

## Enhancing Physics Students' Scientific Worldview For Decision Making Framework Using Dilemmatic Problem-Solving Model

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### ABSTRACT

*This study investigated the effect of Dilemmatic Problem-Solving Model on Physics students' enhancement in their scientific worldview for decision making framework. Quasi-experimental research design, specifically, the non-randomization pretest-posttest control group was used for the study. A sample size of 122 Senior Secondary School 1 Physics students were selected by Purposive sampling technique for the study. Research instrument titled "Integrated Cognitive Reflection and Scientific Worldview Test in Physics and Decision-Making Template" with a reliability coefficient index of 0.82 using the Kuder-Richardson-20 coefficient statistics was used to obtain data for the study. Data were analyzed using the mean statistics for the research questions while hypotheses were tested at 0.05 level of significance using the Analysis of Covariance (ANCOVA). The study revealed that there was a significant difference between the performance of students based on their improvement in their scientific worldview and decision-making framework in the experimental and control groups [ $F = 83.663$ ,  $df = 122$ ,  $p < 0.05$ ]. Dilemmatic Problem-Solving Model (DPSM) enhances better improvement in students' scientific worldview and decision-making framework than the Lecture Teaching Method (LM). There was also a significant difference between the performance of male and female students [ $F = 75.861$ ,  $df = 122$ ,  $p > 0.05$ ]. Male students had better improvement in their scientific worldview and decision-making framework than their female counterpart. It was recommended that Physics teachers use the Dilemmatic Problem-Solving Model (DPSM) in teaching concepts in physics so as to strengthen students' scientific worldview and make quality decisions when confronted with task associated with natural phenomenon.*

**Keywords:** Physics, Scientific worldview, Decision making, Dilemmatic, Problem solving.

### INTRODUCTION

The understanding of nature by man places emphasis on their fundamental systems of belief. It guides the judgment, interactions and response of humans in relations to any prevailing event or situation. Our systems of belief determine what we think as possibility, and this possibility influences the results we create or allow in life. Our belief system portrays what is been considered as real, ideal, logical, beautiful, valuable, rational that establishes the framework for the worldview acquired by an individual. Schlitz, Vieten and Miller (2010) mentioned that each individual has

a personal description and explanation of the nature of reality, as such, genetic tendencies, religion, culture, and geographic region, together with all the experiences people have both internally and in relationship to their environments, give rise to their worldview, or their general way of viewing themselves and the world around them. Abimbola (1977) argued that to maintain equilibrium and sanity, there is need for some guiding principles, attitude and sentiments for making sense out of everyday occurrences and experiences. Therefore, these principles, attitude and sentiments when integrated, constitute a people's worldview.

Worldview according to Samples (2007) forms a mental structure that organizes one's basic or ultimate beliefs. It is a collection of beliefs, values, and assumptions about the basic nature of reality that gives people an epistemological framework for making sense of the world, persuading them to think, act, and feel in predictable ways. Worldview gives an inclination of what we are, our relationship with others and the extent to our interaction with nature. An individual held worldview provides the space of intellectual understanding and fundamental baseline analysis of the "inherent truth" that is about an issue or event. Davies (2009) highlights some significances of worldview as, understanding of one's belief foundation and the belief foundation of others, having the ability to deal with causes rather than symptoms, grasps of objective truth about the nature of reality and acquiring a personal reality that can motivate us. An understanding of worldview has caused tremendous growth and has given rise to credible prediction and explanation of natural phenomenon, equally, directing the patterns of thought that causes profound changes in peoples' views of natural phenomenon and helping them in making rational judgment. Worldview can be categorized according to the environment of intellectual practice which is characterized by such community.

Scientific worldview is basically concerned with way by which the scientific community proffers rational and logical explanation and possible predictions of natural phenomenon based on held guiding principles. Vidal (2008) explained that scientific worldview is mainly concerned with modeling the world. The modeling takes into cognizance answers to fundamental questions that nature posits. Scientific worldview is based on the rules laid down by the exact sciences which are open and self-correcting in accordance with new systematic and methodological findings. Scientific worldview provides explanation on the direction in which guiding principles concern nature are been developed as a fluid body of knowledge of science. Izunwa (2011) referred to scientific worldview as the logical geography of the physical sciences, that is, the categories of understanding and vision of reality with which the scientific man confronts nature. One fundamental requirement for a scientific worldview is to provide observational and experimentally verified support explanations of natural events or occurrence. In other to provide these explanations, there is also the need for predictions and assumptions that connect consistently to every scientific theory to the rest of science as a field of study. The nature of scientific worldview places its tenets on science as an inquiry process such that understanding of scientific concepts and principles requires the building of ideas from the already existing baseline knowledge, restricting or modifying were necessary misconceptions by applying consistent experimental methods. The goal of scientific worldview

provides the much needed framework for science teaching and learning in the 21<sup>st</sup> century through a functional science education programme.

Nwanekezie and Arokoyu (2016) defined science education as the study of the interrelationships between science as a discipline and the application of educational principles to its understanding, teaching and learning. Science education is a professional area of study that provides scientific knowledge through pedagogical processes. Cardinal areas that define the study of science education includes the development of science curriculum materials, approaches and methods for the teaching of science concepts, diagnosing misconceptions and error patterns of learners, sustaining learners' interest in science learning, integration of ICT into science teaching and learning, application of contemporary practical kits for science investigations, among others. The outcome of the above identified components equip learners' with required scientific literacy, development of problem-solving abilities and decision-making skills, stimulate mental discipline and enhance their curiosity about the natural world. One fundamental goal of science education should be a shift from emphases on memorization of scientific concepts to one that can provide the acquisition of scientific literacy and understanding of the process of scientific inquiry especially in the study of Physics.

Physics is one important subject in the field of science education that explains in practicality the functioning and dynamics of nature. It is a science subject that studies the physical properties of matter and energy in their specific forms and their interactive forms as well. The study of Physics generates and contributes significantly to the production of technological infrastructure, enhance the understanding of other science discipline and provide basic understanding necessary for the improvement of life. Izunwa (2011) mentioned that:

*Physics, the Queen of sciences has opened up vistas of human understanding that were unsuspected a few centuries ago. From the inner workings of the atoms to the weird surrealism of the blackhole, physics has enabled us to comprehend some of nature's darkest secrets and to gain control over many physical systems on our environment (p. 151).*

The knowledge derived from the understanding of Physics extends significantly to our everyday life. Actions such as walking, heating of pressing iron, driving a car, including all technologies at our disposal exploit the principles of Physics for their operations. One of the basic goal of Physics is the development of students' critical thinking and decision making skills. These skills can be enhanced through the integration of innovative steps that are in the boundaries of science and its worldview through instructional processes. The ability to make informed decisions on Physics-related issues is considered an important attribute and guiding principles towards scientific worldview. Decision making is the ability to choose the best option in the shortest time between two or more alternatives. Decision making involves giving consideration to a matter, identifying the desired end result, determining the options to get to the end result, and then selecting the most suitable option to achieve the desired purpose. Effective decision is one of the most important competencies that Physics students need to acquire in other to be successful in life. In the context of Physics, Kurniawan, Suhandi and Kaniawati (2019) reiterated that decision making

and problem solving are complimentary, which implies that without problem solving there is no decision making. It has been noted that for every step used during the process of problem solving is associated with decision making. It then portray that problem solving model is a yardstick to enhance students decision making.

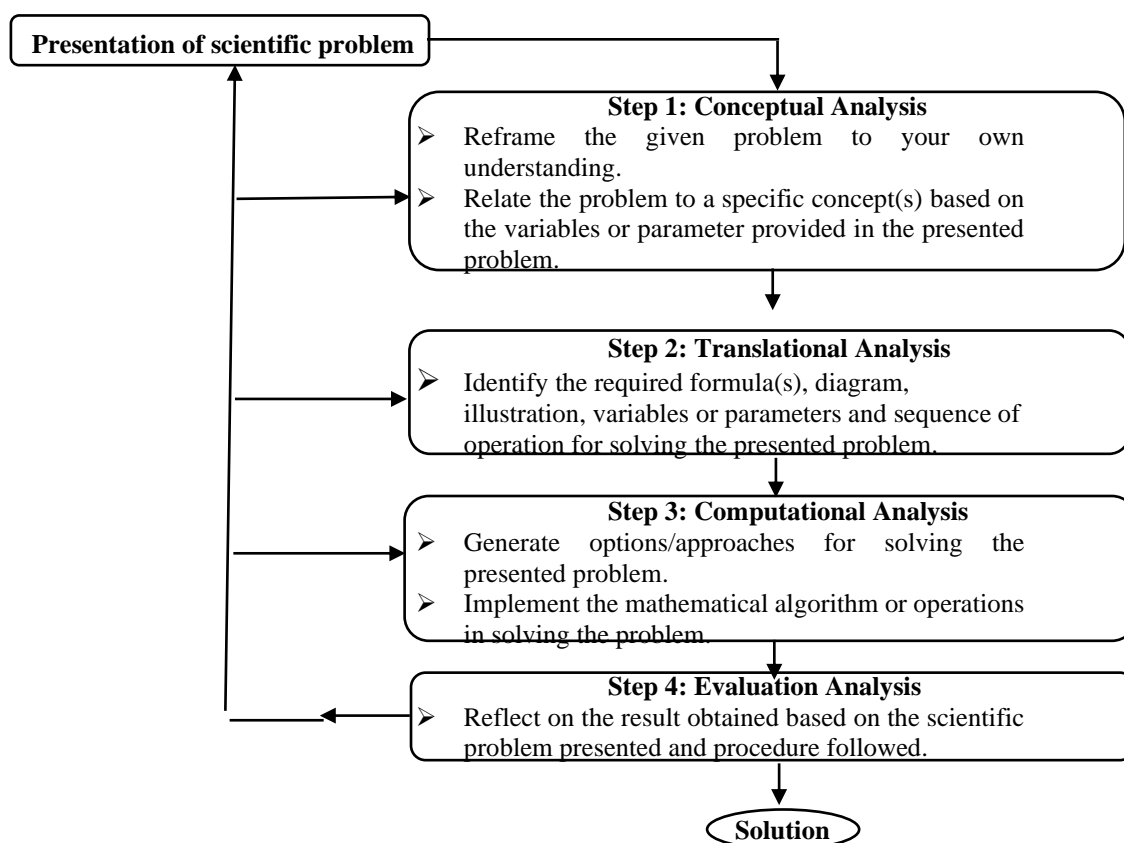
The nature of academic task is most often complex and multidimensional. In other to find solutions to problems, critical evaluation of each element is essential. Most Physics task administered to students are presented in a dilemma form. This implies that students' find themselves in a situation where choice has to be made between two or more alternatives that are closely similar but having their distinctive features. It is quite unfortunate to state that the teaching and learning process of Physics is still at the memorization stage in an era where scientific and technological decisions are made using principles and laws enshrined in Physics. Understanding of Physics principles and concepts have even moved away from mastery level to the application level, which implies that students should make fundamental decisions based on the knowledge of physics they acquire. Therefore, the use of appropriate instructional approaches that are in line with scientific guiding principles that can enable learners to solve a problem.

The Lecture teaching method is one of the oldest and mostly used teaching method in most secondary schools in Nigeria (Arokoyu & Aderonmu, 2018). This method provide an in-depth explanation and presentation of content to students by their teachers. Effective utilization of this method could be very interactive and interesting for students. Sharma (2020) explained that the lecture method of teaching provides better opportunity for content clarification and emphases on salient and significant ideas during the process of interaction.

On the other hand, the Dilemma Problem-Solving Model is a process of identifying a problem or task with dual characteristics and implementing a solution through a multileveled approach. Dilemma problem solving model is one instructional approach that can be utilized for improving students' decision-making skills. The DPSM used for this work with the steps from the presentation of scientific problem to solution is presented in Figure 1.

It is imperative for Physics teachers to assist their students in improving their intellectual abilities by teaching approaches for decision-making and encouraging children to use them in a range of situations especially when confronted with issues that require their knowledge of Physics. The following steps in developing of scientific worldview for making decisions on natural and scientific issues are;

- (i) explicitly teaching the steps of decision-making and providing avenues for learners to practice using evidence-based approach in explaining the connecting patterns of nature and its consequent realities.
- (ii) integration of goal-setting and decision-making steps into science learning tasks by making them an explicit component of task instructions is important. This will enhance their capacity for self-regulated learning, which has been shown to enhance academic performance.
- (iii) provide opportunities by inviting the learners to discuss a scientific problem and also facilitate in thinking of a strategy for solution.



**Figure 1:** Dilemma Problem-Solving Model

It is the prerogative of the Physics teacher to develop in the learner's quality attributes of decision-making skills that are compatible with science and its worldview. Arokoyu and Aderonmu (2018) explained that science teachers that are conversant with the relationship between naïve worldview held by students and scientific worldview will be more effective in helping students to develop understanding of natural phenomenon and making efficient decisions during problem solving. The study was focused on enhancing physics students' scientific worldview and decision-making framework using Dilemmatic Problem-Solving Model.

### **Aim and objectives of the study**

The aim of the study was to enhance physics students' scientific worldview for decision-making framework using Dilemmatic Problem-Solving Model. Specifically, the objectives were to:

1. determine the effect of Dilemmatic Problem-Solving Model (DPSM) and Lecture Teaching Method (LTM) on the improvement of Physics students' scientific worldview for decision making framework.
2. examine the mean difference between male and female Physics students' improvement in their scientific worldview for decision-making framework using the Dilemmatic Problem-Solving Model (DPSM) and Lecture Teaching Method (LTM).

**Research questions**

1. What is the effect of Dilemmatic Problem-Solving Model (DPSM) and Lecture Teaching Method (LTM) on the improvement of Physics students' scientific worldview for decision-making framework?
2. What is the mean difference between male and female Physics students' improvement in their scientific worldview for decision-making framework when exposed to the Dilemmatic Problem-Solving Model (DPSM) and Lecture Teaching Method (LTM)?

**Hypotheses**

- Ho<sub>1</sub>: There is no significant difference between the mean score of students taught with Dilemmatic Problem-Solving Model (DPSM) and those taught with Lecture Teaching Method (LTM) on the improvement of Physics students' scientific worldview for decision-making framework.
- Ho<sub>2</sub>: There is no significant difference between male and female Physics students' improvement in their scientific worldview for decision-making framework when exposed to the Dilemmatic Problem-Solving Model (DPSM) and Lecture Teaching Method (LTM).

**METHODOLOGY**

The study adopted the Quasi-experimental research design, specifically, the non-randomization pretest-posttest control group. The population of the study comprise of all Senior Secondary one (SS 1) Physics students in Port Harcourt Local Government Area of Rivers State. A purposive sampling technique was used to obtain the sample size of 122 Physics students based on the criteria that the students have not been taught the concept of heat energy and the school selected must be a co-educational school. Sixty-four (64) Physics students which comprises of 39 male and 25 female were assigned to the experimental group (those exposed to the Dilemmatic Problem Solving Model) while fifty-eight (58) Physics students that comprised of 31 male and 27 female Physics students were assigned the control group (those exposed to the Lecture Teaching Method). During the treatment stage, the concept that was taught to the students was heat energy. This concept was chosen due to its every day applications to the lives of the students, difficulty students encounter in comprehension of the concept and importantly, its applications in technology. Sub-concepts that permeates the concept of heat energy includes heat and temperature, effects of heat, thermal expansivity, change of state and transfer of heat. The procedure that was employed for the research was categorized into three stages namely, the pretest, treatment and Posttest stages. The Pretest stage involved the familiarization process between the researcher, the teachers and students that participated in the study based on the objectives of the study. Identification of experimental and control groups were done at this stage after which pre-test was administered to students in both groups. The purpose of the pre-test was to ascertain the baseline knowledge of the students before the treatment stage and the data generated was also used as the pretest score. During the treatment stage, the topics imbedded in the concepts of heat energy were taught to the students for an interval of three weeks (3 periods per week) at 40 minutes per period. At the posttest stage, post-

test was administered to the students in both groups immediately after the treatment stage and the data generated was also used as the posttest score.

The research instrument used for the study was developed by the researchers and titled “Integrated Cognitive Reflection and Scientific Worldview Test on Physics for Decision Making Template” (ICRSWTP-DMT). The instrument had two sections that were categorized as section A and B. Section A was designed to elicit information on the participants’ biodata in terms of gender (Male and Female) while Section B was 25 open ended test questions with three columns; Items (Item statements or test questions), Scientific worldview response (students’ responses based on their scientific understanding of the test questions) and decision template (decision based on application to real life experience). A sample question is presented in Figure 2.

s/n	Items	Scientific worldview response	Decision
1.	<p>The diagram below is the arrangement of two solid steel pans in contact. (a) In which direction do you think heat will flow? (Justify your answer with a brief explanation).</p> <div style="text-align: center;"> </div>	<p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>	<p>Which spoon would you prefer to stir continuously a hot cup of tea? (<b>a.</b> metal spoon with wooden handle or <b>b.</b> complete metal spoon).</p>
		3 (marks)	1 (mark)

Figure 2: Sample question

Each of the columns was analyzed and a score was given based on the response of the students. Each item was scored 4 marks making a total of 100 marks equivalent to 100%. The research instrument (ICRSWTP-DMT) was subjected to both face and content validity by two experienced physics teachers, two experts in science education and two experts in educational psychology. A pilot study was carried out to determine the reliability index of the instrument using forty (40) SS 1 Physics students that were not part of the study. Based on the analysis of their response using the Kuder-Richardson-20 coefficient statistics, a reliability index of 0.82 was obtained which makes the instrument 82% reliable to be used for the study. The instrument was administered for both the pre-test and the posttest during the study. The data was analyzed using the mean statistics for the research questions while hypotheses were tested at 0.05 level of significance using the Analysis of Covariance (ANCOVA).

## RESULTS

**Research question 1.** What is the effect of Dilemmatic Problem-Solving Model (DPSM) and Lecture Teaching Method (LTM) on the improvement of Physics students' scientific worldview for decision-making framework?

**Table 1:** Analysis based on instructional method

Treatment	Test	No	Mean	Mean Gain
Experimental Group (DPSM)	Pre test	64	33.9	36.2
	Post test		70.1	
Control Group (LTM)	Pre test	58	29.4	23.3
	Post test		52.7	

Table 1 shows the analysis of students' assessment based on their scientific worldview for decision-making framework after treatment with of Dilemmatic Problem-Solving Model and the Lecture Teaching Method. The result revealed a significant improvement in students' scientific worldview and decision-making framework for both intervening treatments used as shown by both pretest and posttest assessment scores. However, the mean assessment score for the Dilemmatic Problem Solving-Model (DPSM) was 36.2 while the Lecture Teaching Method was 23.3. The findings of the study showed that students that were subjected to the Dilemmatic Problem-Solving Model (DPSM) had better improvement in their scientific worldview for decision making framework than those exposed to the Lecture Teaching Method (LTM).

**H<sub>01</sub>:** There is no significant difference between the mean score of students taught with Dilemmatic Problem-Solving Model (DPSM) and those taught with Lecture Teaching Method (LTM) on the improvement of Physics students' scientific worldview for decision-making.

**Table 2:** Summary of ANCOVA on effects of instructional methods

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	9229.218 <sup>a</sup>	2	4614.609	45.830	.000
Intercept	35932.998	1	35932.998	356.869	.000
Pretest	46.103	1	46.103	.458	.500
Instructional method	8423.951	1	8423.951	83.663	.000
Error	11982.061	119	100.690		
Total	487208.000	122			
Corrected Total	21211.279	121			

a. R Squared = .435 (Adjusted R Squared = .426)

Table 2 depicts the calculated F-value for the instructional methods which was obtained as 83.663 at a degree of freedom of 122 with a probability level of .000 that is less than 0.05 [ $F = 83.663$ ,  $df = 122$ ,  $p < 0.05$ ]. From above, hypothesis one is rejected implying that there is significant difference between the mean score effects of Dilemmatic Problem-Solving Model and Lecture Teaching Method on the improvement of Physics students' scientific worldview for decision making. Since the result showed a significant difference between both groups, a post hoc test,



specifically the Least Significant Difference was further used to determine the direction of the significance difference.

**Table 3: Post hoc test of comparison between the mean based on instructional method.**

(I) Instructional method	(J) Instructional method	Mean Difference (I-J)	Std. Error	Sig. <sup>b</sup>	95% Confidence Interval for Difference <sup>b</sup>	
					Lower Bound	Upper Bound
DPSM	LTM	17.086*	1.868	.000	13.387	20.785
LTM	DPSM	-17.086*	1.868	.000	-20.785	-13.387

Based on estimated marginal means

\*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Table 3 showed the compared mean for both groups based on the instructional methods employed which yielded a 0.000 significant difference at a probability level of  $[p < 0.05]$ . It is observed that the mean difference between the DPSM and LTM was 17.086. Therefore, it was shown that DPSM contributed most to the significant difference that was observed. This implies that DPSM is a better instructional method for the improvement of Physics students' scientific worldview for decision making.

**Research question 2:** What is the mean difference between male and female Physics students' improvement in their scientific worldview for decision-making framework when exposed to the Dilemmatic Problem-Solving Model (DPSM) and Lecture Teaching Method (LTM)?

**Table 4:** Showing the assessment mean score of male and female Physics students

Treatment	Sex	Test	No	Mean	Mean Gain
Experimental Group (DPSM)	Male	Pre test	39	36.4	38.5
		Post test		74.9	
	Female	Pre test	25	30.0	36.7
		Post test		66.7	
Control Group (LTM)	Male	Pre test	32	28.4	28.0
		Post test		56.4	
	Female	Pre test	26	30.6	17.5
		Post test		48.1	

Table 4 reveals the mean assessments of male and female Physics students based on the improvement of their scientific worldview and decision-making when exposed to Dilemmatic Problem-Solving Model (DPSM) and Lecture Teaching Method (LTM). The result showed that male Physics students in the DPSM group showed slight improvement in their scientific worldview for decision making framework [38.5] than their female counterpart [36.7]. The same observation was noticed in the LTM group where the male students had a better improvement in their

scientific worldview for decision making framework [28.0] than their female counterpart [17.5]. Conclusively, the findings of the study showed that male students had better improvement in scientific worldview for decision making framework than their female counterpart when confronted with task in Physics.

**H<sub>02</sub>:** There is no significant difference between male and female Physics students' improvement in their scientific worldview for decision-making framework when exposed to the Dilemmatic Problem-Solving Model (DPSM) and Lecture Teaching Method (LTM).

**Table 5: Summary of ANCOVA on effects of Gender.**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	4448.260 <sup>a</sup>	2	2224.130	15.789	.000
Intercept	31798.228	1	31798.228	225.734	.000
Pretest	441.122	1	441.122	3.132	.079
Gender	3642.993	1	3642.993	75.861	.000
Error	16763.019	119	140.866		
Total	487208.000	122			
Corrected Total	21211.279	121			

a. R Squared = .210 (Adjusted R Squared = .196)

Table 5 showed that the calculated F-value based on gender was obtained as 75.861 at a degree of freedom of 122 with a probability level of 0.000 that is less than 0.05 level of [F =75.861, df = 122, p>0.05]. Hypotheses two was rejected which indicated that there is significant difference between male and female Physics students' improvement in their scientific worldview for decision making framework when exposed to the Dilemmatic Problem-Solving Model (DPSM) and Lecture Teaching Method (LTM).

## DISCUSSIONS OF FINDINGS

The research work was focused on enhancing Physics students' scientific worldview for decision making framework using Dilemmatic Problem-Solving Model (DPSM). Based on the outcome of the study, it was shown that both groups had significant improvement after exposure to treatment. However, when compared, students that were subjected to the Dilemmatic Problem Solving Model (DPSM) had better improvement in their scientific worldview and decision making framework than those exposed to the Lecture Teaching Method (LTM). In line with the findings of this work, Kurniawan, Suhandi and Kaniawati (2019) had shown that the application of dilemmatic problem solving-oriented learning model in physics teaching has effectiveness in the moderate category in improving senior high school decision making skills in the concept of kinetic gas theory.

The findings of Abubakar and Danjuma (2012) also collaborates with the outcome of the present study where it was revealed that there is significant difference in the mean academic performance of physics students whenever the problem solving method as compared to the conventional method of physics teaching. They further commented that mean difference is Gök and Silay (2010) expressed that exposing students to problem solving instructional methods like Dilemmatic Problem Solving Model (DPSM) enable learners improve on their academic performance, increase their interest in the subject thereby strengthen their scientific worldview and importantly

widen their horizon in quality decision making. Physics by its nature is subsumed by solving word problems using several formulas and as such, explicit instruction using problem solving approach is quite fundamental (Adegoke, 2017). One cardinal focus of every educational system is to instill in the learner intellectual capabilities to overcome problems or task confronted during their everyday activities, in other words, problem solving that is cocoon with quality decision is a means to an end in any academic venture.

Most research outcome in Physics education have revealed that gender is a strong predictor or influence on academic performance. All effort geared towards arriving at absolute end on issues of gender on academic performance have been inconclusive. The findings of the present study showed that male students had better improvement in scientific worldview for decision-making framework than their female counterpart when confronted with task in Physics. This outcome was observed in both groups that were used in the study. Ariyibi (2010) had mentioned that male students perform better in subject that deals logical and problem solving like Physics and Mathematics than their female counterpart. Awotua-Efebo, Williams and Aderonmu (2015) is in agreement with the result of this study were it was mentioned that there is a significant difference between the performance of male and female students in Science subjects which is in favour of male students. Onah and Ugwu (2010) also identified that gender have significant effect on students' academic performance in secondary school Physics. However, Croxford (2002) had a contrary opinion to the findings of this study and maintained that girls can perform better than their male counterpart because girls possess untapped intellectual potentials needed for the study of science.

## CONCLUSION

The quest for realization of "real science" which is the onus for explanation of natural phenomena and decision making is critical in sustaining scientific growth. No doubt, humans perceptions of natural happenings is fundamentally hinged on their belief systems which perhaps is linked to environmental, philosophical, religious and scientific interactions that builds their understanding. The field of Physics has rapidly transform and continues to have increasing effects on virtually every aspect of human life. It is no out of place to state that nations that depends on the applications of the principles of Physics progress in all other sectors of their economy. In a drive to achieve the expected beneficial results knowledge of Physics taught in classroom should be done using the teaching method. Dilemmatic Problem-Solving Model (DPSM) should be engaged by Physics and other science teachers so that students be scientific equipped and make right and quality decisions.

## RECOMMENDATIONS

1. The aim of teaching Physics is for the learners to effectively understand the concepts that permeates the subject. Therefore, teachers should make effort in using the Dilemmatic Problem Solving Model (DPSM) in teaching concepts in physics so as to strength their scientific worldview and as well make quality decisions when confronted with task associated with natural phenomenon.

2. In apply the Dilemmatic Problem Solving Model (DPSM), Physics teachers should encourage female Physics students to participate adequately during classroom interaction.

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