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Effects Of A Target-Task Problem-Solving Model On Senior Secondary School Students' Performance In Physics

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ABSTRACT

This study investigate the Effects of a Target-Task Problem-Solving Model on Senior Secondary School Students' Performance in Physics In this study, quasi-experimental design was used. The target population for the study comprises 8 Government Senior Secondary School two (SSII) Physics Students in Gwagwalada Area Council, FCT Abuja The sample of the study comprised of 166 student, 87 males and 79 females. Physics Achievement Test on Motion and Force (PAMF) of 24 items was used for trial testing, data collected was analyzed using Cronbach Alpha to obtain 0.97reliability coefficient after validation. The experimental group was exposed to the Target-Task Problem-Solving Model while lecture method was used for the control group. The experimental and control groups were pre-tested in the first week of the research after which the treatment was applied and post-testing took place in the sixth week using physics achievement test on motion and force (PAMF). The data collected were analysed using mean, standard deviation and analysis of covariance (ANCOVA) to test the research questions and hypotheses raised at an alpha level of 0.05. The study revealed that the Target-Task Problem-Solving Model enhanced performance of students creativity in problem solving and observational skill. On the basis of findings, it is strongly recommended that physics instructors should use explicit problem solving instruction in their lessons to develop students' problem solving performance and the related outcomes such as course achievement and Government should transform the textbooks of physics into problem based learning form because the traditional textbooks do not meet the criteria of problem solving approach. And further suggested that more research should be considered to investigate the effect of Target-Task Problem Solving Model in other Physics concepts to verify this result on observational skills of students which has not so common in the existing literature in order to strengthen this result.

KEY WORDS: *Problem Solving, Observational Skills, Target-Task*

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I. INTRODUCTION

Engaging learners in the excitement of science, helping them discover the value of evidence-based reasoning and higher-order cognitive skills, and teaching them to become creative problem solvers have long been goals of science education reformers. But the means to achieve these goals, especially methods to promote creative thinking in scientific problem solving, have not become widely known or used (Robalt, 2009). In most college courses, instructors teach science, especially, which suppose to be activity oriented, primarily through lectures and textbooks that are dominated by facts and algorithmic processing rather than by concepts, principles, and evidence-based ways of thinking. This is despite ample evidence that many students gain little new knowledge from traditional lectures (Hrepic & Zollman, 2007). Moreover, it is well documented that these methods engender passive learning rather than active engagement, boredom instead of intellectual excitement, and linear thinking rather than cognitive flexibility (Halpern and Hakel, 2003; Nelson, 2008; Perkins and Wieman, 2008). Cognitive flexibility, as noted, is one of the three core mental executive functions involved in creative problem solving (Ausubel, 2000). The capacity to apply ideas creatively in new contexts, referred to as the ability to "transfer" knowledge (Mestre, 2005), requires that learners have opportunities to actively develop their own representations of information to convert it to a usable form.

What capacities students should learn is of great concern to educators in order to facilitate the acquisition of necessary skills in physics that can be used across diverse subjects in science as physics is known to be bed rock of technology and engineering. Csikszentmihalyi (1988) suggests that problem finding and problem solving might require opposite cognitive strategies. Problem solving can be viewed as a choice between existing programs or sets of mental rules, whereas problem finding is the detection of the need for a new program based on a choice between existing and expected future programs (Mackworth, 1965). Problem finding may be most closely related to originality in creative thinking in science. More specifically, for creative achievements, problem solving is necessary but not sufficient; rather, these achievements might largely rely on the discovery of problems, which is often a restriction of the problem by viewing things from different perspectives (Dillon, 1982; Runco & Sakamoto, 1999).

Several models of the creative process have identified the recognition of problems as the first important step to creatively solve problems, and have suggested that problem-finding ability may be more difficult to cultivate than problem-solving ability (Lubart, 2001; Mumford, 2003). Creative Problem Solving (CPS) outlines six steps for effectively generating solutions and solving problems: mess finding, data finding, problem finding, idea finding, solution finding, and acceptance finding (Baer & Kaufman, 2006). Mumford and colleagues (1991) proposed several core processes in creative problem solving, including problem construction, category search, specification of categories, idea evaluation, and actual implementation. This model highlights the importance of convergent and divergent processes, and holds that problem construction, category search, and category combination in particular are essential for generating new ideas.

Despite the important work that has been done on problem finding, problem solving is still widely viewed as the most important topic in creativity scholarship (Hennessey & Amabile, 2010; Simonton, 2006). Indeed, for most psychologists, "problem solving has taken first place as almost synonymous with creative thinking", insight is an important aspect of problem solving, whereby people go beyond their experience and overcome misleading facts by restructuring the presentation of a problem (Dominowski & Dallob, 1995).

Most models of creative problem solving, in short, emphasize either a hierarchical or nonlinear stage decomposition (Hélie & Sun, 2010). One of the most influential theories of creativity is known as Geneplore (Finke, Ward, & Smith, 1992), which proposes that the creative process consist of two distinct components: a generative process and an exploratory process. The first stage is to construct mental representation via memory retrieval, association, and analogy. Then, these pre-inventive structures are transferred into the exploration—a process of interpretation and evaluation—by means of attribute finding, conceptual interpretation, and hypothesis testing to interpret and evaluate these structures. Mumford & Gustafson (1988) contend that creativity can be viewed as a syndrome involving five attributes: (a) the process underlying the individual's capacity to generate new ideas or understandings; (b) the characteristics of the individual facilitating process of various ideas; (c) the characteristics of the individual that facilitate the translation of these ideas into action; (d) the attributes of the situation conditioning the individual's willingness to engage in creative behavior; and (e) the attributes of the situation influencing evaluation of the individual's productive efforts.

A major goal of a base physics course for science and engineering majors is to enable students to develop complex reasoning and problem solving skills to explain and predict diverse phenomena in everyday experience. However, numerous studies show that students do not acquire these skills from a convectional method of teaching (Hake, 1998). The problem can partly be attributed to the fact that the kind of reasoning that is usually learned and employed in everyday life is not systematic or rigorous. Although such hap-hazardous reasoning may have little measurable negative consequences in an individual's personal life, it is insufficient to deal with the complex chain of reasoning that is required in rigorous scientific field such as physics.

Educational research suggests that many base physics students solve problems using surface clues and cues, applying concepts at random without thinking whether they are applicable or not (Hake, 1998). Also, convectional methods of instruction do not explicitly teach students effective problem solving strategies skills in physics. Rather, they may reward inferior problem solving strategies in which many students engage. Instructors often implicitly assume that students know that the analysis, planning, evaluation, and reflection phases of problem solving are as important as the implementation phase. Consequently, they may not discuss these strategies explicitly while solving problems during the lecture. There is no mechanism in place to ensure that students make a conscious effort to interpret the concepts, make qualitative inferences from the quantitative problem solving tasks, or relate the new concepts to their prior knowledge. In order to develop scientific reasoning by solving quantitative problems, students must learn to exploit problem solving as an opportunity for knowledge and skill acquisition.

Thus, students should not treat quantitative problem solving merely as a mathematical exercise but as a learning opportunity and they should engage in effective problem solving strategies.

The importance of the study of physics cannot be overemphasized as it forms the basis for technological advancement of any nation. It is based on this that it is imperative to improve on method of instruction in science education especially to make physics an activity based method of instruction. Therefore, this research is set to look at the effect of a Target-Task-Problem Solving Model on Secondary School Students' creativity skills in physics. Specifically, the study examined;

1. the creativity in problem solving skills in students performance in physics
2. The creativity in problem solving skills in male and female students performance in physics.
3. creativity in observational skills in students performance in physics.
4. the creativity in observational skills in male and female students performance in physics.

II. RESEARCH QUESTIONS

The following research questions were raised to guide the study:

1. What is the mean performance scores of secondary school students in physics problem solving skills taught with Target-Task Problem Solving Model and those taught with lecture method in Gwagwalada Area Council of FCT, Abuja.
2. What is the mean performance scores between male and female secondary school students in physics problem solving skills taught with Target-Task Problem Solving Model in Gwagwalada Area Council of FCT, Abuja.
3. What is the mean performance scores of secondary school students in physics observational skills taught with Target-Task Problem Solving Model and those taught with lecture method in Gwagwalada Area Council of FCT, Abuja.
4. What is the mean performance scores between male and female secondary school students in physics observational skills taught with Target-Task Problem Solving Model in Gwagwalada Area Council of FCT, Abuja.

Research Hypotheses

From the above questions, the following have been hypothesized:

HO_1: there is no significant difference in mean problem solving skill scores on physics students performance when taught with Target-Task Problem Solving Model and those with lecture method in Gwagwalada Area Council of FCT, Abuja.

HO_2: there is no significant difference in male and female mean problem solving skills scores on physics students performance when taught with Target-Task Problem Solving Model in Gwagwalada Area Council of FCT, Abuja.

HO_3: there is no significant difference in mean observational skills scores on physics students performance when taught with Target-Task Problem Solving Model and those with lecture method in Gwagwalada Area Council of FCT, Abuja.

HO_4: there is no significant difference in male and female mean observational skills scores on physics students performance when taught with Target-Task Problem Solving Model in Gwagwalada Area Council of FCT, Abuja.

2.0 Research Design

The study was a quasi-experimental study using a non-randomized, non-equivalent pre-test and post-test control group design. The quasi-experimental design was used because a true randomization of subjects was impossible since intact classes were used. The target population of the study consisted of all senior secondary school physics students year two (SSII). The sampled population consisted of 166 students , 87 males and 79 females. The variables used in this study are independent variables of the model of learning (Target-Task problem solving model and Lecture method) and dependent variable of creativity skills of the subjects. Experimental group was subjected to some selected topics using Target-Task problem solving model while the control group was also exposed to the same topics but with lecture method of teaching.

The instruments used for the study was physics achievement test on motion and force (PAMF) constructed by the researcher. The instructional package (Lesson notes on the Target-Task Problem Solving Model) was used by the researcher for the experimental group while control group was taught by the classroom teacher with lecture method. The physics achievement test contained 24 items drawn from the concepts on Motion and Force, each item has five options with one correct answer, it was validated and used for trial testing, data collected was scored, converted to 100% and analyzed using Cronbach Alpha (SPSS version 21) to obtain 0.97 reliability coefficient.

The study lasted for a period of six weeks. The experimental and control groups were pre-tested in the first week of the research after which the treatment was applied and post-testing took place in the sixth week using physics achievement test on Motion and Force (PAMF). The data collected were analysed using mean, standard deviation and analysis of covariance (ANCOVA),

2.1 Treatment

This study developed the learning activities in the following ways. First, it started with the common teaching activities, like questioning, giving examples, explaining phenomenon and doing experiments. In the past, teachers would ask questions and give explanations, but now students are asked to do these tasks. In short, the first method is reversing the role of teachers and students, that is, changing teacher activities in convectional classroom to student activities.

Second, it induces more freedom of exploration and self-directed elements into the inquiry, discovery and problem-solving process. In the past, teachers gave detailed guidelines and procedures and students do the 'cook-book' experiments, but now teachers ask students to design both the purposes and methods of the experiments, Students are given some ill-structured and daily-life problems to start the inquiry or problem-solving work. The tasks have room for diversified answer, and yet, they are simple and can be completed quickly in classroom (at least for the thinking part of it) or independently at home. To achieve this, the original creative problem solving and open inquiry model are simplified, and simple procedure are put down in worksheet form.

Third, this study purposely induced divergent thinking in nearly all tasks suggested. In the past, teachers were contended with one or a few correct answer in student work, but now teachers encourage the expression of fluency, flexibility, novelty and elaboration in student work. For simple tasks, a large number of answers are requested to stimulate fluency. The tasks would request either 10 or more answers in individual work, and 20 or more answer in group work. Sometimes, they simply state that 'give as many answer as possible'. For difficult or complicated tasks, only one single but novel and imaginative answer is requested. In fact, the number of answers requested depends on the difficulties of the questions. For encouraging flexibility and elaboration, students are explicitly asked to give more different categories of answer, to change directions, or to give more details and elaborations of the answers. In short, common tasks can also foster divergent thinking abilities, provided additional instructions on answering are given.

In strict sense, the above three methods are not creating totally new instructional designs, but modifying existing ones to give more room for creative thinking. The instructional designs include questioning in reverse manner, asking students to redesign some standard experiments, rewrite standard theories or ideas, adding and eliminating some well-accepted things. To encourage imagination, students are asked to make predictions and answer some 'suppose' or 'what if' questions. To encourage creativity and sensitivity, teachers asked students to make use their five senses and intuition to make quess, to discover phenomenon, problems, uncertainties, discrepancies and changes that are difficult to be discovered.

III. RESULT AND DISCUSSION

Research Question One

What is the mean performance scores of secondary school students in physics problem solving skill taught with Target-Task Model and those taught with lecture method.

Table 1.1: Posttest Mean and Standard Deviation Scores of Physics Achievement Test between Experimental and Control group on a Problem Solving Skills.

Group	N	Mean ($\overline{X}$)	Std. Deviatn	Mean Different
Experimental	88	86.60	10.32	
Control	78	63.31	14.25	23.29
Total	166	75.66	16.94	

The table shows the posttest analysis of experimental and convectional (lecture) teaching method group. The mean of the experimental group was 86.60 and standard deviation of 10.32 while the lecture method had a mean achievement of 63.31 and standard deviation of 14.25. The result shows a mean difference of 23.29 between the experimental and control group. It therefore meant that, the experimental group that received treatment with Target-Task-Problem Solving Model had a higher mean than the group which received instruction using lecture method.

Research Question Two

What is the mean performance scores between male and female secondary school students in physics problem solving skills taught with Target-Task Problem Solving Model.

Table 1.2: Posttest Mean and Standard Deviation Scores of Physics Achievement Test between Male and Female Performance in Problem Solving Skills in the Experimental group.

Group	N	Mean ($\overline{X}$)	Std. Deviatn	Mean Different
Male	45	88.22	10.98	
Female	43	84.91	9.41	3.32
Total	88	86.60	10.32	

The table 1.2 shows the posttest analysis of Male and Female Performance in Physics Achievement Test in the Experimental group. The mean of the male group was 88.22 and standard deviation of 10.98 while the mean of the female group was 84.91 and standard deviation of 9.41, the result shows a mean difference of 3.32 between the male and female of the experimental group in favor of male students.

Research Question Three
What is the mean performance scores of senior secondary school students in physics observational skills taught with Target-Task model and those taught with lecture teaching method.

Table 3.3 Posttest Mean and Standard Deviation Scores of Physics Achievement Test between Experimental and Control group on an Observational Skills.

Group	N	Mean ($\overline{X}$)	Std. Deviatn	Mean Different
Experimental	88	86.60	10.32	
Control	78	67.15	15.66	19.45
Total	166	77.46	16.29	

The table shows the posttest analysis of experimental and control group. The mean of the experimental group was 86.60 and standard deviation of 10.32 while the control group had a mean achievement of 67.15 and standard deviation of 15.66, the result shows a mean difference of 19.45 between the experimental and control group. It therefore meant that, the experimental group that received treatment with Target-Task- Problem Solving Modelhad a higher mean than the group which received instruction with lecture method.

Research Question Four
What is the mean performance scores between male and female secondary school students in physics observational skills taught with Target-Task Problem Solving Model.

Table 1.4: Posttest Mean and Standard Deviation Scores of Physics Achievement Test between Male and Female Performance in Observational Skills in the Experimental group.

Group	N	Mean ($\overline{X}$)	Std. Deviatn	Mean Different
Male	45	92.07	9.42	
Female	43	85.33	10.33	6.74
Total	88	88.77	10.38	

The table 1.4 shows the posttest analysis of Male and Female Performance in Physics Achievement Test in the Experimental group. The mean of the male group was 92.07and standard deviation of 9.42 while the mean of the female group was 85.33 and standard deviation of 10.33, the result shows a mean difference of 6.74 between the male and female of the experimental group in favor of male students.

Null Hypotheses
Hypothesis One: there is no significant difference in mean problem solving skill scores on physics students performance when taught with Target-Task model and those with lecture method.

Table 2.1 : Summary of ANCOVA Comparism of Experimental and Control Group on Problem Solving Skills.

Source	Type III Sum of Squares	ofDf	Mean Square	F	Sig.
Corrected Model	8968.625[a]	1	8968.625	9.264	.003
Intercept	738978.685	1	738978.685	763.35	.000
Group(Experiment&control)	8968.625	1	8968.625	9.264	.003
Error	319462.339	330	968.068		
Total	1079978.000	332			
Corrected Total	328430.964	331			

The table shows a significant effect $F(1, 331) = 9.264$, $P < 0.05$. on this basis, the hypothesis was rejected. Therefore, there was significant difference between the mean problem solving scores on physics students performance when taught with Target-Task- Problem Solving Model and those with lecture method.
Hypothesis Two: there is no significant difference in male and female mean problem solving skill scores in physics students performance when taught with Target-Task Problem Solving Model.

Table 2.2 : Summary of ANCOVA Comparison of Male and Female Physics Students scores in Problem Solving Skills performance when taught with Target-Task Problem Solving Model.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	52.698[a]	1	52.698	.041	.841
Intercept	46224.743	1	46224.743	35.628	.000
Group (M & F)	52.698	1	52.698	.041	.841
Error	225754.552	174	1297.440		
Total	708600.000	176			
Corrected Total	225807.250	175			

The table shows a significant effect F(1, 175) =0.041, P > 0.05. The result was not significant at P< 0.05 and hypothesis was retained. Therefore, the Target-Task Problem Solving Model had no significant effect on the Posttest achievement scores of male and female students. This implies that there is no statistically significant difference existing within the two groups.

Hypothesis Three: there is no significant difference in mean observational skill scores on physics students performance when taught with Target-Task model and those with lecture method.

Table 2.3: Summary of ANCOVA Comparism of Experimental and Control Group on Observational Skill.

Source	Type III Sum ofSquares	Df	Mean Square	F	Sig.
Corrected Model	10572.829ª	1	10572.829	11.974	.001
Intercept	889392.672	1	889392.67	1007.299	.000
Group(Experiment &control)	10572.8292	1	10572.829	11.974	.001
Error	291372.834	330	882.948		
Total	1206342.000	332			
Corrected Total	301945.663	331			

The table shows a significant effect F (1, 331) = 11.974, P < 0.05. on this basis, the hypothesis was rejected. Therefore, there was significant difference between the mean observational skill scores on physics students performance when taught with Target-Task- Problem Solving Model and those with Convectional teaching method.

Hypothesis Four: there is no significant difference in male and female mean observational skill scores in physics students performance when taught with Target-Task Problem Solving Model.

Table 2.4: Summary of ANCOVA Comparison of Male and Female Physics Students scores in Observational Skills performance when taught with Target-Task Problem Solving Model.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1770.018ª	1	1770.018	1.612	.206
Intercept	80021.762		80021.762	72.898	.000
Group (M & F)	1770.018	1	1770.018	1.612	.206
Error	191002.709	174	1097.717		
Total	771916.000	176			
Corrected Total	192772.727	175			

The table shows a significant effect F (1, 175) = 1.612, P > 0.05. The result was not significant at P < 0.05 and hypothesis was retained. Therefore, the Target-Task Problem Solving Model had no significant effect on the Posttest achievement scores of male and female students in Observational Skills. This implies that there is no statistically significant difference existing within the two groups.

IV. DISCUSSION ON THE FINDINGS

The results of this study revealed that instruction of Target-Task Problem Solving Model was effective for enhancing physics achievement in problem solving and observational performance. Both groups showed significant improvements from pretest to posttest. As the effect sizes of the instruction given to both groups were compared, it was seeing that both instruction was effective on increasing the students' achievement, however, the effect size of the instruction applied on the experimental group to achieve problem solving skills with the mean difference of 23.29 high than the effect size of the instruction applied on the control group, the mean difference to achieve observational skills is 19.45 in experimental higher than that of convectional (lecture) method. Although being the instruction applied on the control group also effective on increasing the students' achievement was an expected result of the research, in this context it may be commented that the students in the control group may have unconsciously developed their problem solving skills in order to improve their creativity in learning. Because, during the research, it was observed that the students in the control group also participated voluntarily into problem solving process substantially, and they were eager to solve the problems. And being the instruction applied on the experimental group more effective than the instruction applied on the control group is a natural result of the strategy instruction.

In classroom observations, it was observed that the students in experimental group reviewed the learning materials in order to solve the problems, asked questions from instructor who executed the lecture, and requested help. By means of the problem solving activities, active participating of the students to the problem solving instructions was obtained. Activities based instruction require a student to use previously learned knowledge to solve a problem and identify their own learning deficiencies, and the environments which can maintain them to realize their learning deficiencies were obtained. Hence, using an explicit problem-solving instruction can help students' achievement more than traditional problem solving exercises.

Having positive effect of the Target-Task Problem-Solving Model instruction on problem solving performance supports various research findings which determine that the activities based instruction increased the performance in physics and in science (Olaniyi & Omosewo 2015, Adeniran 2011, Suleiman 2010) had come to this conclusion that strategy instruction was effective on problem solving performance. In chemistry (Sutherland 2002, Jeon & Huffman 2005) and in mathematics, Montague & Bos 2008, Montague 2002) obtained similar findings in their research that students exposed to activity based instruction performed better than those exposed to convectional teaching methods.

The result was not significant at $P < 0.005$in creativity skills in term of problem solving, observation, logical reasoning and predictive skills acquired between male and female when exposed to Target-Task Problem-Solving Model instruction in experimental group. Therefore, Target-Task Problem-Solving Model instruction package produced no significant effect on the posttest achievement scores of male and female students when covariate effect (pretest) was controlled. This implies that there is no statistically significant different between the male and female students. This was in disagreement to the findings of Brewton (2011), Gonzuk & Chagok (2001) and Nwosu (2001), who through the use of different problem-solving strategies found that male students outperformed female students.

V. CONCLUSION

This study provides some evidences of the effects of using Target-Task Problem Solving Model instruction on students' physics achievement to acquired problem solving skills and observational skills in physics, In comparison, explicit problem solving instruction was more effective in developing all aforementioned characteristics than conventional instruction. Explicit instruction fosters these student learning outcomes by engaging students actively in solving problems and becoming aware of every phases in this complex process. Regarding the experimental physics that was better than that of the conventional, the academics benefits should be extended and an instructional design framework should be made available for use by curriculum planners, instructional designers, and all stakeholders in education. On the basis of findings, it is strongly recommended that physics instructors should use explicit problem solving instruction in their lessons to develop students' problem solving performance and the related outcomes such as course achievement. However, this study did not cover all concepts of Physics, it is limited to a specific theory skills and limited period was used for the exercise, however, if the number of the concept and period of the study were increased, it might have more impact on the effectiveness of the model and students achievement.

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