

1. Determine the mean achievement scores of students taught quadratic equations using problem solving instructional strategy and those taught without it.
2. Determine the mean achievement scores of male and female students taught quadratic equations using problem solving instructional strategy.
3. Determine the achievement scores of urban and rural students taught quadratic equations using problem solving instructional strategy.

## Research Questions

To investigate the problems of this study, the following research questions guided the study:

1. What are the differences in the mean achievement scores of students taught quadratic equations using problem solving instructional strategy and those taught without it?
2. What are the differences in the mean achievement scores of male and female students taught quadratic equations using problem solving instructional strategy?
4. What are the differences in the mean achievement scores of urban and rural students taught quadratic equations using problem solving instructional strategy?

## Hypotheses

To achieve the purpose of this study, the following hypotheses guided the study at 0.05 alpha levels:

1. There is no significant difference in the mean achievement scores of students taught quadratic equations using problem solving instructional strategy and those taught without it
2. There is no significant difference in the mean achievement scores of male and female students taught quadratic equations using problem solving instructional strategy.
3. There is no significant difference in the mean achievement scores of urban and rural students taught quadratic equations using problem solving instructional strategy.

## Method

A quasi-experimental research design was adopted for this study. Specifically, the pre-test post-test non equivalent control group design was adopted. The study was carried out in Awgu Education zone of Enugu State, Nigeria. The sample of the study consisted of Ninety four (94) SS1 students obtained using multi stage sampling technique from a population of 4,675 mathematics students. Quadratic Equations Achievement Test (QEAT) was used to collect data for the study and a lesson

plan for experimental group was developed by the researcher and used as instructional tool. The two instruments were validated by three experts. The lesson plan was written in two forms, the plan that integrated the use of problem solving instructional strategy in each lesson for control group. Each plan covered the topics listed by the researcher. The lesson plan was used to teach both the experimental and the control group.

Quadratic Equation Achievement Test (QEAT) was constructed to measure the students' achievements. It had twenty items accessed at multiple choices scoring scale. Each correct answer was scored 5 marks; this gave the maximum of 100 marks. Therefore, students that scored below 50 (0-49) achieved poorly and those who scored 50 (50-100) and above achieved well.

The Kuder Richardson formula was used to establish the internal consistency of the instrument. 20 SS1 mathematics students, who were not part of the sample, were used and their responses analysed using Kuder-Richardson formula (KR-20) method. A reliability coefficient of 0.94 for QEAT was obtained which was considered high enough to attest to the reliability of the instrument.

The experimental groups from the urban and rural schools were taught Quadratic Equations using problem solving instructional strategy. Careful effort was taken to select specific problem solving techniques for the teaching and academic achievement of the students of the experimental groups. The schools that served as control were not exposed to any problem solving instructional strategy during the teaching process. These schools were taught by the researchers for a period of four weeks. At the end of the teaching period, Quadratic equations Achievement Test (QEAT) was administered to both the control and experimental groups. The mean scores of the experimental group were compared with that of the control group in order to determine the effectiveness of the treatment.

The data generated from the field was analysed using both descriptive and inferential statistics. The research questions were answered using mean and standard deviation while t-test was used to test the hypotheses at 0.05 alpha levels.

## Results

**Research Questions 1**: What are the differences in the mean achievement scores of students taught quadratic equations using problem solving instructional strategy and those taught without it?

**Table 1: Mean and standard deviation of SS1 mathematics students taught quadratic equations with PSIS and those taught using conventional method**

| | | Pre-test | | Post-test | | |
|---|---|---|---|---|---|---|
| **Group** | **N** | **Mean** | **SD** | **Mean** | **SD** | **Mean gain** |
| Experimental | 47 | 38.41 | 4.23 | 66.61 | 9.94 | 28.20 |
| Control | 47 | 37.35 | 5.14 | 49.07 | 10.95 | 6.14 |

Table 1 shows that the students taught quadratic equations with Problem solving instructional strategy had a higher mean score of 66.61 with mean gain of 28.20 as against students taught with conventional method who had mean score of 49.07 with mean gain of 11.72. This showed that PSIS was more effective than the conventional method in teaching quadratic equations.

**Research Question 2**: What are the differences in the mean achievement scores of male and female students taught quadratic equations using problem solving instructional strategy?

**Table 2: Mean and standard deviation of SS1 male and female mathematics students taught quadratic equations using PSIS.**

| | | Pre-test | | Post-test | | |
|---|---|---|---|---|---|---|
| **Gender** | **N** | **Mean** | **SD** | **Mean** | **SD** | **Mean gain** |
| Male | 48 | 40.39 | 6.36 | 73.38 | 10.43 | 32.99 |
| Female | 46 | 41.17 | 7.52 | 65.10 | 9.48 | 23.93 |

Table 2 showed that the male students taught quadratic equations using PSIS had a higher mean score of 73.38 with a mean gain of 32.99 as against their female counterparts who had a mean score of 65.10 with a mean gain of 9.48. This showed that male students achieved higher in quadratic equations than their female counterparts when exposed to Problem solving instructional strategy.

**Research Question 3**: What are the differences in the mean achievement scores of urban and rural students taught quadratic equations using problem solving instructional strategy?

**Table 3: Mean and standard deviation scores of urban and rural students taught quadratic equations using the PSIS**

| | | Pre-test | | Post-test | | |
|---|---|---|---|---|---|---|
| **Location** | **N** | **Mean** | **SD** | **Mean** | **SD** | **Mean gain** |
| Urban | 50 | 48.41 | 7.26 | 79.38 | 11.14 | 30.97 |
| Rural | 44 | 38.35 | 8.74 | 45.69 | 9.93 | 7.34 |

Table 3 showed that the urban students taught quadratic equations using PSIS had a mean score of 79.38 with a mean gain of 30.97 while the rural students had a mean score of 45.69 with a mean gain of 7.34. This showed that urban students achieved higher in quadratic equations than their rural counterparts after using PSIS on them.

**Hypothesis 1:** There is no significant difference in the mean achievement scores of students taught quadratic equations using problem solving instructional strategy and those taught without it

**Table 4: t-test for difference in the mean achievement scores of students taught quadratic equations using PSIS and those taught with conventional method**

| **Group** | **N** | **X** | **SD** | **Df** | $\alpha$ | **t-crit** | **t-cal** | **Decision** |
|---|---|---|---|---|---|---|---|---|
| Experimental | 47 | 69.48 | 9.94 | 92 | 0.05 | 1.96 | 9.04 | Reject $H_o$ |
| Control | 47 | 55.49 | 10.95 | | | | | |

The result in table 4 shows that t-crit value of 1.96 is less than the t-cal value o f 9.04 at 0.05 alpha levels. Therefore, the null hypothesis is rejected. This indicated that there is a statistical significant difference in the mean achievement scores of students taught quadratic equations using PSIS and those taught using conventional method. Based on the result, students taught with PSIS achieved better than those taught with conventional method.

**Hypothesis 2:** There is no significant difference in the mean achievement scores of male and female students taught quadratic equations using problem solving instructional strategy.

**Table 5: t-test difference in the mean achievement scores of male and female students taught quadratic equations using PSIS**

| Gender | N | X | SD | Df | $\alpha$ | t-crit | t-cal | Decision |
|---|---|---|---|---|---|---|---|---|
| Male | 48 | 63.18 | 9.63 | 92 | 0.05 | 1.96 | 6.05 | $H_o$ rejected |
| Female | 46 | 45.18 | 8.47 | | | | | |

The result in the table 5 showed that t-crit value of 1.96 is less than t-call value of 6.05 at 0.05 level of significant difference between the mean achievement scores of male and female students taught quadratic equations using PSIS. Based on the result, male students achieved higher than their female counterparts when exposed to the PSIS.

**Hypothesis 3:** There is no significant difference in the mean achievement scores of urban and rural students who were taught quadratic equations using problem solving instructional strategy

**Table 6: t-test difference in the mean achievement scores of urban and rural students taught quadratic equations using PSIS**

| Location | N | X | SD | Df | $\alpha$ | t-crit | t-cal | Decision |
|---|---|---|---|---|---|---|---|---|
| Urban | 50 | 63.18 | 12.14 | 92 | 0.05 | 1.96 | 8.14 | Reject $H_o$ |
| Rural | 44 | 45.43 | 11.45 | | | | | |

The result in table 6 showed that t-crit value of 1.96 is less than the t-cal value o f 8.14 at 0.05 alpha levels. Therefore, the null hypothesis is rejected. This means that there is a statistical significant difference in the mean achievement scores of urban and rural students taught quadratic equations using PSIS. Based on the result, urban students achieved higher than their rural counterparts when exposed to PSIS.

## Discussion

The result that emerged from the study as shown on table 1 indicated that students taught quadratic equations using PSIS achieved better than those taught with conventional strategy. The result in Table 4 also showed a significant difference in the mean achievement scores of students taught the concept using PSIS and those taught using conventional strategy. This finding is in agreement with Birgan (2019) who observed that problem solving could improve secondary school achievement in mathematics generally. Kieran (2018) noted that problem solving instructional strategy can give weak students the opportunity to learn and achieve maximally. Similarly, the study by Anaduaka and Okafor (2021) found that problem solving instructional strategy can be employed to help low ability students to improve on their achievement, who had difficulties making success in the conventional classroom. Tarooq (2019) also observed that PSIS allow the students the independence to use their mental processes to contribute to knowledge. Clements (2018) stressing the importance of PSIS noted that cooperative it increases students' academic achievement at all ability levels.

Table 2 revealed that the mean achievement scores of male senior secondary school one students taught Quadratic equations using problem solving instructional strategy was higher than their female

counterparts. Also, the result in Table 5 revealed that gender is a significant factor in determining students' achievement in Quadratic equations using problem solving instructional strategy. This finding is in agreement with the findings of Ezeanyi (2021), Steven (2020), Gimba (2017) who found a significant gender difference in the mean achievement scores of secondary school students taught mathematics with innovative instructional strategy in favour of the males. Similarly, Ebisine (2017) found that problem solving instructional strategy was more effective in improving the mean achievement scores of secondary school male students than their female counterparts. Norman (2021) and Obioma (2017) reaffirmed the ability of problem solving when used as an instructional strategy to bring about significant improvement in students achievement in school science subjects and between male and female students in favour of the males.

Result on Table 3, indicated that students from urban locations taught Quadratic equations using PSIS achieved higher than their rural counterparts. Furthermore, the result on Table 6 indicated a significant difference in the mean achievement scores of senior secondary school students from urban and rural locations with students from urban locations achieving higher than their rural counterparts. These findings are in agreement with the findings by Carbon (2017); Ezeanyi and Okigbo (2021); Odili (2016) that students from urban areas achieve higher in Mathematics than those from rural areas. These findings were not akin to the findings by Opoh and Akai (2017) and Njoku and Suday (2020) that location of the school had no significant effect on students' mastery of Mathematics concepts. Odili (2016) found that rural and urban students had comparable levels of Mathematics performance. Also, Ruel and Bastians (2018) found that there was significant difference in the use of innovative instructional strategies between urban and rural school students. These findings all disagree with the present study. The present findings may be because schools in the rural locations suffer dearth of teaching and learning facilities. Most teachers posted to rural locations abscond and reject their postings thereby leaving the rural schools and their students with insufficient or no teaching staff.

## Conclusion

Based on the findings of the result, there is a significant difference between the mean achievement scores of students taught quadratic equations using problem solving instructional strategy and those taught with conventional method. The students exposed to PSIS did better than the students exposed to the conventional methods of teaching quadratic equations. Male students achieved higher than their female counterparts in Quadratic equations when taught using PSIS. It was also shown from the study that urban students achieved higher than their rural counterparts in Quadratic equations when exposed to PSIS.

## Recommendations

Based on the finding of the study, the following recommendations were made

1. Mathematics teachers should employ the use of problem solving instructional strategy in mathematics classrooms so that teaching and learning of mathematics will be student centred.
2. The school management boards should organize workshops and seminars to expose teachers and students constantly to the use of the strategy for maximum school output.
3. The government in collaboration with curriculum planners should integrate PSIS in mathematics curriculum.

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