Effects of Problem-Solving Teaching Strategy on Secondary School Students' Academic Performance in Chemistry in Ondo State, Nigeria

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ABSTRACT: *The study examined the effects of Problem-Solving teaching strategy on secondary school students' academic performance in Chemistry in Akure South Local Government Area of Ondo State, Nigeria. It also examined the effect of Problem-Solving teaching strategy on gender of Chemistry school students. Purposive and stratified random sampling techniques was used to select a total sample of 130 SS I Chemistry students (this sample was divided into 65student experimental and 65 students control group) from two Senior Secondary schools in Akure South Local Government Area of Ondo State, Nigeria. Three null hypotheses were formulated and tested at 0.05 level of significance. The instrument for this study was Chemistry Achievement Test (CAT). The data collected were analysed using t-test and ANCOVA statistical analysis packages. The results of the analyses showed that no significant difference existed between academic achievement of students in experimental group and control group involved in the study at pretest (this indicated initial academic homogeneity of the groups). However, students' academic performance in the experimental group and control group at post-test level was found to be significantly different in favour of the experimental group. This showed that Problem-Solving teaching strategy significantly influenced students' academic performance in Chemistry in Senior Secondary School. Based on the findings of the study, conclusion and recommendations were made.*

Key Words: *Problem, Problem-Solving, academic achievement and instructional package.*

Introduction

A teacher may profess to hold fifteen years' experience, but the experience means nothing if he keeps on repeating the same thing without bringing innovation into his teaching. The winning edge comes when teachers do not rest on their past laurels but gear themselves up to impart innovative and intellectually challenging education, link their discipline with contemporaneous issues of global import, provide illustrations from life and promote constructive rethinking rather than rote learning, so that the students can be competent, confident and conscientious in a complex and competitive future. If the child is not properly and adequately trained and educated, the nation might find it difficult to attain the developmental goals set for the natives, hence her hope on learning for scientific and technological development will be defeated.

The curriculum must be properly implemented in order to bring about the desired goals. For a curriculum to be properly implemented, appropriate instructional tools, method, learners' interest and attitude towards the teaching and learning of desired subjects must be properly taken into consideration. Hence, greater importance on the strategies, styles and methods of teaching, particularly one that can motivate the learner and bring desired learning outcomes should be employed.

The National Policy on Education of the Federal Republic of Nigeria (2007) emphasized the need to train Nigeria citizens to be able to manipulate the environment towards the development of the society, understand the world around him, acquire appropriate skill, ability and competence in all areas of human endeavour so as to equip the individual to live comfortably within his society and contribute to the development of the society. In the light of this, the National Policy on Education (2007) recommended enrolment ratio of 60:40 in favour of science. Experience over the years showed that few students enroll for chemistry and the performance of the very few students who opted for chemistry are very low (Sansawal, 2009).

Education is an important vehicle of change and development. As Nigeria is struggling to be self-reliant and independent technologically and economically, more research based findings are needed on the teaching and learning of chemistry at the senior secondary school. Education (science in particular) is the factory for the production of the needed technology required for the nation's economy to turn around and usher in the desired technological advancement which is very much required for the elevation of Nigeria from a developing nation to a developed nation (Avaa, 2007).

Acquisition of appropriate scientific and technological skills is necessary to cope with the challenges presented by the evolving needs of modern work placed in our industries and ever growing non formal sector. Education and training systems that respond adequately to these demands will therefore, contribute to the efforts to overcome the growing unemployment and marginalizing of majority of the populace. Such systems will provide access to appropriate learning experience designed to broaden skills and knowledge that can increase productivity and significantly improve the fortunes of the unemployed, thereby reducing poverty and unemployment amongst the youth.

Research evidences have proved that the contributions of Chemistry to quality of life and nation building are worthwhile in all aspects. Any nation aspiring to be scientifically and technologically developed must have adequate level of Chemistry education (Eke, 2008). The role of Chemistry in the development of the scientific base of a country cannot be over emphasized. Chemistry occupies a pivotal position in science and technology and is needed by everybody and in every aspect of human endeavour (Olayemi, 2009 & Eke, 2008).

Chemistry education occupies a central position to all science disciplines and has been identified to be one of the major bedrock for the transformation of the nation's economy. The role of science in the development of modern technological innovations is far reaching in every sphere of man's life. If Nigeria is to build an organized, self-reliant, and technologically compliant society, much emphasis has to be continually made in science and technology in our school system

It is obvious that there have not been remarkable improvement in the interest of student towards Chemistry, then adequate attention must be accorded this problem. Some other recommendations have been made to solve the problems militating against the teaching of science in secondary schools (Boris, 2016). They include; arousing students interest in science subjects, enhancing students attitude towards science (Adesoji, 2008), usage of appropriate and effective teaching methods (Jegede, 2003). Nbina (2012) cited in Boris (2016) submitted that the Federal Government should provide and retain quality teachers and also provide adequate teaching and learning facilities and equipment to schools. It is in view of this that the researcher attempt to find out what effect an innovative curriculum tool called reflective teaching will have on the learning outcome of Chemistry in senior secondary school.

Problem-Solving theory and practice suggest that, thinking is more important in solving problem than knowledge and that it is possible to teach thinking in situations where little or no knowledge of the problem is needed. Mayer (2002) cited in Awodun (2020) defines Problem-Solving strategy as the means by which an individual uses previously acquired knowledge, skills and understanding to satisfy the demands of an unfamiliar situation. The student must synthesize what he or she has learned and applied it to new and different situation. The existence of a problem implies that, the individual is confronted by something he or she does not recognize or cannot apply a model. A problem will no longer be considered a problem once it can easily be solved by algorithms that have been previously learned. During the process of working from the area of known facts to an area of uncertainties, many problems may arise to achieve their goals.

Many different definitions of the concept of problem have made by researches. Problem is defined by many researches as "a situation which people suddenly encounters and does not know how to react at the moment". Problem-Solving process, also defined as organizing cognitive and effective behavioral processes towards a specific target, is closely related to creativity (Elif, 2018).

Awodun (2020) cited Serap, Gamze & Mustafa (2010) that Problem-Solving is to know what to do when you don't what to do. Problem - Solving is the process of investigation where the solution is not obvious to the investigator at the initial stage. The relevant concepts in the cognitive structure of the students must be adequate before the students will be able to solve a given task or problem effectively. As a teaching strategy, Problem-Solving entails training the students on how to solve problems by proceeding in a logical step by step manner from a problem state to its solution. It is on this premise that theorists in problem - solving have identified basic stages involved in the strategy (Johanning, 2006).

Ntibi and Neji (2008) affirms that Problem-Solving is the process of investigation where the solution is not accessible in the memory. The relevant concepts in the cognitive structure of the students must be adequate before the students will be able to solve a given task or problem effectively. As a teaching strategy, Problem-Solving entails training the students on how to solve problem by proceeding in a logical step by step manner from a problem state to its solution.

Gok and Silay (2010) worked on the effects of directive and non directive problem solving on attitudes and achievement of students in a developmental science course and found that attitude becomes more positive after instruction. It has been observed from a research conducted by Adebola (2011) on the

use of advance organizer and problem- solving teaching strategies that students' achievement are improved but, little efforts are made to study the effectiveness of advance organizer and Problem- Solving strategies.

Problem-Solving consists of using generic or ad hoc methods in an orderly manner to find solutions to problems (Awodun, 2020). Some of the problem-solving techniques developed and used in Philosophy, artificial intelligence, computer science, engineering, mathematics, or medicine are related to mental problem-solving techniques studied in psychology. Problem-Solving strategies are the steps that one would use to find the problems that are in the way to getting to one's own goal. Problem-Solving method as generally being an arrangement of specific processes or steps, and identified as being a scientific method by one-third of the cited references in their review. According to Mayer and Wittrock (2006), Problem-Solving is related to thinking reasoning decision making, critical thinking and creative thinking.

Generally, Problem-Solving involves defining a problem, collecting information related to the solution process, reasoning through the problem state to the solution checking and evaluating the solution. According to Dale and Balloti (1997) cited in Adegoke (2017), Problem –Solving skills cannot be inherited but can be learned and improved upon.

According to online (2019) cited in Awodun (2020), seven (7) steps for effective problem-solving method are:

- Step 1: identifying the problem. Ask yourself what is the problem is……
- Step 2: Defining goals……..
- Step 3: brainstorming ……..
- Step 4: assessing alternatives ……
- Step 5: choosing the solution ……
- Step 6: active execution of the chosen solution ……
- Step 7: Evaluation.

Adegoke (2017) cited Mataka, Cobern, Grunert, Mutambuki & Akom (2014) that Problem-Solving as view by cognitive psychologists, encompasses self-analysis, observation, and the development of heuristics. Awodun (2020) cited Abubakar & Danjuma (2012) that Problem-Solving has long been recognized as a skill that fosters a better understanding of scientific and mathematics concepts. It can be an excellent tool to encourage the learning process. Problem-Solving also plays an important role in developing regulative and transformative skills. The transformative skills are: observing the problems, questioning, hypothesizing, playing and investigation, analyzing and interpreting data, communicating results.

In the study of Ifeanyi-Uche & Ejabukwa (2013) to determine the effect of Problem-Solving method on academic achievement of secondary school students in Home Economics in secondary schools in Orumba South Local Government Area of Anambra State found out that the experimental group (problem-solving) achieved significantly higher than the control group (lecture method). Similarly, in the study of Ntibi & Neji (2018) on the effect of problem-solving method of teaching on students' academic performance in Physics and Chemistry in Calabar Municipal, Cross River State, Nigeria found out that the experimental groups performed significantly better than their counterparts taught with conventional method. This shows that the Problem-Solving method is more effective method that can enhance students' academic performance in Physics compared with the conventional method.

Moreover, Adegoke (2017) in his study on the effect of explicit Problem-Solving instruction on secondary school students' achievement in Physics affirmed that explicit problem-solving instruction is more effective than traditional Problem-Solving instruction on the students' achievement in Physics. This is so because Physics by its nature involves solving numerical and world problems. Lioyd, William, Megan, Jacinta & George (2014) cited Lorenzo (2005) that students using Problem-Solving heuristic were more confident at had a higher ability to solve difficult physics problems.

Science education is meant to expose the learners to scientific nature (facts, principles and concepts), processes, attitudes and then equip learners with skills of professional scientist. Instruction in science is aimed at achieving two goals: the first is the acquisition of the body of organized knowledge in a particular domain, and the second important goal in science instruction is the ability to solve problems in that domain (Nwagbo, 2007).

Therefore, this study intends to examine the effects of Problem-Solving Teaching Strategy on Students' academic achievement in Secondary School Chemistry in Akure South local government Area of Ondo State, Nigeria.

Research Hypotheses

The following null hypotheses were formulated and tested at 0.05 α-level of significance:

1. There is no significant difference in the achievement mean scores of students in experimental and control groups before treatment.
2. There is no significant difference in the achievement mean scores of students in experimental and control groups after treatment.
3. There is no significant difference in the achievement mean scores of male and female students in each of the experimental and control groups.

Methodology

The design for this study was Pretest-Posttest Quasi-Experimental. The treatment (Problem-Solving Strategy) was applied to the experimental group. The teacher uses this strategy to teach students and determine the effect on students' academic performance in Chemistry. The pre-test was used to establish the knowledge baseline of the students as well as the academic homogeneity of the two groups before the commencement of the experiment. The post-test was used to determine the levels of academic achievement of students within the two groups after the application of treatment.

The population of the study was made up of all senior secondary student class Two (SS II) in Akure South Local Government Area of Ondo State. Purposive and stratified random sampling techniques was used to select a total sample of 130 public senior secondary class Two (SS II) Chemistry students (this sample was divided into the experimental and control groups in ratio 1:1 meaning that, 65 students from each group) from two senior secondary schools in Akure South Local Government Area, Ondo State. The instrument used for the study was thirty (30) standardized objective questions tagged: 'Chemistry Achievement Test (CAT)' drawn from the topics : periodic table, Atomic properties and Oxidation-Reduction Reaction with four options (A-D) considered for the study.

The teaching covered three weeks with the control group taught using conventional method while the experimental group was taught using Problem-Solving teaching strategy. The tests (Pretest and Posttest) questions were administered to students; each of the tests was marked and scored accordingly.

The three formulated null hypotheses were tested at 0.05 level of significance. The data collected were analysed using t-test and ANCOVA statistical analysis packages.

Results and Discussion

Hypothesis 1

There is no significant difference in the achievement mean scores of students in experimental and control groups before treatment.

Table 1: t-test analysis of achievement mean scores of students in experimental and control groups before treatment.

Group	N	Mean	SD	df	t_{cal}	t_{tab}
Control	65	9.48	3.26			
Experimental	65	8.78	3.48	128	1.186	1.968

$P > 0.05$.

As shown in table 1, when the mean score of students in the experimental and control groups before the treatments (pre-test) were statistically compared, a *t -value* ($t_{cal} = 1.186 < t_{tab} = 1.968$) with $p > 0.05$ alpha level was obtained, which was not significant at 0.05 level. This implies that there is no significant difference between experimental and control groups in pretest achievement mean score. Consequently, the null hypothesis which states that there is no significant difference in the achievement mean scores of students in experimental and control groups before treatment was accepted.

Hypothesis 2

There is no significant difference in the achievement mean scores of students in experimental and control groups after treatment.

Table 2 : t-test analysis of achievement mean scores of students in experimental and control groups after treatment

Group	N	Mean	SD	df	t_{cal}	t_{tab}
Control	65	15.74	5.89			
Experimental	65	21.98	7.81	128	5.144	1.968

$P < 0.05$.

As shown in table 2, when the mean score of students in the control and experimental groups after the treatments (posttest) were statistically compared, a *t-value* (t_{cal} = 5.144 > t_{tab} = 1.968) with P < 0.05 alpha level was obtained, which was significant at 0.05 level. This implies that there exists significant difference between the control and experimental groups achievement mean scores after the treatment in favour of experimental group. Consequently, the null hypothesis which states that there is no significant difference in the achievement mean scores of students in experimental and control groups after treatment was rejected. As such, the conventional method of instruction (control group) can be said to be less effective compared with Problem-Solving teaching strategy (experimental group).

Hypothesis 3

There is no significant difference in the achievement mean scores of male and female students in each of the experimental and control groups.

Table 3: Summary of ANCOVA analysis on the achievement mean scores of male and female students in each of the experimental and control groups

Source	SS	Df	MS	F	Sig.
Corrected Model	3220.184[a]	4	416.246	68.364	.000
Intercept	5438.412	1	5438.412	841.281	.000
Pretest	5.6422	1	5.642	1.67	.266
Gender	4.831	1	4.831	.598	.356
Group	2316.551	2	1228.542	211.128	.000
Gender * Group	.548	2	.324	.057	.810
Error	766.310	126	4.618		
Total	143810.42	130			
Corrected Total	4106.161	129			

P > 0.05

Table 3 showed that there is no significant difference between the achievement of male and female students in the experimental group and the control group in Chemistry academic achievement. (F = 0.057, p > 0.05). The null hypothesis was accepted. This implies that there is no significant difference in the achievement means scores of male and female students in each of the experimental and control groups.

Discussion

The result of this study revealed that the pre-test mean scores of the students in the Problem- Solving teaching strategy was not significantly different from that of those exposed to conventional method. The implication of this is that the two groups involved in the study exhibited comparable characteristics. Thus, they both entered the instructional experiment on equal strength and ability which showed that the two groups were suitable for the study when comparing Problem-Solving teaching strategy with conventional method on achievement in Chemistry.

Furthermore, the result of the study also revealed a relative increase in the post-test mean score of the students in the Problem-Solving teaching strategy group over those taught with the conventional method. Thus confirmed that Problem-Solving teaching strategies are learner-centered and capable of making remarkable impact on instructional practices. This result agrees with the findings of Adegoke (2017) that explicit problem-solving instruction is more effective than traditional Problem-Solving instruction on the students' achievement in Chemistry. It also agrees with the findings of Ifeanyi-Uche and Ejabukwa (2013) that the experimental group (problem-solving) achieved significantly higher than the control group (lecture method). Similarly, it also agrees with the findings of Ntibi and Neji (2018) that the experimental groups performed significantly better than their counterparts taught with conventional method. This shows that the Problem-Solving method is more effective method that can enhance students' academic performance in Chemistry compared with the conventional method. It also agrees with the findings of Scrap, Gamze and Mustafa (2010) all students in class participated in problem-solving activities perform better than their counterparts in the control group. In addition, it also agrees with the findings of Abubakar and Danjuma (2012) that explicit Problem-Solving strategy was better than traditional lecture method in enhancing student achievement in senior secondary school Chemistry.

Moreover, the findings of this study also revealed that: There was no significant difference in the achievement means scores of male and female students in each of the experimental and control groups before and after the treatment. In other words, the achievement of male and female students exposed to Problem-Solving teaching strategy did not differ significantly as female students were found to have similar achievement in Chemistry as their male counterparts in the two groups involved in the study. The implication of this result is that gender was not a significant predictor of students' achievement in Chemistry. The finding agrees with the findings of Robinson and Daniel (2017) that there is no significant difference between the mean academic performance of male and female students exposed to Problem-Solving method of teaching.

Conclusion

Based on the findings of this study, it can be concluded that Problem-Solving teaching strategy is more effective in improving students' academic achievement in Chemistry in secondary schools than conventional method in vogue in the nation in term of academic achievement and retention.

The study however found no significant difference between academic achievement of male and female students in Chemistry when Problem-Solving teaching was used as strategy of instruction. This simply implies that academic achievement of students taught using different teaching strategies is not in any manner affected by either their gender.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. Problem-Solving teaching strategy assessment should be practically applied to classroom situations. Teachers should use Problem-Solving strategy to arouse the interest of their students in Chemistry teaching. They should be trained and encourage to use Problem-Solving teaching strategy.
2. Principals of secondary schools should encourage their Chemistry teachers through sponsorship to attend refresher courses and other forms of in-service training to enable them acquire the needed skill that can help them use or apply different strategies in the classroom teaching and learning. Thus help eradicate mediocrity among Chemistry teachers and expose them to a wide range of methods which can enhance their teaching in classroom situation.
3. Authors of Chemistry textbooks should present the content and concepts alongside the worked examples using Problem -Solving.

References

1. Adebola, S. F. (2011). Effect of Behavioural objectives on Students Achievement in Senior Secondary mathematics Instruction when used as an advance organizer. American Journal of Scientific and Industrial Research. Accessed on 6/7/2011from : http://www.scihub.org/AJSR.
2. Adegoke, B.A. (2017). Effect of Explicit problem-solving instruction on secondary school
3. students' achievement in Physics. International Journal of Scientific Research in Education. 10(1), 87-101. Retrieved (27/12/2019) from http://www.ijsre.com.
4. Awodun, A.O. (2015). Effects of Problem-Solving Teaching Strategy on Secondary School
5. Students' Academic Achievement in Physics. European Modern Studies Journal. 4(3), 21-29.
6. Avaa, A. (2007). Improving Performance in the Sciences. A Support Paper Presented at a Workshop held at Federal Government Girls College Zaria.
7. Boris, O.O. (2016). Effects of reflective teaching on secondary school students' learning outcomes (attitude and achievement) in Chemistry in Ondo State Nigeria. An Unpublished Ph.D Thesis. Ekiti State University, Ado-Ekiti, Ekiti State.
8. Elif, I. (2018). An overview of Problem-Solving studies in Physics Education. Journal of
9. Education and learning. 7(4), 191-200.
10. Eke, G.E. (2008). Regulatory Mechanism for Sound Chemicals Management. A paper presented at the 1st Manadatory Training workshop of ICON in Lagos, Nigeria
11. Federal Republic of Nigeria (2007). National Policy of Education (revised Lagos. NERDC Press
12. Gok, T, & Silay,T. (2010). The effects of problem solving strategies on students' Achievement, Attitude and Motivation. Lat Am. Journal of Physics Education, 4(1), 20-26.
13. Ifeanyi-Uche, U.P. and Ejabukwa, C. (2013). Inquiry based Method and Students Academic Achievement in Secondary School in Home Economics. International Journal of Social Sciences and Education. 2(1).
14. Jegede, S.A (2003). Effects of Component Task Analysis Model of Instruction on Students Performance in Chemistry. Unpublished Ph.D Thesis, University of Ado Ekiti Nigeria.

15. Lioyd, M.M., William, W.C., Megan, L., Jacinta, M.& George, A. (2004). The effect of using an explicit general problem-solving teaching approach on Elementary pre-serve teachers' ability to solve heat transfer problem. International Journal of Education in Mathematics Science and Teaching. 2(3), 164-174.
16. Ntibi, J.E. and Neji, H.A. (2018). Effect of problem-solving method of Teaching on students academic performance in Physics and Chemistry in Calabar municipality, CRS, Nigeria. Global Scientific Journal. 6(2), 121-140.
17. Nwagbo, C. R. (2007). Developing observational and drawing skills in teacher's for effective Conduct of Biology practicals. Science Teachers' Association of Nigeria Biology Panel series, 1-9.
18. Olayemi, O.O (2009). Students' Correlates and Achievement as Predictors of Performance in Physical Chemistry. ABACUS: The Journal of Mathematics Association of Nigeria 34(1), 99 – 105.
19. Sansawal, D.N (2009). Use of ICT in Teaching Learning and Education. Paper Presented at the Central Institute of Educational Technology, NCERT, New Delhi and State Institute of Education, Chandigarh.
20. Serap, C., Gamze, S.S. and Mustafa, E. (2010). Effects of the problem-solving strategies
21. instruction on the students' Physics Problem-Solving performance and strategy usage. ScienceDirect. Procedia Social and Behavioural Sciences. 2(2010).