
EFFECTS OF EXPLICIT PROBLEM-SOLVING STRATEGY ON STUDENTS' ACHIEVEMENT AND RETENTION IN SENIOR SECONDARY SCHOOL PHYSICS

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Abstract

The study determines the effects of Explicit Problem-Solving strategy on students' achievement and retention in senior secondary school physics. Solomon four group design was employed in the study, which involved 80 students randomly selected from SSII and assigned to the various group in the design. Pretest-Posttest-retention test were administered to both the experimental and the control group with an interval of four weeks between the posttest and retention test. 3-Way Analysis of Variance was used for data analysis and the result revealed that Explicit Problem-Solving Strategy is better than lecture method in improving both achievement and retention in Senior Secondary School physics.

Key Words: *Problem-Solving, Achievement, Retention, and Explicit Problem-Solving Strategy*

Introduction

Problem-solving has long been recognized as a skill that fosters a better understanding of scientific and mathematics concepts (Aina, 1986; and Garrett, 1987). It can be an excellent tool to encourage the learning process. Its development should therefore be a vital part of education and the physics classroom could be the right place for it to happen. This is based on the fact that, problem-solving involves processes that incorporate varying levels of thinking, judgment, comprehension, analyses, critical thinking, visualization and conceptualization (Adam, 1979).

Problem-solving also plays an important role in developing regulative and transformative skills. The transformative skills are: observing the problem, questioning, hypothesizing, planning and investigation, analyzing and interpreting data, communicating results. The regulative skills are: planning, monitoring, evaluating one's studying (Dejong, & Ferguson-Herssler, 2003).

Problem-solving requires application of a previously learned theory by the solver (Heller, Keith and Anderson, 1992; Schultz & Lockead, 1992; Foster, 2000). This requires analytical capacity that is a capacity to analyze a problem and solve it. Explicit Problem-Solving Strategy (EPSS) has detailed strategy that can help improve student problem-solving performance better than traditional method (Mestre, Dufresne, Gerace, Hardiman, and Touger 1993; Heller, Keith, and Anderson 1992; Van Heuvelen, 1991a & b; Wright and Williams, 1986; Heller and Reif, 1984; Larkin and Reif, 1979). It has five (5) steps as follows; Focus a problem, describe the problem, Plan the solution, Execute the plan and evaluate the solution.

As the literature on problem-solving is reviewed, the basic problem-solving strategy is a linear, hierarchical process. Each step is a result of previous step and originator to next step. Teaching with problem-solving strategy involves the use of "stage models". Stage models are simplified lists of stages and steps used in general problem-solving (Johnson, 1994). Polya's prescription for solving problems consists of four steps (adapted from Polya, 1957):

1. Understanding the problem (Recognizing what is asked for)

Example approaches for doing so: Asking yourself, "What am I looking for?" or "What information is given in the problem?"

2. Devising a plan for solving the problem (Responding to what is asked for)

Example approaches for doing so: Asking you, "Do I know a similar problem?", "Can I restate the problem?"

3. Carrying out the problem (Developing the result of the response)

4. Looking Back (Checking. What does the result tell me?)

Looking back may be the most important aspect of teaching problem-solving because it provides students the opportunity for checking the calculations and result or try to get the same result using a different method (Schoenfeld, 1985).

Students' achievement in the school situation can be measured by the degree of success attained in a specific area of learning (Haury 1993). The more students score highly in test of achievement, the more the conclusion reached that the teachers are doing well in teaching the subject. Abinbola, (1986) defined under achievement as "the

short fall between level of attainment as predicted by students known or measured intellectual ability and actual performance". On the other hand, poor performance is considered as learner's inability to complete or fulfill an aim in learning situation.

Momoh – Olle (1997) states that retention is how much a person remembers after an interval of time without practice. Eylon & Reif (1984) reported that studies on the effect of knowledge organization on task performance have shown that a hierarchical presentation of information improves the ability of students to solve certain types of problems. An explicit problem-solving strategy that involves the hierarchical presentation is the ability to understand some physical relations such as definitions or laws (Reif, 1979).

The ultimate aim of learning or acquisition of knowledge is that a high percentage of what is learned be retained, easily recalled and applied. To achieve this, the learning material must be presented in hierarchical order and a way that makes it relevant to personal experiences of the learner. This will guarantee meaningful learning and an acceptable level of retention of the learned materials.

In Nigeria, the teaching of science has been blamed for poor achievement probably resulting from poor retention (Ugwuanyi, 2006). Several teaching strategies have been advocated, but still inappropriate teaching strategy remains a major problem of teaching and learning of physics (Derry, 2002). For instance, students generally are exposed to lecture method without gaining conceptual understanding or developing problem-solving skills (Larkin, 2001). Likewise many physics students still have difficulty in solving problems and continue to use novice (inexperience) problem-solving techniques rather than more advanced ones (Maloney, 2006).

Literature review on physics education studies also shows that four classroom-based instructional strategies have been used in physics problems-solving activities. These include the Wright & Williams (1986) WISE Strategy, Van Hevelen (1991a & b) Overview Case Study, Huffman's (1994) Minnesota Problems-Solving Strategies and the Explicit Problem-Solving Strategies by Heller, Keith, and Anderson (1992) and Huffman (1997). A critical analysis of these studies shows that the first three strategies produce very little improvement in students' problem-solving achievement in physics (Mc Dermott, 2000). The Explicit Problem-Solving Strategy (EPSS) on the other hand has been used on cooperative group at the university level and was found to significantly improve the students' conceptual understanding as well as problem-solving skills in physics. Therefore, the need for more empirical studies in order to find out the effect of the strategy at secondary school level.

Purpose of the Study

The purpose of this study was to determine the effect of Explicit Problem-Solving Strategy (EPSS) on Senior Secondary School (SSS) students' Achievement and Retention in physics. The study also sought to ascertain the influence of gender on retention of students in SSS physics.

- a. Determine whether Explicit Problem-Solving Strategy will be better than lecture method in improving students' achievement in Senior Secondary School physics and therefore enhancing students' learning outcome.
- b. Determine Whether Explicit Problem-Solving Strategy will be better than lecture method in improving students' retention in Senior Secondary School physics and therefore increasing students' retention ability.

Research Questions

For the purpose of this study, the following research questions were answered.

- a. Will explicit Problem-Solving Strategy be better than lecture method in improving students' achievement in physics?
- b. Will explicit Problem-Solving Strategy be better than lecture method in improving students' retention in physics?

Research Hypotheses

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

H₀₁ There is no significant difference in the post-test achievement mean scores of students taught physics using Explicit Problem-Solving Strategy and those taught using lecture method.

H₀₂ There is no significant difference in the retention means scores of students taught physics using Explicit Problem-Solving Strategy and those taught using lecture method.

Research Design

A Solomon four group design involving two experimental and two control groups was adopted for the study. The design is diagrammed as follows;

G ₁	R	Y ₁₁	X	Y ₁₂	Y ₃₁
G ₂	R	Y ₂₁		Y ₂₂	Y ₃₂
G ₃	R		X	Y ₂₃	Y ₃₃
G ₄	R			Y ₂₄	Y ₃₄

G₁, G₂, G₃, G₄ = Groups, R = randomization, Y₁₁, Y₂₁ = Pretest, X = Treatment, Y₁₂, Y₂₂, Y₂₃, Y₂₄, = Posttest, Y₃₁, Y₃₂, Y₃₃, Y₃₄ = Testing for retention.

Sample

From the design, the experiment requires four groups. Each group consisted of 20 students half of whom were male and the remaining half, female. The total number of sample students involved in the study was 80 SSII students. The two senior secondary schools from Bauchi state were sampled using simple random sampling. The selection of the students was also done using simple randomization approach. This was achieved by listing all numbers from which the selection is to be made and use table of random numbers to select the participants. The assignment into experimental and control group was done using same randomization approach. In this case yes and no was written on piece of papers for the student to pick, those that picked yes were assigned into the experimental group, while those that picked no were assigned into the control group.

Instrument for Data Collection

The researcher developed the instrument, which was validated by relevant experts and used for pre-achievement test, the post achievement test and the retention test. The instrument used for the pre-achievement test, post achievement and test for retention is the same fifty (50) items of physics achievement test (PAT) that covers the topics “Heat Energy and Measurement of Heat Energy”. The

reliability coefficient 0.66 was found using test re-test technique.

Treatment

Before the two experimental and control groups were subjected to instruction, one of them each was pretested. The instruction was on heat energy and measurement of heat energy using Explicit Problem-Solving Strategy (EPSS). Control groups were taught using lecture method all by their regular physics teachers. At the end of the treatment of four (4) weeks, all the four groups were posttested. After another four weeks, all the groups were tested again to measure retention over time.

Method for Data Analysis

The research questions were answered using mean and standard deviation, while the hypotheses were tested at 0.05 – level of significance using analysis of variance.

Results

Research Question 1 & Ho₁

Will explicit Problem-Solving Strategy be better than lecture method in improving students’ achievement in SSS physics?

Table 1: Achievement Mean and Standard Deviation of the Experimental and Control Groups.

Variable	N	X	SD
Experimental	40	65.87	2.281
Control	40	58.05	1.280

Table 1 showed the mean difference between the two groups (Experimental and Control), with experimental group having the mean of 65.87 and control group 58.05 with all having almost the standard deviation of 2.28. This revealed difference in the achievement mean score of the two groups, indicating that explicit problem-solving strategy was

better than lecture method in improving students’ achievement in physics.

Ho₁: There is no significant difference among the posttest achievement mean score of students taught using explicit problem-solving strategy and those taught using lecture method.

Table 2: Analysis of Variance of the Overall Posttest Achievement Scores.

Source of Variation	SS	Df	MS	F _{cal}	F _{crit}
M	1224.6	1	1224.6		
Error	15132.9	78	208.4	5.88	3.92
Total	16726.9	79			

From Table 1, the experimental group obtained the mean of 65.87 and standard deviation of 2.28 while control group obtained a mean of 58.05 and standard deviation of 2.28. From Table 2, at 0.05 – level and df = 1 and 78, F_{cal} > F_{crit}. Thus hypothesis Ho₁ was rejected. Which means that there was significant difference among the mean achievement scores of students taught physics using explicit

problem-solving strategy and those taught using lecture method? This result supported the answer to research question 1 that is explicit problem-solving strategy was better than traditional lecture method in enhancing student achievement in senior secondary school physics.

Research Question 2 & Ho₂ Will explicit Problem-Solving Strategy be better than lecture method in

improving students' retention in SSS physics?

Table 3: Retention Mean and Standard Deviation of the Experimental and Control groups.

Variable	N	X	SD
Experimental	40	67.50	1.85
Control	40	57.20	1.85

Table 3, shows the mean difference between the two groups (Experimental and Control), with experimental group having a mean of 67.50 and control group 57.20. This represents a slight difference in the retention mean score of the two groups, indicating that explicit problem-solving strategy was better than lecture method in improving students' retention of physics.

Ho₂: There is no significant difference among the retention mean score of students taught using explicit problem-solving strategy and those taught using lecture method.

Table 4: Analysis of Variance of the Overall Retention Scores

Source of Variation	SS	Df	MS	F _{cal}	F _{crit}
M	2205	1	2205		
Error	10507	78	136.7	16.13	3.92
Total	12823	79			

Table 4 shows that, the experimental group obtained a mean of 67.50 and standard deviation of 1.848 while the control group obtained a mean of 57.20 and standard deviation of 1.85. From table 4 above, at 0.05 – level and df = 1 and 78, F_{cal} > F_{crit}. Thus hypothesis Ho₂ was rejected. That means, there was significant difference among the retention mean scores of students taught physics using explicit problem-solving strategy and those taught using lecture method. The answer to the research question 2 is that, explicit problem-solving strategy was better than traditional method in enhancing students' retention in senior secondary school physics.

Discussion of Findings

The findings revealed that explicit problem-solving strategy was better than lecture method in enhancing student achievement in senior secondary school physics. The result agree with that of Heller & Reif, (1984) on laboratory based studies who found that student taught by explicit problem-solving strategy performed significantly better in mechanics than those in the control group. The result is also consistent with the findings reported by (Van Weeren, de Mul, Peters, Kramers-Pals, and Roossink, 1982) on classroom based studies who found that students in restructured course around problem-solving strategy giving explicit suggestions to help in interpreting problem situation did significantly better than their peers in convectional course. It is also in agreement with the work of Heller, Keith and Anderson (1992) on classroom based studies who found that students taught using the five steps of

explicit problem-solving strategy in a cooperative group setting were significantly better than the students in the control group.

The finding also revealed that explicit problem-solving strategy is superior in enhancing retention than lecture method. This finding is supported by that reported by Johnson (1974) who found that prior knowledge of topic influence positively long-term retention. Momoh-Olle (1997) also found that advance organizers enhance long-term retention in physics.

Conclusion and Recommendations

The findings and discussion of this study serve as the basis for making the following conclusion. Explicit problem-solving strategy is significantly better than traditional lecture method in enhancing achievement and retention in physics. This shows that, the understanding of physics requires the rise of active learning strategies that encourage students to be involved actively in the learning process, while the teacher plays the role of a facilitator of learning. It is also deducible that hierarchical approach in physics teaching will improve retention in physics. Therefore, Physics teachers in senior secondary schools should endeavor to use explicit problem-solving strategy (EPSS) so that students' achievement and retention could be enhanced. School administrators should provide physics teaching materials and equipment for classroom activities. Students should be encouraged to learn physics through the use of appropriate teaching methods that are capable of arousing the learners' interest in the subject.

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