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THE EFFECTS OF THREE PROBLEM-SOLVING MODELS ON THE ACQUISITION OF LABORATORY SKILLS BY SENIOR SECONDARY PHYSICS STUDENTS

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ABSTRACT

This work aimed at comparing the facilitative effects of three problem-solving models on students' acquisition of basic laboratory skills such as cognitive, manipulative, observational and computational. The models involved are selvarantnam - Frazer's model (SPSM), Laboratory problem solving model (LAPSOM), and the Traditional practical physics pattern (TPPP). A total of one hundred and one senior secondary one (SS1) physics students in three randomly selected schools were used for the study. The result showed that LAPSOM is the most important model in facilitating the acquisition of all the skills considered except manipulative. This was followed by SPSM. All the three models were found to be at the same level in facilitating the acquisition of manipulative skill. Considering a consistent poor performance of physics students in practicals, one of the main implications of this study is that practical physics performance of students can be improved through the use of LAPSOM.

Some researches have tried to define "problem-solving" in a number of ways to include: Bridging a gap between problem and solution states (Jackson, 1975); using information and reasoning to overcome obstacle or barrier (Mette, et. al, 1980); and a consequence of distinct acts referred to as content and process (Jochem, 1981). Although no two definitions of the concept of problem-solving has exactly the same connotation, a careful analysis of the definitions reviewed shows the following common features: (i) two things exist - the problem and the solution; (ii) the problem-solver is active; (iii) the problem-solver needs to possess relevant information about the problem; (iv) the problem-solver needs to think and reason in line with his previous knowledge and the nature of the problem; and (v) the problem-solver needs to be able to apply every previous and intuitive knowledge in solving the problem.

It is by the ability to solve problems that learning can be most meaningful evaluated. Problem-solving is therefore an ultimate aim of learning. Research findings (Asenuga, 1971; Tamir, 1977; Ogunniyi, 1977; and Onwioduokit 1992) have shown that patterns of laboratory work in schools do not facilitate students' acquisition of laboratory skills in science. In order to solve this problem, problem-solving models have been developed for use in science laboratories. These include Ashmore et al's (1979), Mette's et al's (1981), Selvarantnam - Frazer's (1982), Egbugara's (1989) and Onwioduokit's (1992) models. A careful analysis of these models show similarity in heuristics involved. These are: (a) identifying and structuring problem (b) collecting and selecting information; (c) researching for relationships and formulating hypotheses which lead to solution; and (d) verifying the solution. However, there is no study that shows that these models have different facilitative effects. This problem warrants the comparison of the effects of three problem-solving models on the acquisition of laboratory skills. The results obtained could help in the choice of a particular model to use in teaching secondary school practical physics in Nigeria. The present study therefore intends to determine the relative facilitative effects of the models with respect to acquisition of some basic laboratory skills, viz, cognitive, manipulative, observational and computational.

Delimitation of Study:

Of all the problem-solving models/patterns reviewed, the present study is delimited to the use of three, viz, selvaratnam - Frazer's problem-solving model (SPSM) developed by Selvarantnam and Frazer (1982); Laboratory problem-solving model (LAPSOM) developed by Onwioduokit (1992); and the Traditional practical physics pattern (TPPP) - a pattern commonly used in schools. These are chosen because of their orientation toward physics practicals. LAPSOM is a five - staged model designed to aid in solving practical physics problems in secondary school. The problem-solver using the model is expected to undertake much of preliminary analyses of the problem situation. SPSM on the other hand, is a four -staged model designed primarily to solve theoretical problems in chemistry. It lacks much provision for preliminary analysis of practical problem situation. The TPPP is the traditional way practical physics is taught in schools. It is basically a

cook-book practical model. Moreover, only some basic laboratory skills - cognitive, manipulative, observational and computational are considered, measured and evaluated in the study.

Hypothesis:

The study tested a null hypothesis that there exists no significant difference between selvarantnam - Frazer's model (SPSM), laboratory problem solving model (LAPSOM) and the Traditional physics pattern (TPPP) in their facilitation of students' acquisition of cognitive, manipulative, observational, and computational skills.

Research Instruments:

The three practical physics conditions used in the study were those created through the use of Selvarantnam-Frazer model (SPSM), laboratory problem-solving model (LSPSOM) and the traditional practical physics pattern (TPPP). The first two, are four and five staged models respectively developed and validated for solving theoretical and practical problems respectively, in science. Another instrument used in the study was the Diagnostic Test (DIAT). This was researcher-made and aimed at ascertaining the theoretical background knowledge of the subjects in relation to the practical physics problems posed. In line with the problems, the content of DIAT was cored on mechanics and optics. These two areas are among the recurrent domains of WAEC practical physics examination questions. Moreover, most schools which lack equipment for practicals in other branches of physics tend to concentrate on mechanics and optics where equipment are more readily available. There were a total of twenty (20) objective questions and the reliability index using kuder-Richardson Formula - 21, was found to be 0.79. For each laboratory skill, there was both pretest and posttests. These were collectively called practical physics pre and post tests (PPET and PPOT). It was in attempt to solve the problems posed in these tests that different skills exhibited were evaluated. The PPET was face-validated by a group of experts and the reliability index of 0.93 was obtained using kuder α Richardson Formula - 21.

Population and sample:

All senior secondary one (SS 1) students in Uyo municipality of Akwa Ibom State constituted the population from which the sample used in this study was drawn. Schools in the municipality were chosen on the basis of availability of well equipped physics laboratories. This condition was necessary to ensure that students were familiar with practical work. Out of six qualified schools in the area, three were randomly chosen for the study. All SS 1 physics students in the chosen schools constituted the sample. Subjects in the study were assigned to experimental and control groups on the basis of the schools they belong. This assignment was carried out at the school level using a random sampling procedure. On the whole, one hundred and one (101) subjects took part in the study.

Research design:

A pretest - posttest non-randomised group design was used for the study. This is shown structurally as follows:

$$\begin{array}{l} 0_1 X_1 0_1 (E_1) \\ 0_3 X_2 0_4 (E_2) \\ 0_5 X_3 0_6 (C) \end{array}$$

Where 01, 03 and 05 are pretest scores of the first and second experimental and control groups, respectively. 02, 04 and 06 are posttest scores of the first and second experiment, and control groups, respectively. X1, X2 and X3 are practical physics conditions created by SPSM, LAPSOM and TPPP respectively. E1 = First experimental group E2 = Second experimental group C = control group.

General procedure:

This included: (i) training of observers (ii) training using treatment conditions; and (iii) administration of tests. four observers were trained in each school. The training process involved the observers watching three SS 3 physics students set up and manipulate apparatus in determining the effect of length and mass of a pendulum on its period. The students performed the experiment individually while the observers, who had been thoroughly briefed on the use of laboratory performance code (Onwioduokit, 1990), watched and graded them individu-

ally. An inter-observer agreement of 0.90 was obtained before allowing them to grade the students in pre and post tests. The three models for solving problems (SPSM, LAPSOM and TPPP) constituted the treatment conditions in the study. The treatments based on the first two models were administered by the researcher while that based on the third was administered by physics teachers in each of the schools. These teachers did not need any special training because they were already familiar with the conventional pattern. However, for uniformity, the following guidelines were provided: (i) stating aim of the investigation (ii) providing the theoretical background to include general principles and the mathematical expression necessary for solving the problem; and (iii) teacher demonstration. Besides this specification, the usual detailed instruction associated with traditional pattern was given to subjects in the control group. Exercises used in training sessions were different from the one used in the main study, though of comparable manipulative and difficulty level. Three training sessions (one hour each) were required for 80% of the subjects in the two experimental group to attain a criterion score of 70% before the posttest was administered. These percentages were chosen in accordance with the mastery learning requirement (Block, 1974). On the other hand, only two similar training sessions were required for subjects in the control group to attain the above criterion score. This was, perhaps, because the subjects in this group had already been familiar with the traditional pattern (being what is mostly used in schools). All training started two days after the administration of the practical physics pretest (PPET) and included student's use of an answer booklet (Onwioduokit, 1989). The training was done during morning hours of every other day. It lasted for three days in each group. In the afternoon of every training day, the subjects were allowed to practice the use of the models in solving practical physics problems. The problems designed for this purpose were (a) determining the value of acceleration of free fall using simple pendulum (mechanics) (b) determining the relationship between $\sin i - \sin r$ and $\sin r$ (optics). After each attempt, answer booklets were corrected and graded against the criterion score. Appropriate remediation was provided. Two days after the attainment of criterion score, the post

test (PPOT) was administered to all groups. A simple analysis of covariance (ANCOVA) was employed in analyzing the data. For each skill, pretest scores were used as covariates.

TABLE 1: ANALYSIS OF COVARIANCE ON POST TEST SCORES ON COGNITIVE, MANIPULATIVE, OBSERVATIONAL, AND COMPUTATIONAL SKILLS.

MEASURES	SCORE	SS	DF	MS	F	DEC AT .05 ALP LEV
Cognitive Skills	Between within Total	5008.9	2	2504.5	122.2	**
		2011.7	98	20.5		
		7020.5	100			
Manipulative Skill	Between within total	132.7	2	66.4	2.7	*
		2399.3	98	24.5		
		2532.0	100			
Observational Skill	Between within total	1168.7	2	584.4	42.0	**
		1365.3	98	13.7		
		2534.0	100			
Computational Skill	Between within total	190.2	2	95.1	12.2	**
		769.1	98	7.3		
		959.3	100			

** Significant at $p < .001$

* not significant at $p < .05$
critical F -value = 3.09

As shown in Table 1 above, significant differences were observed to exist between subjects exposed to the three practical physics conditions in their acquisition of cognitive skill ($F_{2, 98} = 122.8, P < .001$); observational skill ($F, 98 = 42.0 P < .001$); and computational skill ($F_{2, 98} = 12.2, P < .001$). This means that the three problem-solving models that created the practical physics conditions have different facilitative effects in helping students acquire cognitive, observational and computational skills. However, there was no significant difference between the subjects and their acquisition of manipula-

tive skill at .05 alpha level. This mean that the three models were of the same facilitative effect in this skill. To ascertain that the significant differences occurred beyond chance, scheffe multiple comparison test was employed for a post hoc analysis as shown in Table 2

TABLE 2: SUMMARY OF THE SCHEFFE'S POST HOC ANALYSIS ON LABORATORY SKILLS SCORES

Measure	Comparison	Observed q - value	Decision at .05 alpha level
Cognitive skill	LAPSOM Vs SPSM	7.42	LAPSOM>SPSM
	SPSM Vs TPPP	17.30	
	LAPSOM Vs TPPP	28.49	
Manipulative skill	LAPSOM Vs SPSM	1.60	LAPSOM=SPSM
	SPSM Vs TPPP	0.05	
	LAPSOM Vs TPPP	1.80	
Observational skills	LAPSOM Vs SPSM	5.49	LAPSOM>SPSM
	SPSM Vs TPPP	3.80	
	LAPSOM Vs TPPP	11.19	
Computational skill	LAPSOM Vs SPSM	4.34	LAPSOM>SPSM
	SPSM Vs TPPP	1.52	
	LAPSOM Vs TPPP	5.76	

1. LAPSOM = Laboratory problem - solving model
2. SPSM = Selvarantnam - Frazer's problem - solving model
3. TPPP = Traditional practical physics pattern

4. Critical q - value = 2.68

As shown in Table 2 above, for all, except manipulative, skills, the order of effectiveness of the problem - solving models in facilitating students' acquisition of laboratory skill was found to be LAPSOM > SPSM > TPPP. LAPSOM has the most facilitating effect while SPSM ranks second. The three problem - solving models used were found to be at the same level of facilitation with respect to manipulative skill (LAPSOM = SPSM = TPPP).

DISCUSSION AND CONCLUSION:

The main question in this study was whether or not students exposed to practical physics conditions created by SPSM, LAPSOM and TPPP will differ significantly in their acquisition of some basic laboratory skills such as Cognitive, manipulative, observational and computational skills. As shown in Table 1, significant differences were found between students exposed to the conditions created by the three models/patterns in the acquisition of all the skills considered except manipulative skill. The order of facilitation was found to be: LAPSOM > SPSM > TPPP for cognitive, observational and computational skills. The three models thrived at the same level in facilitating manipulative skill acquisition.

The superiority of LAPSOM and SPSM over TPPP may have, perhaps, been due to the cookbook nature of TPPP which has almost no provision for reflective and creative thinking. The superiority of LAPSOM over SPSM may have resulted from the practical basis of LAPSOM. SPSM was developed mostly for theoretical problems although adaptable to practical conditions.

The lack of significant difference in the effectiveness of the three problem - solving models with respect to students' acquisition of manipulative skill may be attributed to the fact that most students could have already been familiar with the handling of the apparatus.

From the findings of this prototype study, it is necessary to further investigate the facilitative effects of LAPSOM relative to other models. Moreover, influence of factors like reasoning ability, cognitive style, problem-solving attitude and mathematical ability of learners on the

acquisition of basic laboratory skills, should be investigated.

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