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Effect of Explicit Problem Solving Instruction on Secondary School Students' Achievement in Physics

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Abstract

In this study, the author examined the effect of explicit problem solving instruction on senior secondary school one students' (Age 16+) achievement in Physics. Pretest-posttest quasi experimental design was adopted. Two groups of students participated in the study; these were Experimental Group and Control Group. The experimental group received explicit instruction on solving problems while the control group did not receive explicit instruction for solving problem. Data were collected using Physics Achievement Test. Results indicate that giving explicit instructions on problem solving has positive effect on Physics Achievement. In this study, both boys and girls benefited from giving explicit instructions on problem solving. On the basis of the findings of this study, Physics teachers should give, to their students, explicit instruction on problem solving during lessons in order to enhance their students' achievement in Physics.

Keywords: Instruction, Problem solving, Problem solving technique, Physics Achievement, Problem solving skills, Secondary school, Nigeria.

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INTRODUCTION

In recent times, the level of performance of candidates in Physics in public examinations being conducted by the West African Examination Council (WAEC) and National Examination Council (NECO) has improved slightly. In Nigeria, for example, on the average, in the past five years (2011-2015) about 60% of the total candidates who sat the Physics Examinations passed at the credit and distinction levels. When compared with the results before 2011, there was an increase in the number of candidates who passed Physics. However, the ultimate has not been achieved. This is because, between 2011 and 2015, about 40%, on the average, of the candidates who sat the examinations failed Physics. This should be a source of concern to major stakeholders (Physics teacher, researchers, parents, and government) in physics education. After all nobody (parent) sends his or her child to school to fail.

Researchers in Physics education are expected to come up with plausible reasons why about 40% of the population of candidates failed. In addition, researchers in Physics education are expected to come up with the best ways of assisting all secondary school students who offer Physics, to not only learn Physics meaningfully but also do well in both public and school-based examinations. It is on the basis of this that researchers need to continually examine and critique the methods of teachings that are being employed by Physics teachers in the classroom.

According to Chief Examiners' Report WAEC 2011-2015, one of the reasons why some candidates failed Physics was their low level of problem solving skills. Specifically in the questions where candidates were expected to solve problems, most of the candidates were unable to handle correctly equations, formulas and arithmetic processes and conversion of units. More importantly most candidates display poor understanding of the theoretical bases of Physics concepts. These inadequacies have a link with the instructional strategies being employed by Physics teachers.

Examinations of the teaching strategies being employed by some Physics teachers show that classroom teachings and practical instructions are carried out using traditional lecture method and emphasis was always on finishing the syllabus at the specified time. Research (Adegoke, 2013; Chukwuneye & Adegoke, 2014) has shown that this strategy does not give enough opportunity for students to be actively engaged in teaching and learning activities and consequently students do not have a firm grasp of the fundamental and theoretical foundations of Physics concepts. The learner thus, acquires an unstable level of knowledge which is not transferrable to problem solving situation (Akuche, 2008; Çalişkan, Selçuk & Erol, 2010).

Among the lifelong learning skills that students of all ages need to acquire is problem-solving (Jonassen, 2010 in Mataka, Cobern, Grunert, Mutambuki & Akom 2014). Individuals solve different types of problems of varying complexities throughout their life cycle. Some of the problems are well-structured while others are ill-structured (Jonasssen, 2010). Normally, individuals meet these problems during formal education and informally in other endeavors. Mataka, Cobern, Grnert, Mutambuki, and Akom (2014) states, that, most often, during formal education, students encounter well-structured problems. These problems "engage a limited number of rules and principles that are organized in a predictive and prescriptive arrangement; possess correct, convergent answers; and have a preferred, prescribed solution process" (Johansen, 2010, p. 2). Although ill-structured problems are usually more difficult, some well-structured problems do pose a great challenge for students (Jonassen, 2010).

Generally problem solving involves defining a problem, collecting information related to the solution process, reasoning through the problem state to the solution checking and evaluating the solution. According to Dale and Balloti (1997), problem-solving skills cannot be inherited but can be learned and improved upon. Students learn better when they have opportunities to participate in the arranged activities directly, and when they succeed in solving the presented problems. Hence, education in the sciences must address the crucially important task of teaching students to become more proficient in problemsolving.

Cognitive interventions directed towards teaching of problem solving in a systematic way are called often called "strategy instruction" (Owen & Fuchs in Çalişkan, Selçuk, & Erol, 2010). By means of strategy of instruction programmes, students are facilitated and are able to follow a series of steps to simplify understanding and solve the problem. However, one of the most important instructional methods that have been used to address problem solving performance is explicit problem solving instruction, According to Huffman (1997), "explicit problem solving is instruction that directly teaches students how to use more advanced techniques for solving problems.

Schoenfield (2013, p. 11), as stated in Mataka, Cobern, Grunert, Mutambuki, and Akom (2014), believes that success in problem solving depends among other factors on the "individual's use of problem solving strategies, known as heuristic strategies." Heuristics help to "convert a non-procedural cognitive skill to a procedural one (VanLehn et al., 2004, p. 522). Metallidou (2009, p. 76) in Mataka, Cobern, Grunert, Mutambuki, and Akom (2014) define problem solving as a "goal-directed behavior [that] requires an appropriate mental representation of the problem and the subsequent application of certain methods or strategies in order to move from an initial, current state to a desired goal state."

Problem solving, as viewed by cognitive psychologists, encompasses self-analysis, observation, and the development of heuristics (Hardin, 2002 in Mataka, Cobern, Grunert, Mutambuki, and Akom (2014)). Cognitive psychologists (such as Sternberg, 1981; De Jong and Ferguson-Hessler, 1986) in their investigations on mental processes involved when individuals learn and solve problems stressed the need for knowledge organization in order to improve efficiency of its retrieval from the conceptual schemata during problem solving. According to Johnstone (1991) the hope is to organize and connect knowledge in long-term memory such that it is easily recalled when needed. This led to the development of cognitive approaches to solving problems. A notable cognitive psychologist, Polya (Hardin, 2002 in Mataka, Cobern, Grunert, Mutambuki, and Akom (2014), developed a stepwise model of problem solving. This included "(1) understand the problem, (2) devise a plan, (3) carry out the plan, and (4) look backward". These steps are not content specific hence are just referred to as general problem solving skills (Hardin, 2002 in Mataka, Cobern, Grunert, Mutambuki, and Akom (2014). Although Polya's steps seem to follow a linear path, researchers (such as Carson & Bloom, 2005) have found that the steps are actually cyclic in nature. In Carson and Bloom's (2005) study on how mathematicians approach problem solving, it was reported that mathematicians while solving problems, usually pass through one step, remember something, go back and check before proceeding. Carson and Bloom (2005) stated that when the solution was not acceptable during checking, the mathematicians usually returned to the planning phase.

Successful problem solvers understand the problem by initially constructing a description of the problem to help in the search of an appropriate solution (Reif, 1981 in Mataka, Cobern, Grunert, Mutambuki, and Akom (2014). This is done by translating the problem into an easily understandable form. This summary must include key concepts required to describe the problem. In physics, the statement of a problem is usually in some verbal form which requires a careful analysis to determine what the problem is, what the pertinent data are, and within what mathematical system and physics principles and laws one is working. In problem-solving students have to translate verbal statements of relationships into formulas by the use of letters symbols to represent the related elements and then use the relationship as expressed by the equation to solve problem. For example in linear motion, the Distance travelled equals rate of speed multiplied by time. When this is put into symbols we have: $d = v \times t$ (where d = distance, v = rate of speed and t = time). Finding the *d* may not be so difficult, but difficulties arise when the student is to find either the *v* or the *t*.

The difficulties inherent in problem-solving in physics fall into four distinct categories. These are:

- *comprehension,*
- *structure,*
- *operation, and*
- *judgment*

There are suggestions on the instructional patterns that the teacher can adopt to deal with each of the problems. In this study, the major focus is on testing the effectiveness of these instructional patterns on achievement of secondary school students in physics.

The first type of difficulty which many students face in problem-solving in physics is that of *comprehension*. Let us examine a question culled from Physics (Essay) Paper 2 May/June, WAEC, 2015 to illustrate the problems that some students encounter while solving problems. The comments of the Chief Examiners' (Physics) shall also be examined.

> Question 2 Physics (Essay) Paper 2 May/June, WAEC, 2015
>
> A body is projected at an angle of 30^o to the horizontal with a velocity of $150ms^{-1}$. Calculate the time it takes to reach the greatest height. [Take g = 10 ms^{-2} and neglect air resistance]

The comments of the WAEC Chief Examiners' Report (Physics) are as reported:

> The question on projectile numerical was popular among the candidates and it was fairly attempted. Some candidates could not differentiate total time of flight 'T' from the time taken to reach the maximum height 't'. The time **t** was needed to solve the question. Few candidates omitted correct unit of time while others wrote wrong units.

The content of the WAEC Chief Examiners' report (Physics) shows that some candidates had difficulty in solving the problem. When a problem such as this is given and a student seems unable to solve it then the following questions must asked: Does the student have a clear understanding of what the problem is? Does the student know the data to be used in seeking solution? Does the student know within what context, or restrictions, the solution is to be sought? And what type of information is to be furnished by the solution, if and when it is found? When a student is confronted with any of such difficulty, his or her troubles very likely are due to vocabulary weakness, inefficient reading habits, inability to distinguish known from unknown, inability to phrase the essential part of the problem in one's own words, or inability to detect hidden questions, interpretations, and implications.Though it might seem dated, Johnson and Gerald (1967) suggested some instructional techniques which might be used to remove such difficulty. Some of the instructional techniques suggested were: Physics teachers should assist in giving specific training in the use of a dictionary; Physics teachers should encourage and train students to ask oneself pertinent questions and provide answers to discover hidden questions and meanings; Physics teachers should inculcate in the students the habit of slow, careful, and critical reading; and the practice of telling in one's own words what one has read.

The next type of difficulty likely to cause trouble in problem solving is that of determining the *structure* of the solving process. Some of the sources of such difficulty are inability to distinguish between essential and nonessential data, and inability to recognize basic relationships. In order to help students overcome such problems the Physics teacher should: Direct students attention to the selection of pertinent data with such questions as -what is given? What are required to be found? What should be known in order to answer the question? And why does one need to use certain data and not other data supplied in the statement of the problem?

The physics teacher should also instruct students on how to identify basic relationships, pertinent formulas, hidden questions which need to be answered, and help students acquire the ability to formulate similar problems which have the same basic pattern but not so difficult to solve.The third type of difficulty associated with problem-solving is that of being able to perform the *operation* needed to accomplish the solution. Among the sources of this type of difficulty are inadequate comprehension of basic principles, fundamental laws and principles of physics within which the problem is stated, unfamiliarity with the implications of the basic algorithms and formulas of the mathematical system, and carelessness in working procedures. In order to improve the problem-solving skills, Johnson and Gerald (1967) suggested that the teacher should help students learn how to: review basic laws and principles underlying the concept for clearer understanding; and analyse the algorithms (problem solving strategies that may or may not involve mathematical equations) and formulas for better comprehension of the structure of the physics concept. This is necessary, because according to Cohen, Kennedy-Justice, Pai, Torres, Toomey, DePierro, and Garafalo, (2000), if students do not have adequate understanding of the fundamental mathematical concepts used in solving problems, such as meaning of ratios, change of subject and formula, inverse and linear relationships, problem-solving has the potential of becoming "an exercise in mere symbol manipulation. For example, an introductory student (senior secondary school One students) (Age 16+) may memorise the algorithms for determining the height attained by an object in a motion under gravity such as $H = \frac{1}{2}gt^2$.

While this algorithm is correct in the sense that it will give the correct answer for the height attained, it shows no understanding of the concept of motion of objects under gravity. This is because students who lack problem-solving skill may find it difficult to find time to reach maximum height. An introductory student lacking in conceptual knowledge may not understand why this algorithm works. They will, however, be able to correctly apply this meaningless algorithm to homework and exam questions. Using this algorithm without conceptual understanding does not enhance or improve a student's problem solving abilities.

Cohen et al. (2000) respond to this common occurrence by proposing "meaningful" problem solving in the classroom. When students are solving quantitative problems, instructors should not be satisfied with numerically correct answers. Rather, they should require students to demonstrate their conceptual understanding of every aspect of the problem, including the equations and ratios used to solve the problem. Cohen et al. propose that this process of developing conceptual understanding of problem solving should occur at the secondary level, as it requires more time than may be available in a college course.

Generally the instruction on problem solving should include inculcating in the students the following skills, among others: The skill to:

- Construct an informative diagram of the physical situation;
- Identify and list the given information in variable form;
- Identify and list the unknown information in variable form;
- Identify and list the equation that will be used to determine unknown information from known information;
- Substitute known values into the equation and use appropriate algebraic steps to solve for the unknown information;
- Check final answer to insure that it is reasonable and mathematically correct.

Some past studies (such as Cohen et al. 2000; Bunce & Heikknen, 1986) on the effect of problem-solving instruction on students' achievement in science show that there was no improvement in the achievement of students. In Bunce and Heikkne's (1986) work in which they implemented a curriculum focused on teaching students how to solve problems in general chemistry. In the study the students were trained to follow a series of problem solving steps with hopes that they would improve their ability to successfully solve mathematical problems in chemistry. Results showed no improvement in problem solving success with the trained students. Similarly the results of the study of Cohen et al. (2000) show that instruction in problem solving techniques, including explanations and examples has little value in helping students become better problem solvers.

However, some studies (Çalişkan, Selçuk & Erol, 2010; Ghavami, 2003; Jeon, Huffman & Noh, 2005) reported that instruction in problem solving could bring about improvement in achievement of students. In the study of Jeon, Huffman and Noh (2005) in which thinking aloud pair problem-solving instruction was used in Chemistry lesson, the achievement of students in the experimental group improved better than those in the conventional group. In the study of Çalişkan, Selçuk and Erol, (2010), results of their study showed that students who received instruction in problem-solving performed better in Physics Achievement Test than their colleagues in the traditional method in which instruction in problem-solving method was not used.

These contrasting results show that there is the need for further studies in this field. Moreover, the extent to which these results can be generalized to African setting has not been properly documented in literature in physics education. It is on the basis of this that in this study the author examined the extent to which instructions in problem-solving can enhance the achievement of students in secondary school physics.

Gender as a strong predictor of human behavior has been a central focus in classroom research. Efforts made through research to link sex difference to learning outcomes in Physics have been inconclusive, as there has been conflicting results in an attempt at finding gender related differences in physics achievement. Generally studies have shown that boys are better at more logical and theoretical subjects such as mathematics and science, while girls have been found to be better in creative subjects like art and reading (Ariyibi, 2010). However, in the literature there is little information on the extent to which instructions on problem-solving can improve or otherwise the achievement of girls in physics. However in physics education programme in secondary schools, boys enrolled more than girls. If effort must be made to increase the enrolment of girls, instructional techniques that will encourage more girls into physics must be sought. It is on the basis of this that in this study the author examined the extent to which problem-solving instruction can improve girls' achievement in physics, with a view to encouraging more girls into physics. This is because, according to Adegoke (2012), if girls perform in physics there is likelihood that more girls will be attracted to physics.

Hypotheses

- Hypothesis One: There is no significant difference in the mean scores in Physics of students who received instruction in problem-solving and those who did not receive instruction in problem-solving.
- Hypothesis Two: There is no significant gender effect on the mean scores in Physics of students who received instruction in problem-solving and those who did not receive instruction in problem-solving.
- Hypothesis Three: There is no interaction effect of treatment and gender on the mean scores of the students in Physics Achievement Test.

METHODS

Sample

In this study, quasi-experimental design was adopted. Two schools were randomly selected from Ona-Ara Local Government Area, Oyo State, Nigeria. In each of the senior secondary schools (SSS), only science class one (SSS I) was selected. In most Nigeria schools, in science class, students offer physics, chemistry and further mathematics. In this study, only students who were offering physics, chemistry and further mathematics as part of their probable subjects for senior secondary school certificate examination. In all, there were 108 students (62 boys and 46 girls). Their ages ranged between 14 years and 16 years (Mean Age = 16.7; Standard Deviation = 0.78). There were two groups: Group I - school in which students received instruction on problem solving techniques while learning projectile motion. In this group there were 53 students (37 boys and 16 girls). Group II - school in which students learnt projectile motion without the teacher emphasizing on problem solving techniques. In this group there were 55 students (36 boys 19 girls).

Materials

In this study, two instruments were used. These were: Instruction Guides and Physics Achievement Test (PAT).

Instructional Guides: There were two forms of Instructional Guides viz: Form A and Form B. Form A contains guidelines for the teacher in the problem-solving group, while Form B contains the guidelines for the teacher in conventional method group. The two forms present the steps to be taken by the teacher in each group.

Group I – Form A

The students in this group were exposed to problem solving techniques in addition to instruction on the meaning of the concept of motion under gravity.

Steps

In a typical lesson the teacher and the students activities were the following:

Introduction

The teacher
Step I: Introduces the topic by writing it on the chalkboard and communicates the focus of the lesson
Step II: Link the new lesson with previous knowledge.

Presentation

The teacher
Step III: Explains the content of the topic by giving the definition and explaining the concepts
Step III: Instructs the students to check for the meaning of the concepts, using dictionary
Step IV: Gives formulas and equations for solving numerical problems
Step V: Explains how to change the subject of the formula
Step VI: Gives and solves three examples of problems using the formula and equations

Evaluation

The teacher
Step VII: Writes three questions on the chalkboard for the students to solve
Step VIII: Instructs the students to solve the three questions in their note books
Step IX: Instructs the students to explain the content of each problem and what they were asked to solve
Step X: Instructs the students to explain why they think the answers to the problems were correct

The students
Step XI: Using the techniques learnt, solve the problems in their note books and explain how they got their solutions to the problems

The teacher
Step XII: Gives correct solutions to the problems for the students to review the steps for getting correct answers
Step XIII: The teacher and the students discuss the deficiencies and mistakes on the solutions which the students give to the problems

Group II – Form B

The students in this group were exposed to instruction on the meaning of the concept of motion under gravity and no explicit instruction on techniques for solving problems was given.
In a typical class the teacher and the students activities were the following:

Introduction

The teacher
Step I: Introduces the topic by writing it on the chalkboard and communicates the focus of the lesson
Step II: Link the new lesson with previous knowledge.

Presentation

The teacher
Step III: Explains the content of the topic by giving the definition and explaining the concepts
Step IV: Gives formulas and equations for solving numerical problems
Step VI: Gives and solves three examples of problems using the formula and equations

Evaluation

The teacher
Step VII: Writes three questions on the chalkboard for the students to solve
Step VIII: Instructs the students to solve the three questions in their note books
The students
Step XI: Using the the equations and formulas, solve the problems in their note books.
The teacher
Step XII: Calls on a volunteer student who has solved the problem to show the solution to the problem on the board. The teacher however guides the student.
Step XII1: If a problem could not be solved by the student the teacher then explains how to solve the problem on the chalk board.
The major differences in the instructional techniques of the contrasting groups are in steps

Physics Achievement Test (PAT)

The PAT consists of five constructed response items in Physics (See Appendix 1). The items were selected from the topic in motion under gravity. Each item was scored on a 5-point scale of 0, 1, 2, 3, and 4. The difficulty indices and discrimination index of each item were determined using General Partial Credit Model of Item Response Theory. The maximum obtainable score was 20 and minimum obtainable score was 0.

Procedure

Two physics teachers (A and B) participated in this study. Each of the teachers holds B.Ed (Physics). They were unemployed. Teacher A taught students in Group I, while teacher B taught in Group II. The two teachers made use of the instructional guides and the study lasted one week.

Before the commencement of the experiments in the two schools, the researcher visited the school and solicited the assistance of the physics teacher and the school principal. The students were encouraged to participate in the study. There were three sessions of teaching and one session was used for pretest and one session for posttest. These took place during the normal time scheduled for physics on the official time table. This was to avoid disruptions to normal school schedules.

The two tests, that is pretest and posttest was the PAT. During the posttest, the students used 43 minutes, while during posttest the average time used by the students was 35 minutes.

Method of data Analysis

The groups mean scores and standard deviation were calculated. The hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. This was to test for significant differences between the group means and to control for the effects of covariates.

RESULTS

The results are presented in the order in which the hypotheses were stated.

Hypothesis One: There is no significant difference in the mean scores in Physics of students who received instruction in problem-solving and those who did not receive instruction in problem-solving?

***Pre-test*:**

In the pre-test (not shown in the table) the students in group one had a mean score of 2.02 (SD = 1.01), while the students in group two had a mean score value of 2.19 (SD = 1.12). This shows that the two groups were quite equivalent before the experiment.

Post-test:
Table 1 presents the mean score and the standard deviation of the two groups in the PAT

Table 1: Mean and Standard Deviation of the Groups in PAT

Treatment/Groups	**Number**	**Mean**	**Std. Deviation**	**Mean Difference**
Group I	60	10.87	2.95	2.48
Group 11	48	8.39	3.71	

From the table, students in Group I had higher score than their colleagues in Group II. The mean difference of 2.48 was significant F (1, 103) = 10.89, p =0.001. The null hypothesis was therefore rejected. The calculated effect size of 0.096 was moderate showing that the observed difference in the mean scores of the two contrasting groups was due to the methods of instructional technique that was adopted. More importantly, about 9.6% of the observed variance in the students' mean scores was due to treatment. That is instructing students the techniques of problem solving can enhance their achievement in Physics. This is because students in Group I had better gain in score of 8.85 (Posttest [10.87] – pretest [2.02) than their colleagues in Group II who had gain in score of 6.20 (Posttest [8.39] – pretest [2.19]).

Table 2: Tests of Between Subjects Effects

Source	SS	Df	MS	F	Sig.	η^2
Corrected Model	208.275[a]	4	52.069	4.725	.002	.155
Intercept	2300.275	1	2300.275	208.759	.000	.670
Covariate2	13.684	1	13.684	1.242	.268	.012
Treatment	119.970	1	119.970	10.888	.001	.096
Gender	3.596	1	3.596	.326	.569	.003
Treatment * Gender	20.192	1	20.192	1.833	.179	.017
Error	1134.938	103	11.019			
Total	11649.000	108				

Hypothesis Two: There is no significant gender effect on the mean scores in Physics of students who received instruction in problem-solving and those who did not receive instruction in problem-solving. Table 3 presents the mean score and the standard deviation of the boys and girls in the PAT.

Table 3: Mean and Standard Deviation of the Boys and Girls in PAT

Gender	Number	Mean	Std. Deviation	Mean Difference
Male	67	9.60	3.46	0.45
Female	41	10.05	3.70	

From the table, it girls had higher score than boys. However, the mean difference of 0.45 was small and not significant F (1, 103) = 0.36, p =0.569. The null hypothesis was therefore not rejected. The calculated effect size of 0.003 was very small.

Hypothesis Three: There is no interaction effect of treatment and gender on the mean scores of the students in Physics Achievement Test.

A further analysis of boys and girls scores in the two contrasting groups was carried out to note which of the gender benefitted more from instructions in problem-solving. Table 4 shows the results of the analysis

Table 4: Mean Score and Standard Deviation of Treatment by Gender

Treatment	Gender	N	Mean	Std. Deviation
Group I	Boys	37	11.05	3.05
	Girls	23	10.57	2.95
Group II	Boys	30	7.80	3.11
	Girls	18	9.39	4.49

From table 4, both boys and girls in Group I performed better than boys and girls in Group II. In fact boys in Group I with Mean Score of 11.05 gained better than their colleagues (Mean score of 7.80) in Group II. The mean difference was 3.25. However, the mean difference in the mean score of girls in the two Groups was small (1.18). These results point to the fact that instructions in problem-solving are useful for both boys and girls. It enhanced girls' achievement in Physics while boys were not at any disadvantage.

DISCUSSION

The results of this study show that students' achievement in Physics can be enhanced by giving explicit instructions to students on problem-solving. This is so because physics by its nature involves solving numerical and word problems. As indicated in the preceding paragraph, Physics is filled with equations and formulas that deal with such concepts and topics as angular motion, fluids and fluid motion, forces, moments of inertia, linear motion, projectile motion, motion under gravity, simple harmonic motion, thermodynamics, and work and energy. Many concepts in Physics are explained by using equations and formulas, therefore for a students to do well in physics he or she must have the ability to use these equations and formulas to solve numerical problems. The results of this study, that is, that instruction in problem-solving improved students' learning outcomes in physics are in line with that of Çalişkan, Selçuk, and Erol, (2010), McCalla (2003) and Ghavami (2003) who found out that giving students instruction on problem solving in Physics could help enhance their achievement.

However, the results of this study were in contrast with some studies such as Cohen et al. (2000). For example in the study of Cohen et al. (2000) on the effect of problem-solving instruction on students' achievement in science the results of their study showed that there was no improvement in the achievement of students. Specifically, the study of Cohen et al. (2000) show that instruction in problem solving techniques, including explanations and examples has little value in helping students become better problem solvers.

One of the reasons why the results of this study were not in consonance with that of Cohen et al. was that in this study efforts were made to have the students have conceptual understanding of the concepts that were taught during the experiment. For example, the teacher in experimental Group I took time to explain the difference between the "*time of flight*" and the "*time that the object took to reach the maximum height*". In the teaching and learning of motion under gravity, many students are always confused between the two terms, that is, "*time of flight*" and the "*time that the object took to reach the maximum height*". Also usually the concept of time as defined in motion under gravity requires that $t = \sqrt{\frac{2h}{g}}$. Some students when asked to find t gives the formula as $t = \sqrt{\frac{g}{2h}}$. This problem usually arises as a result of lack of understanding of change of subject of formula.

Moreover, during the problem solving process, students are required to use their prior knowledge and find their deficiencies in learning. In addition, as indicated by Huffman (1997), while in the traditional problem solving focuses only on quantitative aspects, in explicit problem solving process, a problem is dealt with from both quantitative and qualitative dimensions. This qualitative aspect of the explicit problem solving process may have not only improved students' problem solving performance but also enhanced their understanding of physics concepts and principles. In this context, it can be said that explicit problem solving instruction is more effective than traditional problem solving instruction on students' achievement in Physics.

CONCLUSION AND RECOMMENDATION

In line with the findings of this study, physics teachers should endeavour to in addition to teaching the concepts in physics, instruct their students on how to solve numerical problems. This can be achieved by making sure that students have adequate understanding of the concepts and techniques for solving problems. Physics teachers should teach students how to select pertinent data which are required to solve the problem. The student must know what and what information are given? What are required to find? What should be known in order to answer the question? And why does the one need to use certain data and not other data supplied in the statement of the problem? In this study, both boys and girls benefited from explicit instruction on problem solving, this suggests that more girls can be attracted to Physics if Physics teachers can adopt this method while teaching Physics at the secondary school level.

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Appendix 1
Physics Achievement Test

Instruction: Answer all questions. Each question carries five marks.

Time: I hour

1. A mango fruit is projected horizontally from the top of a mango tree with a speed of $6ms^{-1}$. It lands on the ground level at a horizontal distance of 15 m from the foot of the mango tree. Calculate the height of the mango tree. [Take g = $10ms^{-1}$]
2. The horizontal component of the initial speed of a particle projected at 30^o to the horizontal is 50ms-1. Calculate its initial speed. [Take g = $10ms^{-1}$]
3. A stone of mass 0.5kg is thrown vertically upwards from the ground with a speed of 15ms-1. Calculate its potential energy at the maximum height. [Take g = $10ms^{-1}$]
4. A ball thrown vertically upwards reaches a maximum height of 40 m above the level of projection. Calculate the time it takes the ball to reach the maximum height. [Take g = $10ms^{-1}$]
5. A ball is projected at an angle of 60^o to the horizontal with a speed of 50ms-1. Calculate the speed of the ball at its maximum height. [Take g = $10ms^{-1}$]