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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: The study investigated the Effects of a Target-Task Problem-Solving Model on Senior Secondary School Students' Performance in Physics. The research design was a quasi- experimental, non-randomized, non-equivalent pre-test, post-test using a control group. The study was conducted in two schools purposively selected and involved a total of 120 Senior Secondary School II students, 60 students per school. The experimental group was exposed to the Target-Task Problem-Solving Model while for the control group lecture method was used. 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 a performance test on Current Electricity (PTCE). The data collected were analysed using mean, standard deviation and analysis of covariance (ANCOVA), and the hypotheses put forward tested at an alpha level of 0.05. The study revealed that the Target-Task Problem-Solving Model enhanced performance of low scoring level male students. Other findings, implications, recommendations and suggestions for further studies were explored.

KEY WORDS: Problem-Solving, Target-Task Problem-Solving Model, Performance Test on Current Electricity, Gender.

INTRODUCTION

Modern technology leans heavily on Physics (Williams, 1990). The discipline is essential for the socio-economic and cultural development of a nation. As one of the basic sciences, physics is indispensable in the technological development of the nation. It is the increased understanding of physics that led to the development of modern aircraft, satellite communication systems and the computer among many others. Despite the importance of this subject to the development of a nation, both male and female students are still performing poorly in Physics especially at the West Africa Examination Council (WAEC) level (Omosewo, 2002). The following reasons had been identified for poor performance of students in physics: inadequate qualified physics teachers, abstract nature of physics

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concept, lack of ambition for students, poor mathematical background, method of teaching, problem-solving skills, lack of creativity in terms of improvisation, and poor background of the students at the elementary stage.

Research undertaken in different areas of physics showed that methods of teaching and problem-solving skills are major factors to be considered for better performance in the subject (Orji 2000, Brewton 2001, Gonzuk & Chagok 2001). Different methods and problem-solving models were used and they observed that the experimental group performed better than the control group, but their findings varied between the performance of male and female students. Also, the research by Sola, Portoles and Lope (2007) stated that mental capacity (m-space) is associated with students' ability to deal with problem-solving. There is a relationship between working memory capacity and science achievement. Students with high and low memory capacity are different significantly in their performance in chemistry. Suleiman (2010) and Achibong (1997) found that students exposed to an activities-based approach, like problem-solving, performed better in mathematics than those exposed to conventional teaching methods. Adeniran (2011) also observed that a physics specific problem- solving model enhanced better performance of high, medium and low scoring level students. This study was carried out to underscore the effects of a Target-Task problem-solving model in physics.

The state of affairs based on research results on teaching method showed that the strategies employed in teaching students were inconsistent and inconclusive (Adeosun, 1996). The concept of teaching, according to Mkpanang (2005), implied that it was a set of stimuli initiated and regulated by an individual who was professionally trained to do so. In this context, the physics teacher was one who had acquired a learned skill and who conformed to ethical standards within the teaching profession.

Mankilik (2005) indicated that the teaching of physics in schools should be concerned with an education, which should lead students to understanding physics terms and more importantly its technological aspects. However, Olowu (2006) believed that it was the general opinion that the instructional methods of disseminating knowledge to learners were inadequate to the students' needs. The difficulty encountered by students in learning physics was related to the method, which teachers used to teach the subject. The instructional methods used in most secondary schools were inadequate for achieving the desired objectives of teaching physics at that level.

Canter (2004) suggested the use of a problem solving model as a systematic approach that reviews students' strengths and weaknesses, identified evidence-based instructional interventions, frequently used to collect data to monitor students' progress and to evaluate the effectiveness of interventions implemented with students. When a problem-solving intervention was not successful in several education classrooms, the cycle of selecting intervention strategies and collecting data could be repeated with the help of a grade level intervention assistance or a problem-solving team. Rather than relying primarily on test scores (e.g. from an IQ or math test), the students' responses to general education interventions becomes the primary determinant of their need for special education evaluation services (Marston, 2002).

Canter (2004) opined that although problem-solving steps could be described in several stages, the steps essentially reflected a scientific method of defining and describing a problem, generating potential solutions and implementing, monitoring and evaluating the effectiveness of the selected intervention. Problem-solving interventions could make use of models adopted or developed for a specific set of learners in order to achieve a desired academic achievement. There were many models available for teaching and learning. Most of these were basically developed for mathematics and scientific problem-solving. These included, Johnson's model (1955), Polya's model (1957), Bingham's model (1958), Newell and Simon (1972), Wickelgren's model (1974), LeBlanc (1977), Lester's model (1980), Bransford and Stein (1984), Gick's model (1986), Rubenstein (1986), Schoenfeld (1992) and Webb's model (1997). The choice of a model for an intervention depended on the nature of the problem to be solved. Related to the teaching of physics, some of the multitude of educational problems were seen as; development of passivity, mis-representation, docile learning, dependence on the teacher and books, poor performance, absence of skills and appropriate scientific attitudes, dwindling interest and enrolment in physics (Adeniran, 2011). It was not sufficient to teach physics for the sake of knowledge, but there was a necessity for the acquisition of skills.

Teaching Approaches

Factors that contribute to the situation described above are many, but the most important is the method of teaching. There are different studies on the methods of teaching and their effects on students' performance. Several emphasize the need to shift from a formal method to informal method of teaching sciences especially for physics. Among these, Daramola (1994) notes that several methods are available for lesson presentations for which the choice depends on several other factors such as the learners' age, nature of the topics, class size, resources available and the period of the day when a particular lesson is to be taught.

Moog and Spencer (1999) studied a Process Oriented Guided Inquiry Learning (POGIL) method. They described POGIL as any number of students working in small groups on specially designed guided inquiry materials. These materials supplied students with data or information followed by leading questions designed to guide them toward formulating their own valid conclusions - essentially a recapitulation of a scientific method. The instructor served as facilitator, observing and periodically addressing individual and classroom-wide needs. The POGIL method has shown that teaching by telling does not work for most students. Also students who were part of an interactive community were more likely to be successful. Knowledge was seen as personal; students enjoyed themselves more and develop greater ownership over the material when they were given an opportunity to construct their own understanding (Moog and Spencer, 1999).

In another related study by Kocakaya and Gonen (2014), the influence of a computer assisted roundhouse diagram was examined on high school 9th grade students' academic achievements in the topic of "Force and Motion." The study was carried out in a public high school in Diyarbakir, a province in the Southeast of Turkey. The study pre-tested and post-tested the experimental and control groups using a multiple-choice achievement test of 20 questions related to the concept of Force and Motion. The lessons were taught to the control group students by carrying out the activities previously determined in the curriculum; in other respects, besides these activities, the lessons were taught to the experimental group students by forming roundhouse diagrams that included the subject-related concepts. The study showed that computer-assisted roundhouse diagrams had a significant effect on students' academic achievement in the subjects of "Force and Motion."

Huitt (1992) identified that most problem-solving models are in at least four phases, or stages, namely;

1. An input phase – at this stage a problem is perceived and an attempt is made to understand the situation or problem.
2. A processing phase, in which alternatives are generated and evaluated and solutions selected.
3. An output phase, which includes planning for and implementing the solution.
4. A review phase in which the solution is evaluated and modifications are made, if necessary.

He further stated that most researchers describe the problem-solving process as beginning with the perception of a gap and ending with the implementation and evaluation of a solution to fill the gap.

When students use the guided inquiry approach, they utilize processes that allow them to demonstrate the mental and physical behaviours of scientists. In the process, they learn more than discrete science concepts and skills. They learn a practical, useful approach to solving problems and answering questions. Willoughby (2005) stated that the inquiry process involves the following steps.

1. Observe a process or event.

2. Formulate questions based on observations.
3. Develop a workable hypothesis.
4. Devise a strategy for testing it.
5. Analyse and draw conclusions from collected data.
6. Communicate findings to others

The Target-Task Model

The trend of students' performance in physics over the years has been poor; hence the need for an activity-based approach to solving problems in physics. Problem-solving models in sciences and mathematics are many and they have been found to have different effects on students of varying academic ability. Different research has made use of problem-solving models to solve specific problems in order to improve student performance.

The Target-Task Model is an adaptation of the guided discovery method for teaching science. It involves presentation of a major problem, the solution of which requires the application of rules and principles, with which the students may not be familiar. It is expected that the teacher presents some solutions similar to the target task and guides the students to solve the problem. The Target-Task model involves six stages:

1. Pre-task: the teacher introduces the topic, explains the topic in detail and ensures the students understand what they are to do at the task stage.
2. Task: The students complete the task in pairs or groups, while the teacher monitors and offers encouragement.
3. Planning: Students prepare a written report on what they went through during the task in their group.
4. Report: The students make their reports available to the teacher for assessment. After correction, the teacher presents the report back to the students.
5. Analysis: The teacher highlights relevant parts of the learning on the board.
6. Practice: The teacher selects areas of practice for the students.

The research of Huitt (1992) and Willoughby (2005) are similar to the Target-task model used in this study both in the step-by-step approach and the presentation by the students.

This study sought to find the effect of the Target-Task Problem-Solving Model on students' performance base on their gender and scoring level.

Purpose of the Study

The main purpose of this study was to determine the effects of the Target-Task Problem-Solving Model on senior secondary school students' performance in physics. Specifically, the study examined;

i. Differences in the performance of high, medium and low scoring students taught using the Target-Task Problem-Solving Model.
ii. Differences in the performance of male and female students taught using the Target-Task Problem-Solving Model.

Research Questions

Three research questions were identified:

1. Is there any difference between the performance of students taught using the Target-Task Problem-Solving Model and those taught through lecture methods on a Performance Test on Current Electricity?
2. Is there any difference in performance of high, medium and low scoring students, identified through a Performance Test on Current Electricity, when taught using the Target-Task Problem-Solving model?
3. Is there any difference between the performance of male and female students taught using the Target-Task Problem-Solving model?

Research Hypotheses

The following research hypotheses were tested in this study;

HO1: There is no significant difference in the performance of students taught using the Target-Task Problem-Solving model and those taught using lecture methods on the Performance Test on Current Electricity.

HO2: There is no significant difference in performance of high, medium and low scoring students taught using the Target-Task Problem-Solving Model.

HO3: There is no significant difference between the performance of female and male students taught using the Target-Task Problem-Solving Model.

METHODOLOGY

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. The sampled population consisted of 120 senior secondary school physics students who were selected from two schools (60 students per school). School with at least one graduate teacher and at least 60 science students were purposively selected. The regular physics teachers undertook the teaching in the study.

The instruments used for the study were a Research Instructional Package and Performance Test on Current Electricity (PTCE). The instructional package (Lesson notes on the Target-Task Model and Lecture Methods) were made available for teaching the intact classes. The Performance Test on Current Electricity contained 10 items drawn from concepts on current electricity. It was validated and the reliability (coefficient of 0.84 was obtained using the Kuder-Richardson KR21 formula).

Design of the intervention

The study lasted for a period of six weeks. The first week of the study involves three activities, which were; training of the two teachers for a period of two hours per school, collection of terminal result for grouping students into scoring levels and pre-test using a researcher designed Performance Test on Current Electricity (PTCE). The teacher for the experimental group was exposed to the researcher designed instructional package (Target-Task Instructional Model), which contained a step-by-step guide to solving problems. The teacher of the control group was exposed to lesson notes on lecture methods. The students were taught the selected current electricity concepts for a period of four weeks, two periods per week with each period lasting for 40 minutes. The researcher was there during some periods of the teaching and learning to observe and to encourage the teachers so as to ensure appropriate use of the instructional package. In week six, the students undertook a post-tested using the same instrument (PTCE) as in the pre-test. The data collected were analysed using mean, standard deviation and analysis of covariance (ANCOVA).

The Treatment

The treatment was undertaken using the Target-Task Instructional Model (TIM). It involved six stages of problem-solving as stated by Frost (2004). The stages covered; Pre-task, Task, Planning, Report, Analysis and Practice.

1. Pre-task: At this stage, the teacher introduces the topic (the concept of current electricity), breaks the topics into units of instruction and let the students have an understanding of what they are expected to do in each unit. The teacher states the objectives of the instruction, explains the theory behind each problem without solving any of the problems and may recall relevant points

that can assist the students during the task. The pre-task also involves demonstration to the students of what they are expected to do during the task. The teacher also divides the students into groups of two, three and four depending on class size. The last part of this stage is for the students to take notes and get prepared for the task.

2. Task: At task stage, the teacher stays back and watches as the students perform the task by working in groups of two, three or a maximum of four. They solve problems using the knowledge acquire at the Pre-Task stage. This is the core stage in the target-task instructional model, because students solve both the mathematical and non-mathematical problems by combining the knowledge of group members. The students complete the task in pairs or groups using the apparatus or information given to them, while the teacher monitors and offers encouragement.
3. Planning and Presentation: Students prepare clearly written solutions of their developments, or the problem(s) they solved during the task in their groups. Each group leader steps forward at the same time to present the solution to the entire class. The solution is presented group by group to the entire class for other members of the class from different groups to make their contributions, offer corrections or criticize constructively.
4. Report: The students make their solutions available in the form of reports to the teacher for assessment. After correction, the teacher gives the report back to the students to allow them to see their mistakes or misconceptions.
5. Analysis: The teacher highlights major points of the lesson on the board, clarifies students' misconceptions and summarizes the lesson. The summary includes all undertaken in the class during the period.
6. Practice: The teacher selects areas of practice and assignments for the students. This may be in the form of definitions or calculations on aspect relevant to the topic discussed during the lesson. The students are expected to practice and solve the problems by performing the task, do the planning and present their reports (Frost, 2004).

DATA ANALYSIS AND RESULTS

Data analysis and results are presented based on the research questions and research hypotheses.

Research Question 1

Is there any difference between the performance of students taught using the Target-Task Problem-Solving Model and those taught by the lecture method, on the Performance Test on Current Electricity?

Table 1 Mean Scores of Students on the Performance Test on Current Electricity Based on the Instructional Model (N= 60 in both cases)

Treatment		Pre-Test Scores	Post-Test Scores	Mean Gain Scores
Target-Task	Mean	13.90	29.57	15.67
	Standard Deviation	5.911	12.191	
Lecture	Mean	11.32	12.30	0.98
	Standard Deviation	6.738	8.871	

Table 1 presents the mean scores of students. It can be concluded from the outcome that there is a difference in the performance between students taught with the target-task model and those taught using lecture methods. The treatment has a positive effect for the experimental group. The Chart in the figure further presents the difference in performance of students when tested with PTCE.

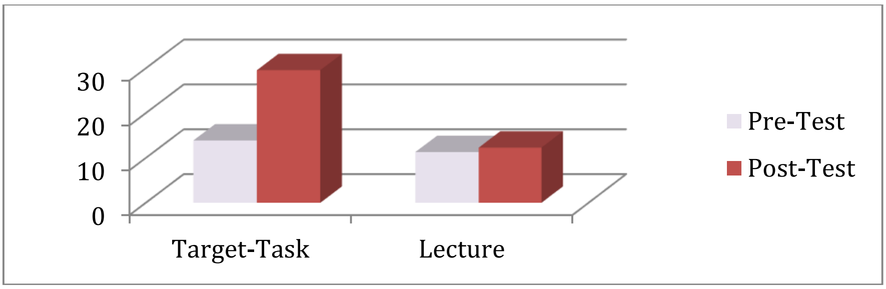

Figure 1 Bar Chart of Mean Scores of the Experimental Group and Control Group

Hypothesis 1

There is no significant difference in the performance of students taught using the Target-Task Problem-Solving model and those taught by the Lecture method on the Performance Test on Current Electricity.

Table 2 **Analysis of Covariance of Post-Test Score of Students Exposed to the Target-Task Problem-Solving Model and Lecture Methods on the Performance Test on Current Electricity (PTCE)**

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.
Corrected Model	8082.957[a]	2	4041.478	63.085	.000
Intercept	3001.219	1	3001.219	47.590	.000
Pretest	6032.823	1	6032.823	95.062	.002
Treatment	824.608	1	824.608	13.076	.012
Error	7378.510	117	63.064		
Total	93084.000	120			
Corrected Total	15461.467	119			

Table 2 shows the P value (.012) is less than the P alpha level of 0.050, ($P < 0.050$). This suggests that the Hypothesis HO1 needs to be rejected. There is a significant difference in the performance of students exposed to the Target-Task Problem-Solving models compared with the performance of students taught using a Lecture method.

Research Question 2

Is there any difference in performance of high, medium and low scoring level students taught using Target-Task Problem-Solving model?

Table 3 **Mean Scores of Students on the Performance Test on Current Electricity based on their Scoring Level Instructional Models**

Gender	Mean	Pre-Test	Post-Test	Mean Gain Score
High	Mean	20.37	45.70	25.33
	N	12	12	
	Standard Deviation	7.726	6.368	
Medium	Mean	18.40	33.67	15.27
	N	18	18	
	Standard Deviation	5.121	2.787	
Low	Mean	15.55	44.90	29.35
	N	30	30	
	Standard Deviation	3.357	5.601	

The mean gain scores reveal that low scoring students perform better than high scoring students. Hence, there are differences in performance of high, medium and low scoring level students taught using Target-Task Problem-Solving Model. Figure 2 further presents the relationship between pre-test and post-test scores of students based on their scoring level.

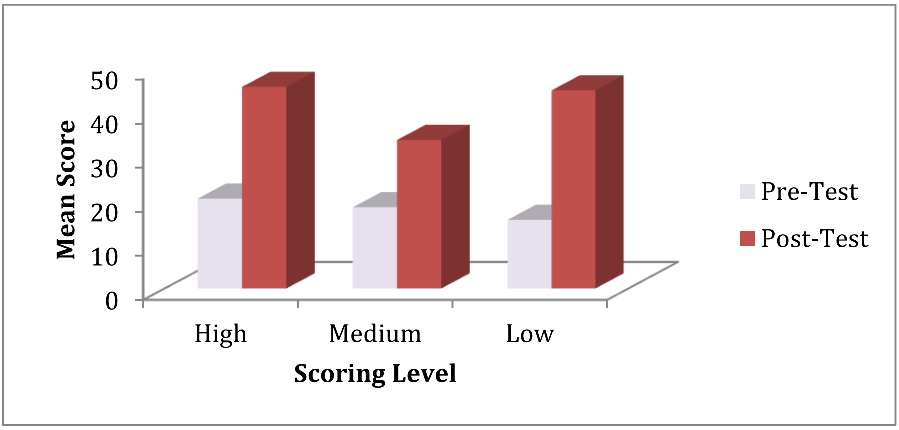

Figure 2 **Bar Chart of the Post-Test Mean Scores per Scoring Level for Students Taught Using the Target-Task Problem-Solving Model**

Hypothesis 2

There is no significant difference in performance of high, medium and low scoring students taught using Target-Task Problem-Solving models.

Table 4 **Analysis of Covariance on the Post-Test Scores of High, Medium and Low Scoring Level Students Taught Using the Target-Task Problem-Solving Model**

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.
Corrected Model	7613.722[a]	3	2537.907	123.049	.000
Intercept	3923.076	1	3923.706	190.208	.000
Pretest	332.856	1	332.856	16.138	.000
Scoring Level	3795.798	2	1897.899	92.018	.000
Error	1155.011	56	20.625		
Total	61220.000	60			
Corrected Total	8768.733	59			

Table 4 showed that the P value (0.000) is less than the P alpha level of 0.050 ($P<0.050$); therefore the null hypothesis is rejected. There is a significant difference in the performance of high, medium and low scoring students taught with the Target-Task Problem-Solving Model. Figure 2 further shows the relationship between mean scores of the students.

Research Question 3

Is there any difference between the performance of male and female students taught with Target-Task Problem-Solving model?

Table 5 Mean Scores of Students on the Performance Test for Current Electricity Based on Gender

Gender	Mean Score	Pre-Test Score	Post-Test Score	Mean Gain Score
Male	Mean	15.71	33.86	18.15
	N	29	29	
	Standard Deviation	6.944	13.263	
Female	Mean	12.71	25.55	12.84
	N	31	31	
	Standard Deviation	4.547	9.674	

Table 5 presents the mean scores of male and female students taught using the Target-Task Problem-Solving Model. The difference in mean gain scores of male and female students is 5.31. The figure presents the differences in scores of male and female students taught with Target-Task Problem-Solving Model.

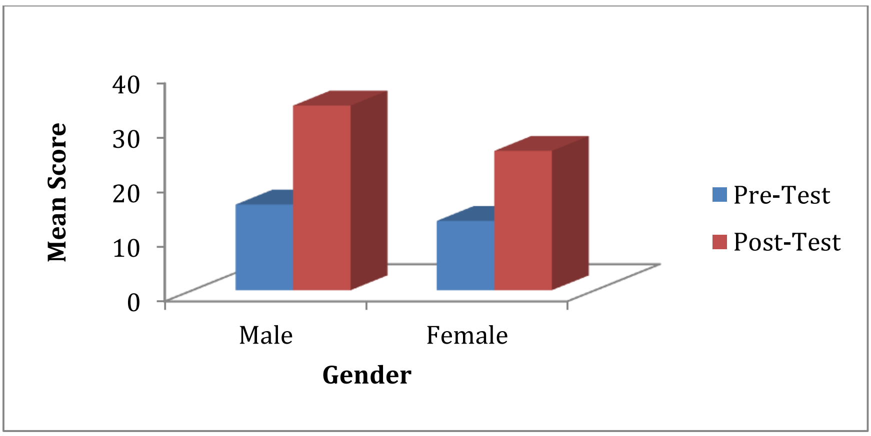

Figure 3 The Bar Chart Showing the Mean Scores of Male and Female Taught Using the Target-Task Problem-Solving Model

Hypothesis 3

There is no significant difference between the performances of female and male students taught using the Target-Task Problem-Solving model.

Table 6 Analysis of Covariance of the Post-Test Scores of Male and Female Students Taught Using the Target-Task Problem-Solving Model

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.
Corrected Model	4203.864[a]	2	2101.932	26.246	.000
Intercept	1254.583	1	1254.583	15.666	.000
Pretest	3168.256	1	3168.256	39.561	.000
Gender	385.939	1	385.939	4.819	.032
Error	4564.870	57	80.085		
Total	61220.000	60			
Corrected Total	8768.733	59			

Table 6 presents the result of analysis of covariance on the post-test mean scores of male and female students taught using the Target-Task Problem-Solving Model. The P value (.032) is less than the P alpha level of 0.050. ($P<0.050$), and shows that the null hypothesis needs to be rejected. There is a significant difference in the performance of male and female students taught using the Target-Task Problem-Solving Model.

DISCUSSION ON THE FINDINGS

The findings related to research question one showed that students taught with the Target-Task Problem-Solving Model performed better than those taught using lecture methods when exposed to the Performance Test on Current Electricity (PTCE). Hypothesis 1 also confirmed that there was a significant difference in the performance of students exposed to Target-Task Problem-Solving models and a Lecture method, This finding was in agreement with Harbor-Peter (1989) who found that the Target-Task Approach was more effective in teaching geometry concepts in mathematics than expository methods. The finding was also in line with Adeniran (2011), Suleiman (2010) and Achibong (1997) who found that students exposed to an activity based approach performed better than did students exposed to lecture methods. It was also in agreement with Moog and Spencer (1999) who found students exposed to Process Oriented Guided Inquiry Learning (POGIL) performed better than those exposed to conventional teaching methods.

It was also observed that there was a significant difference in the performance of low, medium and high scoring level students exposed to the treatment. Target-Task Problem-Solving model enhanced better performance among low scorers. This might be due to the fact that Target-Task Model encouraged active participation of students so that no student group was left out. All three scoring levels were able to interact thereby making the low scorer better able to learn. This finding was also in consonant with Adeniran (2011), who found that low scoring level students had the highest mean gain score in an optics performance test. The findings also showed a significant difference in the performance of male and female students taught using the Target-Task Problem-Solving Model. The male students performed better than female students. This was in agreement with Brewton (2011), Gonzuk and Chagok (2001) and Nwosu (2001), who through the use of different problem-solving strategies found that male students outperformed female students.

CONCLUSION

Both experimental and control groups took a post test using the Performance Test on Current Electricity (PTCE) after they had been taught by a different teacher for each group. It was concluded that the Target-Task Problem-Solving Model enhanced better performance of those students tested with current electricity performance test. The target-Task Model, being an activity-oriented model, also enhanced better performance among male students compared with female students. This might be because the male students had better affinity for such activities and an ability to work together as a team than female students. The model also enhanced better performance of low scoring level students. Table 3 recorded a mean gain score of 29.35 as against 25.33 and 15.27 for high and medium scoring level students respectively.

Recommendation

The following recommendations were made based on the findings from the research;

1. In a class where there are more male students and male students who are low scorers, physics teachers should endeavour to use the Target-Task Problem-Solving Model more often.
2. Physics teachers should endeavour to shift away from the use of lecture methods to using activity-based methods.
3. Pre-service physics teachers should be exposed to problem-solving models during their training in order to learn various models for teaching so as to enhance their ability to diversify and employ different models for problem-solving.
4. Efforts should be made to organize training and re-training programmes on the use of Target-Task Problem-Solving Models

in Physics for practicing teachers. This would enhance their teaching leading to better performances among students.

5. Textbook authors should endeavour to incorporate the Target-Task Problem-Solving Models of teaching when writing new editions of the textbook. This would encourage the use of the model by both teachers and students.

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