Effects of Problem-Solving Teaching Strategy on Secondary School Students' Academic Achievement in Physics

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Abstract. The study investigated the Effects of Problem-Solving teaching Strategy on secondary school students' academic achievement in Physics in Ekiti State, Nigeria. The study employed two-group pretest-posttest quasi experimental design comprising of one experimental (Problem-Solving) group and a control group. Purposive and stratified random sampling techniques was used to select a total sample of 120 SS II Physics students (this sample was divided into experimental and control groups in ratio 1:1) from three Senior Secondary Schools in Ekiti West Local Government Area, Ekiti State. Three null hypotheses were formulated and tested at 0.05 level of significance. The instrument for this study was Physics Achievement Test (PAT) and the treatment packages used for the study was Problem-Solving Instructional Package (PSIP). 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' achievement 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 achievement in Physics in Senior Secondary School. Based on the findings of the study, conclusion and recommendations were made.

Keywords: problem, problem-solving, academic achievement and instructional package

Introduction

The teaching-learning process is as old as human being on the earth. It has been carried out by human beings and even by animals, to teach their young ones for successful adjustment to existing conditions in their environments (Owoeye, 2017). Teaching as conventionally understood by the traditional teacher, is just the act of disseminating information to learners in the classroom. An observation of the traditional classroom teaching reveals that either the teacher is delivering information, or one of the students is reading from the text book and other students are silently following him in their own text books. Conventional teaching is simply chalk-talk approach in which students remain passive as learners. Instruction is not properly organized and rote learning is heavily emphasized. Mostly, the results of the students are not satisfactory due to the use of this approach.

According to Elif (2018) at every stage of our lives, we encounter various problems, which can sometimes be difficult, and we strive to solve these problems. While trying to solve these problems, either we apply strategies that we used to solve similar problems before or use different approaches. According to Mataka, Coben, Grunert, Mutambuki & Akom (2014) cited in Adegoke (2017) that among the lifelong learning skills that students of all ages need to acquire is Problem-Solving. Individuals solve different types of problems of varying complexities throughout their life cycle. Some of the problems are well-structured while others are ill-structured (Jonassen, 2010).

According to Haury (1993) cited in Abubakar and Danjuma (2012), students' achievement in the school situation can be measured by the degree of success attained in a specific area of learning. The more students score highly in test of achievement, the more the conclusion reached that the teachers are doing well in teaching the subject.

According to Elif (2018), 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.

Atun (2001) cited in Serap, Gamze and Mustafa (2010), 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).

According to Ntibi and Neji (2008), 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.

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) defined 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 surveys on Problem-Solving strategy indicate that most students are not capable enough in acquiring knowledge independently and in the application of this knowledge to solve everyday life problems (Tomar, 2005). Johanining (2006) suggested a Problem-Solving strategy to use in classroom setting as follows:

1 Establishing a content for interest incorporating Problem-Solving in lesson;
2 Teaching a variety of heuristics e.g. organizing data in tables making drawing or diagrams working back toward solutions may be helpful in solving the problem. The similar solutions can be applied to new problems;
3 Starting with simple problems makes it easier for students to solve the next problem quickly as their confidence is raised;
4 Reward students for little successful steps such as small words of praises: again and again, and given positive comments like rewards for students. On the other hand, during the problem solving process suggestions or hints can also help the students;
5 Record the used tactics for problem solving in a journal way may be compiled with the help of students;
6 Provide sufficient time to solve problem;
7 Guide the students in simplifying numbers given in the problem; and
8 Help students to reduce reading difficulties.

This strategy helps the teacher to develop right attitude towards science among the students. 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. 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 (Wikipedia, 2019). 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), 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.

Mataka, Cobern,Grunert, Mutambuki and Akom (2014) cited in Adegoke (2017), Problem-Solving as view by cognitive psychologists, encompasses self-analysis, observation, and the development of heuristics. Abubakar and Danjuma (2012) cited Garrett (1987) 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 and 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 and 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.

Furthermore, Scrap, Gamze and Mustafa (2010) in their study on the effects of the problem solving strategies instruction on the students' Physics Problem-Solving performance and strategy usage found out that all students in class participated in problem-solving activities perform better than their counterparts in the control group. In addition, Abubakar and Danjuma (2012) in their study on the effects of explicit Problem-Solving strategy on students' achievement and retention in senior secondary school Physics found out that explicit Problem-

Solving strategy was better than traditional lecture method in enhancing student achievement in senior secondary school Physics.

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).

According to Adegoke (2017), Physics is filled with equations and formulas that deal with such concepts and topics as angular motion, fluids and fluid motion, forces, moments of inertia, linear motion, projectile motion, thermodynamics, and work and energy. Many concepts in Physics are explained by using equations and formulas, therefore for a student to perform well in Physics he or she must have ability to use these equations and formulas to solve numerical problems.

Physics is among the three major pillars of science (i.e. Physics, Chemistry and Biology). The importance of Physics for the development of a nation is, therefore, glaring. Physics is the most basic of the sciences and its concepts and techniques underpin the understanding of other disciplines: A thorough understanding of mechanics is necessary to the chemists and the material scientists since the structure of every atom in the universe is determined by mechanics. There is no doubt that a good part of the scientific knowledge is derived from the principles of Physics. Indeed, the knowledge of Physics has led to so many inventions such as the production, application and utilization of integrated circuits, production and use of machines and other contrivances. It also accounts for the discovery and production of hydroelectric power, gas turbine and thermonuclear power plant, telephones, refrigerators, heaters and gas/electric cookers (Awodun, 2015).

A number of factors have been identified militating against students' attainment of the objectives of science (Physics in particular) instruction, and the most pronounced factor identified by researchers is the inappropriate and uninspiring teaching methods adopted by science teachers (Ali, 2015). In addition, Ugwuanyi (2006) asserted that the teaching of science has been blamed for poor achievement probably resulting from poor retention. Similarly, Derry (2002) opined that the teaching strategies have been advocated, but still inappropriate teaching strategy remains a major problem of teaching and learning of Physics. For instance, students generally are exposed to lecture method without gaining conceptual understanding or developing problem-solving skill (Larking, 2001). In addition, Abubakar and Danjuma (2012) cited Maloney (2006) that many Physics students have difficulty in applying appropriate Problem-Solving techniques to solve given problems. Similarly, Achufusi (2015) opined that the ignorance of teachers and the neglect of activity-oriented methods by teachers grossly contributed to students' low performance in Physics.

Therefore, this study is intends to examine the effects of Problem-Solving Teaching Strategy on Students' academic achievement in Secondary School Physics in Ekiti State, Nigeria.

Research Hypotheses

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

Ho_1. There is no significant difference in the achievement mean scores of students in experimental and control groups before treatment.

Ho_2. There is no significant difference in the achievement mean scores of students in experimental and control groups after treatment.

Ho_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 design afforded the researcher the opportunity to collect relevant data which helped to facilitate better understanding and evaluation of the problem under study. 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 One (SS1) in Ikere Local Government Area of Ekiti State. Purposive and stratified random sampling techniques was used to select a total sample of 120 public senior secondary class one (SS I) Physics students (this sample was divided into the experimental and control groups in ratio 1:1 meaning that, 60 students from each group) from four senior secondary schools in Ikere Local Government Area, Ekiti State. The instrument used for the study was thirty (30) standardized objective questions tagged: 'Physics Achievement Test (PAT)' drawn from the topic (Measurement, dimension, motion and kinematics) 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	60	14.15	4.12			
Experimental	60	13.89	3.57	118	0.369	1.976

Note. P > 0.05 (Result Not significant at 0.05 level), NS = Not Significant.

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} = 0.369) 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	60	21.38	3.76			
Experimental	60	27.95	1.02	118	13.074	1.976

Note. P < 0.05 (Result Significant at 0.05 level). * = Significant.

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} = 13.074) 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	2330.287[a]	4	388.381	74.742	.000
Intercept	4938.342	1	4938.342	950.360	.000
Pretest	6.295	1	6.295	1.212	.273
Gender	3.536	1	3.536	.681	.411
Group	2257.667	2	1128.834	217.239	.000
Gender * Group	.507	2	.253	.049	.952
Error	898.957	173	5.196		
Total	128260.000	180			
Corrected Total	3229.244	179			

Note. P > 0.05 (Result Not significant at 0.05 level), NS = Not Significant, and * = Significant

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 Physics academic achievement. ($F_{2,173}$ = 0.049, 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 Physics.

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 impart 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 Physics. 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 Physics 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 Physics.

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 Physics 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 Physics. 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 potent in improving students' academic achievement in Physics 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 Physics 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 Physics teaching. They should be trained and encourage to use Problem-Solving teaching strategy.

2. Principals of secondary schools should encourage their Physics 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 Physics teachers and expose them to a wide range of methods which can enhance their teaching in classroom situation.

3. Authors of Physics textbooks should present the content and concepts alongside the worked examples using scaffolding strategy.

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