# IMPACT OF PROBLEM SOLVING STRATEGIES ON PHYSICS STUDENTS' ACADEMIC PERFORMANCE

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**Abstract**

*The paper examined the effectiveness of problem solving strategies (PSS) in transforming teaching and learning of physics into creativity and skill acquisition. The framework of the strategies comprises of five pedagogical steps. The sample for the study was eighty (80) students randomly selected from each NCE LEVEL of studies, and all are from Federal College of Education, Katsina. The study was divided into two sessions; experimental session during which the students were instructed on selected physics concepts utilizing the problem solving strategies, and the control session where they were guided without the strategies. Pre- and post achievement tests were administered to test their ability in connecting classroom situations with real life problems, and to test the applicability of the strategies on physics teaching and learning. The outcomes of the study showed that students' acquired improved understanding of physics classroom lessons and other physics learning processes through the use of the framework of problem solving strategies. It revealed that learners becomes more practical oriented , and the task of teaching and learning becomes more simplified and interesting, and there would be significant reduction in the level of abstraction in the physics concepts , high-level competency and good mastery of subjects with improved scientific process skills which will translate to teaching and learning for self-reliance and creativity. The challenges include lack of adequate instructional materials, competent man power, and conducive teaching and learning environment. Recommendations for way forward include active involvement on the part of the public, private and corporate organizations in the area of fund intervention, training and re-training of personnel, and active deployment of the problem solving strategies to aid and simplify the teaching and learning processes in physics classroom and laboratory exercises.*

Innovations of science and technology have turned the whole world into a global society driven by creativity and novel inventions. This has led to increasing attention and radical shift on the mode of teaching and learning in science related fields

in schools all over the world. Thus, it has become imperative for every nation to strive with the available human and material resources to achieve scientific and technological breakthrough in their respective environment. Olakulehin (2009) believed that effective teaching of science must be promoted to target learners' creative styles, which will serve as models to subsequent learners and impact same.

Science education, which is seen as concerted effort by man to understand and explore the universe by ways of systematic and organized skills such as observation, identification, description, experimentation and theoretical explanation of natural occurrences, was viewed by Egunjobi (2012) and Akagu (2014), in line with the policy objectives of the National Policy on Education (2013), as an activity based discipline which deserved to be guided by methods that make learning instructions much more simplified and interesting, and by competent, skilled and academically qualified personnel. This implies that physics being an activity based discipline needs instructional approaches that can offer best opportunities for quality creativity and inventions, in line with the scientific and technological advancement of the modern world.

Creativity, according to Torrance (2016), is an act of identifying physical problems, recognizing the connections between taught concepts and real situations, finding ideas or hypotheses, testing and developing the hypotheses, and transmitting the data obtained into useful forms for consumption. Thus, the tendency to generate ideas which is useful in solving practical problems is an act of creativity. Problem solving, creative hypotheses, designing experiments and other novel innovations are part of process skills which require a special scientific creativity. For physics learners to become creative there is need for a paradigm shift in the teaching and learning processes to reflect modern realities. Creative teaching and learning in physics is hoped to offer new possibilities, originality of ideas and new alternatives to cope with the challenges of the modern societies. Howard (2012) believes that a creative thinker is possibly a great personality. Thus, to produce physics graduates that are creative thinkers, then learning instructional strategies must shift towards engaging learners in evident-based reasoning and higher order cognitive skills, together with attributes such as inquisitiveness, open-minded in evaluation, high flexibility and manipulative skills, orderly in complex situations, prudent in judgment and analysis, willing to reconsider, honest to personal biases, reasonable in selection of criteria and persistence in seeking results.

**Steps in Problem Solving Strategies**

The task of translating complex physical problems in physics into simpler forms is indeed an arduous responsibility. Egunjobi (2012) emphasized that activity oriented instructions should be guided with well-organized approaches and procedures, and the components of the problem solving strategies are quite useful in this regard.

The framework of problem solving strategies, according to Reif and Scott (2009), comprised of five steps, highlighted as follows as applied to physics;

Focus on the Problem; the statement of a typical physics problem is not directly obvious, therefore it has to be translated to some calculable quantities. It becomes instructive at this step to go through the statement of the problem carefully and visualizing the objects and their interaction with the context meanings and then construct a mental picture by way of rough sketching, bearing in mind the implied problem tasks.

Identifying underlying physics description; the physics descriptions associated with a given word problem help to translate the literal situations into some idealized forms on which the laws and principles of physics are applicable. It defines the parameters that can be manipulated to estimate the desired quantities, and also presents the models that can be solved to obtain results.

Planning a solution to the problem; having scaled down the given problem into simpler forms for easy apprehension and applicability of the related physics concepts, principles and laws, then it is right to invoke the relevant formula appropriate for the problem.

Execution of plan; at this point, the plan is carried out, bearing in mind the expected results. Some of the major activities include invoking formula, definition of terms and calculations.

Evaluation of result; the activities that are highly necessary at this point include checking for consistency of the result obtained with real situation, whether the result is realistic, and whether the units and dimension of the objects of the problem are in conformity with those of the result.

**Importance of Problem Solving Strategies**

Howard (2012,) and Agommuoh and Ndirika (2014) were of the opinion that a well-strategized teaching and learning approach provides greater opportunities for multiple perspectives such as multiple learning styles, different format of handling a given physical problem, focusing and connecting word problem to real situations, alternative solution to a given problem, creative and critical thinkers with novel innovative ideas vested with new possibilities in strange situations. Therefore, proper application of the elements of problem solving strategies (PSS) in physics classroom and laboratory activities is believed to provide the appropriate avenue to equip the graduate teacher with the enabling procedures of teaching for self reliance, skills acquisition and wealth creation in line with the realities of the 21$^{st}$ century as captured in Torrance (2016). Further to this, Agommuoh and Ndririka (2014) posited that the challenges of teaching and learning is not limited to lack of relevant and adequate instructional materials alone, but to lack of competent man power, lack of conducive learning environment, and lack of effective teaching and learning approaches.

**Problem Statement**

There is general poor performance in physics courses by secondary school students gaining admission ether into pre-NCE or the first level NCE studies, and this is taught to affect their learning ability during the course of study. This problem becomes evident on their poor entry behaviours as some could not even comprehend most basic analytic physical problem in physics. Some of the causes of this problem may be due to lack of adequate use instructional materials and use of effective teaching methods; This study intends to emphasized and encouraged the use of problem solving strategies in assisting physics students' understanding of general elements in a given physical problem.

**Aims and Objectives**

This study is aimed at using the framework of the problem solving strategies (PSS) in the teaching and learning of physics with the clear objectives of equipping the teacher-trainees special physics process skills, creative styles and enormous possibilities in new or complex situations' who in turn shall impact same to their future learners at basic and post-basic levels of education.

**Research Questions**

The following research questions were raised to guide the study:

(1) To what extent does the use of problem solving framework impact on students' achievement in physics?

(2) To what extent does the use of problem solving framework affects gender achievement gap in physics?

Hypotheses

The following hypotheses were formulated and were tested at 0.05 level of confidence;

$H_{01}$ There is no significant difference in the learning outcomes of physics students when problem solving strategies are used or not.

$H_{02}$ There is no significant difference in the learning outcomes of both female and male physics students when problem solving strategies are used or not.

**Methodology**

The study made use of field observation method utilizing problem solving techniques to investigate the academic performance of NCE students on physics classroom and laboratory exercises with the purpose of determining whether their achievement differ significantly as compared to other students taught without. The students were divided into two sessions (control and experimental), and a well constructed instrument were applied on the two groups to elicit vital information with respect to the research questions.

**Population for the Study**

The study area was Katsina metropolis and the population of study was the entire 327-physics students (from Pre-NCE, NCE I, NCE II, NCE III) at the federal college of education, Katsina. Stratified sampling technique was used to form a sample size of 80-students which comprised of 38-female and 42-male.

**Research Instrument**

Achievement test was used to pre- and post-test the students during the two sessions respectively. The items of the achievement tests, which were constructed from selected concepts in physics together with the grading-guide, were subjected to face and content validity under strict scrutiny of a senior expert in measurement and evaluation, and two others in the physics department. Thereafter, a pilot study was conducted In order to validate the research instrument, and test-retest method was used to establish a reliability coefficient of 0.72, and consequently the items were certified to be able measure the set objectives of the research which include students' ability to recognize and apply the framework of problem solving techniques on any physics word problem.

**Research Procedure**

The whole exercise lasted for eight (8) weeks. During the first session which lasted for four (4) week, a two-day contact per week was used to just familiarize the sampled students to items on the research instruments without introducing the components of the framework, and they were tested. During the second session, the components of problem solving framework were introduced and used on the students, and they were tested. The raw data collected from the pre- and post-achievement tests were treated using frequency distribution.

**Data Presentation and Discussion**

The ranking scale used to grade the students performance were; Below 40 = poor; 40 - 50 = Fair; Above 50 = Good.

Table 1 provides information on the number of student with performance level in the achievement tests based on adherence to the components of PSS framework, while Table 2 shows the percentage number of students with their overall performance in the achievement tests.

Research Question I; To what extent does the use of problem solving framework impact on students' achievement in physics?

**Table 1(Performance Level of Students in the Framework Components of PSS)**

| Session | Framework of PSS components | Gender | Number of students with performance rank. | | | Total |
|---|---|---|---|---|---|---|
| | | | Good | Fair | Poor | |
| Control | Focus on objects of problem | Male | 4 | 7 | 31 | 42 |
| | | Female | 2 | 3 | 33 | 38 |
| | Identifying physics descriptions | Male | 10 | 5 | 27 | 42 |
| | | Female | 10 | 4 | 24 | 38 |
| | Plan what to do | Male | 1 | 4 | 37 | 42 |
| | | Female | 0 | 4 | 34 | 38 |
| | Execute the plan | Male | 1 | 3 | 38 | 42 |
| | | Female | 1 | 3 | 34 | 38 |
| | Evaluation | Male | 3 | 10 | 29 | 42 |
| | | Female | 1 | 4 | 33 | 38 |
| | Focus on objects of problem | Male | 22 | 13 | 7 | 42 |
| | | Female | 20 | 12 | 6 | 38 |
| | Identifying physics description | Male | 25 | 15 | 2 | 42 |
| | | Female | 20 | 10 | 8 | 38 |
| | Plan what to do | Male | 26 | 12 | 4 | 42 |
| | | Female | 23 | 12 | 3 | 38 |
| | Execute | Male | 28 | 11 | 3 | 42 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Experimental | plan | Female | 30 | 5 | 3 | 38 |
| | Evaluation | Male | 31 | 8 | 3 | 42 |
| | | female | 29 | 5 | 4 | 38 |

Table 1 shows that more than two third of the students performed poorly in identifying elements of physical problem during the first session when the framework of PSS was not introduced. However, almost all the students performed better in the second session when components of PSS framework was introduced as depicted by the high number of students with "Good" and "Fair".

**Research Question II;** To what extent does the use of problem solving framework affects gender achievement gap in physics?

**Table 2 (Percentage Distribution of Students Overall Performance)**

| Session | Performance rank | Number of students with rank | | Percentage number of students with rank | |
|---|---|---|---|---|---|
| | | Male | Female | Male | Female |
| Control | Good | 2 | 3 | 4.76 | 7.89 |
| | Fair | 6 | 4 | 14.29 | 10.53 |
| | poor | 34 | 31 | 80.95 | 81.58 |
| | Total | 42 | 38 | 100 | 100 |
| Experimental | Good | 32 | 26 | 76.19 | 68.42 |
| | Fair | 8 | 11 | 19.05 | 28.95 |
| | poor | 2 | 1 | 4.76 | 2.63 |
| | Total | 42 | 42 | 100 | 100 |

Table 2 shows that 81.58% of female and 80.95% of male (corresponding to 31 out of 38 and 34 out 42 respectively) of the students have poor overall performance in the pre-

achievement test, while 97.37% of female and 95.24% of male students (corresponding to 37 out of 38 and 40 out of 42 respectively) performed well in the post-achievement test. Only 4.76% of the male students (corresponding to 2 out of 42) and 2.63% of the female students (corresponding to 1 out of 38) have poor performance in the post-achievement test.

**Discussion**

The result showed that the use of problem solving strategies in teaching and learning of physics, with emphasis on the components of its framework, is likely to improve and enhance the general understanding and comprehension of physics classroom exercises as evident in the performance table in which almost all the sampled students scored above average. This result corresponds with Agommuoh and Ndirika (2014), Akagu (2014), Ugoechi (2014) that effective teaching strategies has the effect of encouraging individualized learning and participation, and improves students' logical reasoning in complex situations. Thus, from the table, it becomes obvious that the use of the strategies invoked and instilled thought provoking learning abilities in the students which are capable of translating into learning for creativity and invention. Evident from the performance ratio of male to female students, it becomes obvious that effective use of components of the framework of problem solving strategies is not gender bias on learning ability.

**Conclusion**

The paper targeted on the use of the components of the framework of problem solving strategies in transforming teaching and learning in physics into an interesting avenue for creativity and inventive ideas where learners at all stages can benefit. The framework of the strategies comprised of five (5) components which are vital steps that are very useful to simplify and analyze a given physical problem in physics. The strategies, when adequately used, are useful in preparing physics learners to become critical thinkers and equipped them with needed scientific procedures that are adequate in carrying out the required scientific process skills. Consequently, the transformed NCE graduates of physics education will transfer the acquired knowledge on problem solving framework on their learners at the basic and post-basic level of education.

**Recommendations**

Teachers should adopt the framework of problem solving strategies in conjunction with non-convectional teaching methods in the teaching of sciences generally to simplify the levels of abstraction in the concepts, and students should be encouraged and guided meticulously to enjoy the excitement of physics, and science generally.

Since teaching/learning demands high resource materials, public/private intervention are high requirement for the provision, and training and re-training of

personnel. Motivation of teachers and the students through prize-award in honour of excellence should be promoted.

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