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A Study of Information Acquisition on Solar Energy Concepts among Physics and Technical Teachers: Implications for Global Environmental Degradation and Energy Crisis

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Abstract: The main purpose of this study was to investigate the efficacy of equipping physics and technical teachers with adequate information on solar energy concepts and its implication for Global Environmental Degradation (GED) and Energy Crisis (GEC). To achieve the purpose of the study, two research questions and two hypotheses were posed and formulated, respectively. The study adopted quasi-experimental design, specifically, static-group pre-test post-test design. The population for the study comprised 2,143 Physics and technical teachers of the all government-owned senior secondary schools in Oyo state, Nigeria. A purposive sampling technique was used to select 82 physics and technical teachers from the thirty-three (33) LGA of Oyo state for the study. Solar Energy Concept Test (SECT) was used to collect data for the study. Also, SECT questions covered areas such as Global Environmental Degradation (GED) and Energy Crisis (GEC). Five experts from the Department of Science Education and Technical Education validated the instrument for data collection. The instrument was trial tested on a sample of 20 Physics teachers in Akure education zone of Ondo state and reliability coefficient of 0.83 was obtained using Kuder-Richardson 20 (KR-20) formula. The data obtained for the study were analyzed using mean and standard deviation to answer the research questions and Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance. The result of the study revealed that there was a statistically significant difference in the SECT scores of physics and technical teachers exposed to adequate information on solar energy concepts compared to those that were not exposed to the information with physics and technical teachers exposed to adequate information having a higher gain. Also, location does not have a statistically significant influence on the physics teachers exposed to adequate information on solar energy concepts. Therefore, location is not a significant factor to be considered in as much as physics and technical teacher's in colleges acquire adequate information on solar energy concepts. Thus, it was recommended that physics and technical teacher's should be equipped with adequate information on solar energy concepts so as to combat GED and GEC.

Key words: Physics and technical teachers, solar energy concepts, global environmental degradation, global energy crisis, static-group, technical education

INTRODUCTION

The global demand for energy is rising as developing nations are becoming significant in economic power. It is highly likely that the cost of energy, especially in the form of increasingly scarce fossil fuels will continue to rise. According to the Anonymous (2006) world demand for energy is projected to be more than double by 2050 and to be more than triple by the end of the century. Incremental improvements in existing energy networks will not be adequate to supply this demand sustainably. In Europe as at 2006, the energy equivalent of 1,725 million tonnes of oil was consumed every year per person at a cost of EUR 500 billion or more than EUR 1,000; it was estimated to grow up to 1900 million tonnes in 2015 (Anonymous, 2006). The US Energy Information Administration reported that approximately, 67% of electricity consumed in the US is generated through burning fossil fuels. Thus, the WEC., (2013) submitted that continuous increase in the global consumption of energy (supplied from fossil fuel) and energy prices will likely be an inevitable problem. And over-reliance on

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energy imports, persistent hike in prices of energy supplied from fossil fuel and climate change will likely pose a real threat to sustainable global development and a future Nigeria prosperity in particular.

Convincingly, the burning of fossil fuels produces an available and instantaneous supply of electricity for industry or power move machines (Anyakoha, 2011) but generates air pollutants such as carbon dioxide, sulphur dioxide and Nitrogen oxides, etc. In the united states, over one-third of all global warming emissions have been estimated to come from generating electric power while the larger fraction is generated from coal-fired power plants and natural gas-fired power plants (EPA., 2010). Thus, it is evident that fossil fuels are the leading cause of global warming as well as climate change. A postulate based on this fact may be that reducing the electricity drawn from the grid is reducing the amount of carbon emissions. Thus, earning the global world a sustainable environment as cleaner air, water and soil will be available for the community and future generations to come.

Analysis of gas bubbles trapped in polar ice shown in time past that Co_2 and methane had somewhat at lower concentrations during the ice ages but quite stable concentrations from the end of the last major glaciations until the beginning of the industrial revolution (Lindzen, 1997). The Co_2 and methane concentration of the atmosphere increased even more rapidly over the past two centuries and were expected to reach twice its natural, post glacial value sometime in the 21st century but now, it seems to be stabilizing (Lindzen and Emmanuel, 2014). Reasons may be possibly related to the influence of human activities which has a constant effect on the concentration of ozone, nitrous oxide and the Chlorofluorocarbons (CFCs). Therefore, it is glaring that environmental degradation will be the resultant effects of industrialization and anthropogenic activities in this 21st century, even as the quest for technological advancement grows.

Environmental degradation as Okafor *et al.* (2008) pointed out, means to make the environment worse in quality or to pollute it. For example, the bad environmental condition of the petroleum exploration area in Nigeria is alarming. This environmental challenge experienced in this part of the country is as a result of great demand in the supply of energy in the form of fossil fuel. Farinloye (2006) reported that oil spillage and gas flaring problems have graduated to problems of damage to marine wildlife, modification of the ecosystem through species elimination, decrease in fishery resources, loss of aesthetic values of natural beaches, etc. Increase in the magnitude of environmental degradation has also led to several crises such as youth restiveness in this area, bottlenecks at refineries, forceful protests against the activities of oil prospecting firms, less stringent environmental protection laws and lackadaisical attitude of the government and formation of militant groups (Okafor *et al.* 2008). While the real crisis awaits the world, precautions are not taken where necessary.

According to Anyakoha (2011), energy crisis is any great bottlenecks in the supply of energy resources in an economy. Examples are monopoly manipulation of the market, vandalisation of pipelines, power outages and scarcity. The energy crisis has been defined as a great shortfall in the supply of energy resources to the economy or price rise of the energy resources. It is referred to the shortage of oil, electricity and other natural resources. In the view of Ozturk *et al.* (2013), energy crisis is termed the real crisis which will arise when there are not enough energy sources to cope with the demand of world as the demand for energy increases and the supply of energy becomes far less than the actual demand. It is therefore, very difficult to say that the solution of this crisis which will leave the world in a big economic crisis will not be solved by the technology (Ozturk *et al.*, 2013) when findings on the supply of clean energy for the future abounds.

Research on clean energy has evidenced that supply for clean energy for human consumption is still one of society's most daunting challenges. In the Nigeria case, Nadabo (2010) pointed out some factors that hinder the use of renewable energy to include the following. First is lack of capacity (i.e., inadequate infrastructure) which makes the renewable electricity components scarce, thus, making the country relying totally on imports of components for the maintenance of renewable energy electricity. Second is the lack of standard quality control for building consumer's confidence in the new and growing market of renewable energy. Third is the Nigerian energy policy on financial incentives focusing mainly on centralized and conventional sources of electric power. Fourth is that government's subsidy is mainly on the grid power and this discourages and paralyzes investment in renewable energy solutions. Deregulated and liberalized energy industry is another factor. Lastly, the high initial investment cost of renewable energy is quite expensive which makes the electricity generated from the system to have a high initial cost, thus, limiting the penetration of the renewable energy electricity system into the Nigeria market when considering the level of income of majority of Nigeria population.

Right now, renewable energy is providing affordable electricity across the country and can help stabilize energy prices in the future (Abdulkarim, 2005). The costs of renewable energy technologies have declined steadily and are projected to drop even more. For example, the average price of a solar panel has dropped almost 60%, since, 2011 (SEIA, 2012). The cost of generating electricity

from wind dropped more than 20% between 2010 and 2012 and more than 80%, since, 1980 (AWEA, 2012). In areas with strong wind resources like Texas, wind power can compete directly with fossil fuels in cost (Borkar *et al*., 2016). The cost of renewable energy will decline even further as markets mature and companies increasingly take advantage of economies of scale.

To this effect, the federal government of Nigeria signed an agreement with the United Kingdom on the use of solar energy to provide electricity to rural people shortly after the launch of the Africa Energy Campaign initiated by the UK Department for International Development, DFID (Kenning, 2015). The implication is that renewable energy technology is becoming a promising solution to the global energy crisis. And adopting the use of renewable energy sources through solar energy will lead Nigeria in particular, to achieving stable energy supply and environmentally friendly energy.

Solar energy is the energy that comes from within the sun itself. Like most stars, the sun is a big gas ball made up mostly of hydrogen and helium gas. The sun makes energy in its inner core through a process called nuclear fusion. It radiates more energy in one day than the world uses in 1 year (NEED., 2015). The energy generated from the sun can be converted by a direct method using the Photovoltaic (PV), oran indirect method by focusing the sun's light or energy to boil and heat water which is later used to provide power. This indirect method is called Concentrating Solar Power (CSP). Unlike traditional depleting sources of power like coal and natural gas, the sun's power is unlimited and available everywhere in the world having several benefits like solar power energy which does not produce dangerous greenhouse gas emission and therefore are not unfriendly to the environment, they do not produce noise pollution do not let off any form of scent and are made out of commonly available materials. Solar panels reduce carbon emissions released into the atmosphere and do not improve public health and environmental quality.

Therefore in order to make Nigeria do her best in ensuring that the Africa Energy campaign boost supply and consumption of solar energy as to the fulfilment of DFID objectives, the role of education cannot be underrated. To ensure that all citizens of Nigeria are energy-aware which is the major aim of this study, the European Commission idea has to be shared. This idea of the Anonymous (2006) was the role of education and information initiatives in schools. It implies that education has a strategic role to play in improving energy efficiency through solar. And teachers must be equipped with adequate information on solar energy to educate the students and the general public on what solar energy has to offer.

To support this claim, the content of Physics syllabus stipulated by Nigerian Educational Research and Development Council (NERDC) is grouped into six sub-themes, namely: interaction of matter, space and time, conservation principles; wave, motion without material transfer; fields at rest and in motion; energy quantization and duality of matter and Physics in technology. Renewable energy and solar energy are topics under "Conservation Principles". Therefore, physics and technical teachers will be able to pass the correct information on solar energy to students and then to the general public.

Statement of problem: Nigeria is the most populous black nation in the world. The nation is endowed with vast oil and gas reserves and the abundance of renewable energy potentials. Despite its huge natural resources, the country is still suffering from the energy crisis which hampers its economic development and promotes poverty among its citizens. Energy is one of the key fundamentals for economic development, it is also fundamental to all human activities in this era. An estimated 60-70% of the Nigerian population does not have access to electricity. The energy sector in Nigeria relies on government-subsidized fuel and funding of major energy plants and energy capital projects by the federal government, state governments and government agencies. While the increasing carbon emissions and environmental pollution from fossil fuel are drawing world attention and forcing national governments to formulate policies that will make nations adapt to the use of renewable energy sources to cut environmental pollution to the barest minimum possible because global warming has become a major issue and problem of the world today.

With recent development on solar energy, PV panels have dramatically fallen in price with improved battery technology and more efficient appliances such as light bulbs. Common access to mobile payments also allows access to energy via micro- pay-as-you-go schemes. The initiative of DFID is an incredible opportunity for Africa and Nigeria in particular. However, the demand for energy through fossil fuel and the cost of generating electricity is still on the increase in Nigeria. Also, both urban and rural settlements do not have access to electricity. The feeling, therefore is that the general public lack adequate information on energy generation through solar power for sustainable development. Energy education programmes could set the basis for the accepted sustained changes and here comes the role of physics and technical teachers and hence, the need to investigate the effect of acquiring adequate information on solar energy by physics and technical teachers and its implication on global environmental degradation and energy crisis.

Purpose of the study: The purpose of the study was to investigate the efficacy of equipping physics and technical teachers with adequate information on solar energy concepts and its implication for Global Environmental Degradation (GED) and Energy Crisis (GEC).

Research questions: What are the mean achievement scores of physics and technical teachers exposed to adequate information on solar energy concepts compared to those who are not exposed to the information? What is the influence of location on the physics and technical teachers exposed to adequate information on solar energy concepts?

Hypotheses:

- Ho_1: There is no statistically significant difference in the SECT scores of physics and technical teachers exposed to adequate information on solar energy concepts compared to those that were not exposed to the information
- Ho_2: Location does not have a significant influence on the physics and technical teachers exposed to adequate information on solar energy concepts

MATERIALS AND METHODS

The design of the study was a quasi-experimental design. Specifically, the static-group pretest-post test design was used for the study. The choice of the design according to Nworgu (2015) was because it was the most powerful and valid design to establish cause and effect relationship. This study was carried out in Oyo State, where 2,143 physics and technical teachers in all the government-owned senior secondary schools in Oyo State constitute the population for the study. A purposive sampling technique was used to select 82 physics and technical teachers used for the study comprising of 42 physics and technical teachers from the urban and 40 from the rural settlement. The reason for purposive sampling techniques was because the researchers intended to select specific elements which would satisfy some predetermined criteria. Solar Energy Concept Test (SECT) was used to collect data for the study. Section 'A' of the Questionnaire sought information on physics/technical teachers demographic data while section 'B' was twenty multiple-choice questions on solar energy concepts structured to proffer solutions to global environmental degradation and energy crisis. Test blueprint or table of the specification was used in preparing the test which was based on the six levels of the cognitive domain of Bloom's taxonomy of education to ensure proper content coverage. Three experts from the Department of Science Education, UNN and two experts from the Department of Vocational and Technical Education, UNN validated the instrument for data collection. The instrument was trial tested on a sample of 20 physics and technical teachers in Akure education zone of Ondo state and reliability coefficient of 0.83 was obtained using Kuder-Richardson 20 (KR-20) formula. The instrument for collection of relevant data was administered to the sample in the state before the commencement of the training which served as pretest score. After the pretest, the subjects were randomly assigned to two groups and the actual training commenced on the subject. The data obtained for the study were analyzed using mean and standard deviation to answer the research questions and Analysis of Covariance (ANCOVA) was used to test the null hypothesis at 0.05 level of significance.

RESULTS AND DISCUSSION

Research question one: What are the mean achievement scores of physics and technical education teachers exposed to adequate information on solar energy concepts compared to those not exposed to the information?

Results in Table 1 show that the group exposed to adequate information on solar energy concepts had a post-test achievement mean score of 22.39 with a standard deviation of 6.86. But the difference between their pre-test and post-test achievement mean score was 14.16. Meanwhile, the group that was not exposed to adequate information on solar energy concepts had post-test achievement mean score of 15.38 with a standard deviation of 5.02. The difference between the pre-test and post-test achievement mean score was 7.26. However, for each of the groups, the post-test achievement mean scores were greater than the pre-test achievement mean scores with the group exposed to adequate information on solar energy concepts having a higher mean gain (14.16>12.26). This is an indication that may have some influence on physics and technical education teachers when exposed to adequate information on solar energy concepts.

Table 1: Mean achievement scores and standard deviation of physics and technical teachers exposed to adequate information on solar energy concepts and those not exposed to the information

		Pre-test		Post-test		
Variable group	N	$\bar{x}$	SD	$\bar{x}$	SD	Mean gain
With adequate information on solar energy concepts	42	8.23	1.84	22.39	6.86	14.16
Without adequate information on solar energy concepts	40	8.12	2.07	15.38	5.02	7.26

Table 2: Analysis of Covariance (ANCOVA) of achievement scores of physics and technical education teachers exposed to adequate information on solar energy concepts and those not exposed to the information

Source	Sum of squares	df	Mean square	F	Sig.
Corrected model	218.344[a]	2	109.172	3.170	0.047
Intercept	1233.477	1	1233.477	35.815	0.000
Pretest	124.130	1	124.130	3.604	0.061
Information on solar energy	88.018	1	88.018	2.556	0.003
Error	3134.081	79	34.440		
Total	46076.000	82			
Corrected total	3352.426	81			

Table 3: Mean achievement scores and standard deviation of physics and technical education teachers exposed to adequate information on solar energy concepts in terms of location

			Pre-test		Post-test		
Variable group	Location	N	$\bar{x}$	SD	$\bar{x}$	SD	Mean gain
With adequate information on	Urban	22	4.56	0.98	11.94	3.17	7.38
solar energy concepts	Rural	20	3.67	0.99	10.45	2.75	6.78

Table 4: Analysis of Covariance (ANCOVA) of achievement scores of physics and technical education teachers exposed to adequate information on solar energy concepts in terms of location

Source	Sum of squares	df	Mean square	F	Sig.
Corrected model	0.194[a]	2	0.097	3.442	0.036
Intercept	36.427	1	36.427	1291.920	0.000
Pretest	0.039	1	0.039	1.394	0.241
With Information on solar energy	0.000	0	.	.	.
Location	0.147	1	0.147	3.201	0.165
Error	2.566	39	0.028		
Total	638.720	42			
Corrected total	2.760	41			

H_1: There is no statistically significant difference in the SECT scores of physics and technical education teachers exposed to adequate information on solar energy concepts compared to those that were not exposed to the information.

The result in Table 2 shows an F-ratio of 2.56 with an associated exact probability value of 0.00. The null hypothesis (H_{01}) is not accepted, since, the associated probability value 0.00 is <0.05 set as the level of significance for testing the hypothesis. The inference drawn is that there is a statistically significant difference in the mean SECT scores of physics and technical teachers exposed to adequate information on solar energy concepts and those not exposed to the information.

Research question two: What is the influence of location on the physics and technical education teacher's exposed to adequate information on solar energy concepts?

Results in Table 3 show that the urban group taught adequate information on solar energy concepts had a post-test achievement mean score of 11.94 with a standard deviation of 3.17. But the difference between their pre-test and post-test achievement mean score was 7.38. Meanwhile, the rural group having adequate information on solar energy concepts had post-test achievement mean score of 10.45 with a standard deviation of 2.75. The difference between the pre-test and post-test achievement mean score was 6.78. However, for each of the groups, the post-test achievement means score was greater than the pre-test interest mean scores with the urban group having a higher mean gain (7.38>6.78). Therefore, adequate information on solar energy concepts seems to favour urban group more than their rural counterpart when compared.

H_2: Location does not have a significant influence on the physics and technical education teachers exposed to adequate information on solar energy concepts.

The result in Table 4 shows an F-ratio of 3.20 with an associated exact probability value of 0.17. The null hypothesis (H_{02}) is accepted, since, the associated probability value 0.17 is >0.05 set as the level of significance for testing the hypothesis. The inference drawn was that location does not have a significant influence on the physics and technical education teachers exposed to adequate information on solar energy concepts.

The results of the findings in Table 1 reveal that physics and technical education teachers exposed to adequate information on solar energy concepts achieve more in SECT compared to those not exposed to the information. Further analysis using ANCOVA in Table 2 reveals that there is a statistically significant difference in the mean SECT scores of physics and technical education teachers exposed to adequate information on solar energy concepts and those not exposed to the information. The findings of the study are consistent with the findings of Nadabo (2010) who revealed that the growth of renewable

energy sources in Nigeria will close the gap of almost 60-70% of Nigerians who did not have access to energy or environmentally friendly energy. Also, this finding is in agreement with the initiatives of Anonymous (2006) who emphasized energy conservation and use of renewable energy in energy on education teaching tomorrow's energy consumers: the results of the findings in Table 3 show that adequate information on solar energy concepts seems to favour urban group more than their rural counterpart when compared. Furthermore, location does not have a significant influence on the physics and technical education teachers exposed to adequate information on solar energy concepts. Hence, location is not a significant factor to be considered provided physics and technical education teachers in secondary schools acquire adequate information on solar energy concepts.

CONCLUSION

Based on the findings of this study, the following conclusions have been made: physics and technical education teachers equipped with adequate information on solar energy concepts achieve more in solar energy achievement test compared to those not equipped with adequate information on solar energy concepts.

Adequate information on solar energy concepts has positive effects on global environmental degradation and energy crisis. The implication is that solar energy which is renewable and environmentally friendly will be used by the Nigerians. Location of physics and technical education teachers is not a factor to be considered provided these teachers have adequate information on solar energy concepts.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made: physics and technical education teachers training institutions should structure and restructure their courses to accommodate adequate information on solar energy concepts.

Researchers and textbook writers in physics and technical education should apply and provide useful illustrations to facilitate teaching and learning of solar energy concepts in schools.

The government in conjunction with professional associations should organize workshops, seminars, conferences and in-service training regularly to equip teachers on adequate information on solar energy concepts.

Curriculum planners should expand the content on 'Physics of Renewable Energy' with adequate information on solar energy concepts for colleges in Nigeria.

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