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Assessment of Renewable Energy Education among Senior Secondary School Students in South-Western Nigeria

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ABSTRACT

The objective of this study is to evaluate renewable energy literacy among senior secondary school students in south-western Nigeria. Nigeria is mostly dependent on fossil fuels for power generation; however, the fuel scarcity/fuel crisis witnessed in the country has made renewable energy a better option for power generation. Nigeria is a country with vast renewable energy potentials. Although renewable energy technologies is fast developing, less attention is still being paid to renewable energy education in some developing countries. In order to find out the renewable energy knowledge level in south-western Nigeria, a questionnaire on renewable energy basics is administered to five senior secondary schools in three states. A crosstab correlation of the student's responses is carried out against their school type, fields of study, gender and level of education. According to the response of 225 students, the renewable energy knowledge of the students is about 41.24% which is lower than expected.

INTRODUCTION

The world has witnessed a geometric increase in the demand of energy thanks to the diversity in the usage of fossil fuels. The GHG emitted while processing, extracting and utilizing fossil fuels is a major disadvantage to the energy world if we are to keep living on this planet [1,2]. The projection of fossil depletion at the end of 21st century if exploration continues at its current rate also makes energy related issues important globally [2,3]. Although sunlight is generally regarded as the primary source of all renewable energy sources but three sources of renewable energy gives rise to a wide range of energy flow and carriers due to the conversion processes occurring in nature [1]. With much focus on implementation and development of different renewable energy technologies in third world countries like Nigeria, little or no programs has been implemented in the education of her citizens about renewable energy issues.

While education is a system or a form of learning in which a group's knowledge, beliefs, skills, values and habits are transferred from one generation to the next [4], energy education is a means of informing the general public about what energy entails and how to use/make energy related decisions [5,6]. It entails various aspects which includes renewable energy education. It's not only limited to the renewable aspect of energy but this includes all aspects of energy and this brings a long lasting result if properly and carefully implemented.

In other to improve renewable energy and increase the sustainability of third world countries, it is highly important to equip younger generation with necessary information needed to explore, develop, utilize and maximize renewable energy potentials. In this research, the renewable energy knowledge of some students was assessed in some selected schools in south-western Nigeria. In other to validate the usefulness/effectiveness of this study, it is highly important to check the renewable energy potential available in Nigeria.

Nigeria Renewable Energy Potential

Renewable energy potential is considerably high in Nigeria and this could reduce the energy gaps between the rural areas and urban areas in the country (especially in Northern Nigeria) [7]. Nigeria is blessed with renewable energy resources like biomass,

wind, hydropower, and solar [8,9]. Biomass potentials in Nigeria is mostly in fuel wood forms, biogas and bio-crops with about 90% of the energy consumption by rural area dwellers is from biomass [10,11].

Solar energy is radiated on the earth surface at a rate of 3.8 × 1023 kW/day (1,082 million tons of oil). This is 4,000 times the crude oil production in Nigeria daily and 13,000 times the natural gas daily production [12-15]. The distribution of solar energy is fair in Nigeria with the northern region having a lion share. Average solar radiation value for this country is about (19.8 MJ/m^2) with a mean sunshine hour of 6 hours per day. This sunshine hours ranges from 9 h in far north to 3.5 h in the coastal region [12,16]. Solar potential in Nigeria is enormous because of her location in the high sunshine belt. According to Global Energy Network Institute [12], "If solar collectors or modules were used to cover 1% of Nigeria's land area, it would be possible to generate 1850 × 10^3 GWh of solar electricity annually. This is over one hundred times the current grid electricity consumption level in the country. Generally, the solar capacity for Nigeria ranges between 3.5 KW/m/day–7.0 kW/m/day and average sunshine daily of 4–7 h" [12,17].

Although wind energy is not yet used for electricity production in Nigeria, the passion to seek a lasting solution to the epileptic energy/power situation in the country prompted the government and other researchers to assess the national wind energy potential [12,13]. The wind study in Umidike (South-Eastern Nigeria) assessed its economic viability and the area is found to have a mean wind speed of 5.36 m/s annually going by the wind speed data from 1994-2003 in the area [14]. According to Studies [15], wind energy potential in Ibadan (An ancient city in South-Western Nigeria) is averagely good, having a mean wind speed of 2.947 m/s annually and solar power density of 15.484 W/m^2.

Hydropower is the only renewable energy source currently on active use for power generation in Nigeria currently. Two (Shiroro and Kainji/Jebba power plants) out of six generating power plants in Nigeria operates with hydropower and these account for 13% of the country's power generation. Hydropower, though is a major source of electricity generation currently, can still play a better role in the generation and supply of electricity in Nigeria. The country is endowed with large waterfalls, rivers and dams [18] and this are the main source of hydropower plants.

Biomass is the largest renewable energy source that is in use (actively or passively) in Nigeria. The country is very rich in biomass resources like forage grasses and shrubs, wood, wastes from forest, municipal and industrial waste, agricultural waste and aquatic biomass. Nigeria's biomass potential is estimated to be 8 × 10^2 MJ and 80 million m^3 worth of firewood is being used annually for cooking and some other domestic purposes [18]. About 6 × 10^8 MJ worth of energy has been consumed in Nigeria in the form of firewood. Also, 95% of the firewood consumed was used for domestic cooking and industrial activities (bread baking, cassava processing, oil seed processing and for cottage). As at 1973, the available biomass energy in Nigeria was estimated to be 9.1 × 10^{12} MJ [19], but currently an estimate of 2.18 × 10^6 MJ worth of energy can be obtained from dry biomass (forage grasses and shrubs) [20]. Geothermal energy is also available in small quantity in the country.

ENERGY EDUCATION

The world energy crisis in 1973 gave rise to a lot of energy organizations and this also brought about the thought of energy as being a separate discipline. Energy education is not only limited to the renewable aspect of energy but this includes all aspects of energy and this brings a long lasting result if properly and carefully implemented [21]. The actual development of energy course-curricula and its implementation at different educational level maybe very demanding, complex and will require a lot of multi-prolonged approaches. Some important energy education issues as discussed by [22] are:

- Evaluation, assessment and identification of the required inputs to be given to students at each stage of education so as to meet different job requirements.
- Integrating crucial energy aspects into general course-curricula so as to ensure a holistic approach to energy-education.
- Ensuring synergy in the mix of energy and environmental education.
- Design development and proper implantation of special or separate course(s) on energy for technicians, mechanics, energy experts and engineers.

The broad objectives of any sound energy-education scheme/program should include the following [23-27].

- To create, impact necessary skills and knowledge on energy basics.
- Develop a good awareness among students (participants) of the scheme/programme about the causes of energy crises and its nature.
- To make students embrace various energy-related policy or laws and also solve present/future energy crisis.
- To teach student about differences between renewable and non-renewable energy/energy sources. Providing them with necessary information to help make best decision when choosing energy sources.
- Creating awareness of various energy resource potentials, existing and upcoming technologies, economics and techno-economic analysis of energy, and the environmental and socio-cultural effects of energy.

- To make student appreciate energy-environment nexus and equip them to innovate new solutions to ensure sustainability.

Identifying the problems with energy sector will be incomplete without giving a scope of what a desirable energy education should look like. Energy education being at its early and developmental stage all over the world and some new energy-economy-environment nexus to be understood [22], it is important to state the features of a quality energy education which will admit all the aspect of energy into it successfully. Some of the features and contents include:

- It should include both renewable and non-renewable energy with emphasis paid to some aspects of energy desirable for that particular location.
- Energy technologies like resource assessment, economics and energetic, ecological and environmental impacts, socio-cultural issues and energy technology generally should be covered.
- Different levels of education (primary, secondary, college of education, polytechnics, and universities) should have different curriculum.
- To ensure high effectiveness of energy education, it should be taught in the language understood by the students and if possible in local languages to ensure better understanding.
- Scheme should be designed to pass necessary information required to its student at a very minimal time reference and this education should be free or at an affordable cost so that a lot of people can benefit from it.
- It should be of same standard as the energy education acquired in other developed countries.
- Finally, this education should bring about employment to students and also self-employment should be encouraged in this aspect while students are being taught.

Energy being an "underlying currency that governs everything we do with each other and with the natural environment that supports them" [28,29]. Studies explored the issues concerning energy literacy development in depth. A framework to develop surveys that adequately assess the energy literacy among high school and middle school students is laid.

Studies [28] specifically initiated that an energy literate individual must:

- Have an understanding of the effect the energy production and consumption has on the environment and society at large.
- Know how energy is used with a basic understanding of energy in our everyday life.
- Be sensitive to energy conservation and the need to encourage, develop and device alternative technologies to fossil fuel-based applications and energy resources.
- Strive to make decisions and choices as a function of energy resources, energy consumption and development.

Energy literacy is mostly assessed from the affective domain, behavioral and cognitive domain. While the cognitive measures the knowledge and understanding of the student and this is relatively simple to measure using assessment techniques. The behavioral and affective domain is a bit difficult to quantify using mere closed-questionnaires and so "a Likert, Semantic differential, Thurstone, or Guttman scale" can be used [28,30,31].

In a bid to follow up the model that developed in [28], Studies check the energy literacy level of secondary school students in USA (New York State) placing more emphasis on the affective, behavioral and knowledge of the students' energy background [32]. 3708 secondary school students were interviewed. In addition to the students' interview, 38 High school teachers and also 41 Middle school teachers were encouraged to participate in the research. 93% of the teachers said they have delivered fewer than 5 hours of energy lessons to the students before the questionnaires were administered. In the study, it was concluded that the energy literacy level in New York State is discouraging low although the high school students showed a better response than the middle school student.

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concluded that the energy literacy level in New York State is discouraging low although the high school students showed a better response than the middle school student [33].

METHODOLOGY

Problem Statement of the Study

The aim of this study is to evaluate the following problems:

1. The main statement problem for this study is the current renewable energy literacy level of the students acceptable globally.
2. Is there a statistical significant relationship between the student's renewable energy knowledge and their gender, class, type of school, field of study and age range?

Research Design

A questionnaire was designed to checks the renewable energy knowledge of the students in south-western Nigeria. The questionnaire is designed in accordance with a model created by DeWaters and Powers [6]. Some questions were also added in order to adapt the study to Nigerian renewables, social and cultural realities. The descriptive research is carried out to check the degree to which students are knowledgeable renewable energy.

Sample of the Study

The universes of this research consist of students in south-western senior secondary schools in Nigeria. The sample consist of 225 students [35.1% (n=79) male, 64.9% (n=146) female] who were selected from five different secondary schools in 3 different states in south-western Nigeria. The information about the demographic characteristics of the students is presented in **Table 1.**

Research Instrument

5-items is prepared in the research model to collect the data about students' age, type of school, gender, class, field of study. 15 items from 2 sections in the questionnaire is used to determine the students' renewable knowledge.

Independent Variable		n	%
Type of school	Federal Government college	50	22.2
	Public/State Government secondary school	100	44.4
	Private secondary school	25	11.1
	Missionary school	50	22.2
	Total	**225**	**100.0**
age	11–13 years	26	11.6
	14–17 years	186	82.7
	17-20 years	12	5.3
	above 20 years	1	.4
	Total	**225**	**100.0**
Gender	male	79	35.1
	female	146	64.9
	Total	**225**	**100.0**
Class	SS 1	64	28.4
	SS 2	68	30.2
	SS 3	93	41.3
	Total	**225**	**100.0**
Field of study	Science	132	58.7
	Arts	55	24.4
	Social Science	38	16.9
	Total	**225**	**100.0**

Table 1. Students' demographic characteristics.

Data Analysis

The 16.0 version of SPSS is used to generate charts and tables to present the findings. Also crosstab and correlation analysis are used to check the relationship between the students' age, sex and class level, field of study and the type of school and their energy knowledge. While the frequency table shows the frequency of their response, some charts are also used to display the result of the research.

Pearson correlation is used to show the relationship between their response and their general information. Pearson correlation measures the strength of association between two variables and it is used basically to investigate the between two

continuous and qualitative variables. It is used to establish if the correlation is significantly different or not buy checking the closeness of the result to the set point. Crosstab is then used to check the degree of the factors with significant difference.

RESULTS AND DISCUSSION

This section presents results and discussions obtained from the data of the questionnaire used in interviewing 225 students in south-western Nigeria. The following displayed frequency table shows the students' renewable energy knowledge status and a correlation test is used to check the students' response against their personal data. Section 1 of this result and discussion shows the student's personal data, the renewable energy knowledge of the students' is summarized in section 2 according to the questions asked in the questionnaire and section 3 shows the opinion of the student about this research and renewable energy generally.

The test about the basic definition of renewable energy is the first question asked to the students in this section, 66.7% of the students know that "renewable energy as the source of energy that can be replenished in a short while by nature". A question is asked to follow up the definition of the renewables and a serious disparity in the response of the students is observed. They were asked to identify the option that is not a renewable energy source and only 24% of the students could identify the right answer (coal) which negates their good response about renewables definition. 23.1% chose geothermal energy as an energy source that not renewable. This also shows the low publicity of geothermal energy in Nigeria despite the fact that the country has a very small geothermal potential. When asked on the "Primary source of Renewable Energy", 65 % of the student could identify sun as the source of all renewable energy sources while 35 % gave wrong response. These results shows that the students have some basic knowledge about renewable energy although the percentages and unbalanced results in consecutive questions lead the authors to conclude that the student have not learnt enough about renewable energy at their level.

Furthermore, the students were asked to identify the major drawback of renewables which is actually cost but the response of the student was very proportional. Only 21.3% of the students could identify the major setback as cost while a larger percentage thinks its 26.7% possibly due to the limited number of renewable energy experts available in the country. Rest of the responses on time, availability and technology amounts to nearly 51%. When the main advantage of renewables is questioned, it is observed that the students doesn't have a good knowledge about this aspect of renewable energy sources also as, only 17.3% of the students could identify the correct option (carbon emission). 35.1%, 28.9%, 12.4% and 6.2% chose reliability, ease access, cost and technology, respectively, as presented in **Table 2**. 63.6 % of the student knows that renewables (Electricity generation by Solar (PV) cells doesn't affect the environment and just 17.3% could identify these as being the "solar perforator" as the odd means/ technology of converting solar energy to useful energy. A question about sustainability was asked to the student. While a less convincing response was given by the students to the question as being geothermal energy (56.4%). On the other hand, 12.9% responded to this question as being petrol and 10.7%, 11.6% and 8.4% were of the opinion it is kerosene, firewood and diesel, respectively, as seen in **Tables 2 and 3.**

The term "renewable energy resources" means	**Frequency**	**Percent**
Resource that are free and convenient to use	8	3.6
Resources that can be converted directly into heat and electricity	40	17.8
Resources that do not produce pollution	13	5.8
Resources that are very efficient to use for producing energy	14	6.2
Resources that can be replenished by nature in a short period of time	150	66.7
Total	225	100.0
Which of the following energy resources is NOT renewable?	**Frequency**	**Percent**
Solar	49	21.8
Coal	54	24.0
Biomass (wood, waste, plants)	45	20.0
Water (hydro) power	25	11.1
Geothermal.	52	23.1
Total	225	100.0

What is the Primary source of Renewable Energy	Frequency	Percent
Water	33	14.7
Sun	146	64.9
Wind	8	3.6
Moon	5	2.2
None	33	14.7
Total	225	100.0
The major drawback of renewable energy technologies generally is?	**Frequency**	**Percent**
Cost	48	21.3
time	30	13.3
Availability	49	21.8
Technical expertise	60	26.7
Technology	38	16.9
Total	225	100.0
What is the main advantage of Renewable Energy over Fossil Fuels	**Frequency**	**Percent**
Carbon Emission	39	17.3
Reliability	79	35.1
Cost	28	12.4
Ease Access	65	28.9
Technology	14	6.2
Total	225	100.0

Table 2. Renewable energy basics.

The students' opinions regarding Renewable Energy applications and education were asked, 88.5% agrees that energy education should be part of the secondary school education curriculum. This shows the urgency and the thirst to learn about energy education and other energy related issues. 92.9% of the students recognize that saving energy is important both for the present world (climate change effect/carbon emission problem) and the future generation (in other to avoid possible energy crisis in the future). Conclusively, development of renewables by Nigeria was widely encouraged by the students with 88% agreeing to the fact that more ways should be developed to utilize and harvest the renewable energy resources available in the country. Also 68.5% believe that Nigeria should make efforts to develop more ways of using renewable energy technologies other than fossil fuels even if it means it will cost more as presented in **Table 3.** In summary of the research the student were asked if they have taken a subject/course related on energy before. A larger percentage (56%) of the student have taken an energy related courses before most likely from there elementary science or physics, chemistry or biology.

% Response Questions	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Energy education should be an important part of every school's curriculum	58.7	29.8	8.0	2.2	1.3
Saving energy is important	70.7	22.2	3.1	1.8	2.2
Nigeria should develop more ways of using renewable energy, even if it means that energy will come more	55.1	32.9	6.2	5.3	0.4
Efforts to develop renewable energy technologies are more important than efforts to find and develop new sources of fossil fuels	40.9	27.6	24.0	6.2	1.3

Table 3. Ways of using renewable energy technologies.

Correlation Analysis

Since the result above has a lot of disparities, a crosstab correlation analysis was carried out to determine the factors that may be responsible for the responses gotten from the students. The analysis is done by using a Pearson Correlation and crosstab correlation tool. The students' socio-economic characteristics/personal data **(Table 1)** was checked against their responses.

No significant difference was recorded when the age and class of the student was correlated against their responses. This means the renewable energy knowledge of the students is the same irrespective of their age and class. However, the type of school the students attend, their sex and field of study have some effects on some of their responses. Three significant differences were recorded from the crosstab of the students' type of school against their responses. In terms of the definition of renewable energy students from missionary school had the best response (88% correct) while private school students have the worst result (52% correct). A significant difference is also recorded when the student were asked "which of the following energy sources is NOT renewable, federal government owned secondary school has the best response (46% correct) and public/state government owned secondary school had the worst response (15% correct). Finally, federal government owned school has the least/ worst response (2% correct) while public/state government owned secondary school has the best response when the students were asked the question "solar energy can be converted to useful energy using the following technology except:" **(Table 4).** Three significant differences was recorded when the sex of the students were checked against their response with the female gender having a better knowledge **(Table 5)**. Finally, the field of study of the students affected two of their responses. With arts students showed the best knowledge in a question and the science knew more in the other question **(Table 6)**.

Type of school * The term "renewable energy resources" means

Crosstab

		The term "renewable energy resources" means					Total
		Resource that are free and convenient to use	Resources that can be converted directly into heat and electricity	Resources that do not produce pollution	Resources that are very efficient to use for producing energy	Resources that can be replenished by nature in a short period of time	
Type of school	Federal government college	4	3	6	1	36	50
	Public/state government secondary school	3	28	4	8	57	100
	Private secondary school	1	6	3	2	13	25
	Missionary school	0	3	0	3	44	50
Total		8	40	13	14	150	225

Type of school * Which of the following energy resources is NOT renewable

Crosstab

		Which of the following energy resources is NOT renewable?					Total
		Solar	Coal	Biomass (wood, waste, plants)	Water (hydro) power	Geothermal.	
Type of school	Federal government college	8	23	9	6	4	50
	Public/state government secondary school	33	15	24	8	20	100
	Private secondary school	7	2	3	7	6	25
	Missionary school	1	14	9	4	22	50
Total		49	54	45	25	52	225

Type of school * Solar energy can be converted to useful energy using the following technology except:

Crosstab

		Solar energy can be converted to useful energy using the following technology except:					Total
		Solar Photovoltaic	Concentrated Solar Power	Solar Water Heater	Solar Chimney	Solar Perforator	
Type of school	Federal government college	15	15	10	9	1	50
	Public/state government secondary school	13	21	19	20	27	100
	Private secondary school	4	3	4	11	3	25
	Missionary school	4	7	4	27	8	50
Total		36	46	37	67	39	225

Table 4. Type of school crosstab correlation summary.

Sex * Which of the following energy resources is NOT renewable

Crosstab

		Which of the following energy resources is NOT renewable					Total
		Solar	Coal	Biomass (wood, waste, plants)	Water (hydro) power	Geothermal.	
sex	male	21	23	14	9	12	79
	female	28	31	31	16	40	146

Total		49	54	45	25	52	225
Sex * The major drawback of renewable energy technologies generally is							
Crosstab							
		The major drawback of renewable energy technologies generally is					Total
		Cost	time	Availability	Technical expertise	Technology	
sex	male	16	5	18	20	20	79
	female	32	25	31	40	18	146
Total		48	30	49	60	38	225
Sex * What is the main advantage of Renewable Energy over Fossil Fuels							
Crosstab							
		What is the main advantage of Renewable Energy over Fossil Fuels					Total
		Carbon Emission	Reliability	Cost	Ease Access	Technology	
sex	male	16	34	9	16	4	79
	female	23	45	19	49	10	146
Total		39	79	28	65	14	225

Table 5. Sex crosstab correlation summary.

Field * Which of the following energy resources is NOT renewable							
Crosstab							
		Which of the following energy resources is NOT renewable					Total
		Solar	Coal	Biomass (wood, waste, plants)	Water (hydro) power	Geothermal.	
Field	Science	34	32	26	14	26	132
	Acts/Arts	10	16	10	7	12	55
	Social Science	5	6	9	4	14	38
Total		49	54	45	25	52	225
Field * Most of the Renewable Energy used for electricity generation in Nigeria comes from							
Crosstab							
		Most of the Renewable Energy used for electricity generation in Nigeria comes from					**Total**
		Solar	**Coal**	**Biomass (wood, waste, plants)**	**Water (hydro) power**	**Geothermal.**	
Field	Science	18	11	8	94	1	132
	Acts/Arts	4	4	8	38	1	55
	Social Science	13	4	6	15	0	38
Total		35	19	22	147	2	225

Table 6. Field crosstab correlation summary.

CONCLUSION

The above findings and discussions based on the data collected from 225 students in 5 different senior secondary schools in South-Western Nigeria shows that in spite of the abundant renewable energy potentials in Nigeria, the students' renewable energy knowledge is only 41.24%. Although a large percentage of the students answered some of the fundamental questions correctly, some of the basic questions were answered incorrectly which is a sign of casual/inadequate energy education. If Nigeria would like to be one of the top countries in terms of maximizing renewable energy potentials available at her disposal, a lot of informal and formal renewable educational programs should be strategically placed in order to affect both the students (younger generation) and the general public at large (including the older generations). On the other hand, some responses show the students' belief on the importance of energy education and willingness to learn about renewables. The crosstab correlation used in checking the factors that may affect the students' renewable energy knowledge clearly shows that the students are generally not knowledgeable enough about renewable energy subject as no constant factor is seen to affect the students' response. The state owned secondary school which had a poor performance (57%) in terms of response to the definition of renewable energy recorded the best (27%) response when ask about the technology that can be used to covert solar energy into useful energy. The female gender is better than the male gender in two questions while the male gender is better in another question. While social science students could identify the source of energy that is not renewable more than the other field, the science student had a better understanding of the source of renewable energy used for power generation in Nigeria. The disparity in this research clearly confirms that energy education is not taught as a separate course/subject in any school, to any gender and to any specific field as none of these proved to be totally outstanding compare to the others in their overall response. The correlation of the age and class that also has no significant effect on the students' response shows that that the students' knowledge is quite equal regardless of their age and class.

Based on the results of this study, it is recommended that renewable energy education should be a core part of Nigerian (senior secondary) educational curriculum with more attention should be given to technologies/ways to also develop and maximize the renewable energy potentials in the country. It is also important to create a general course that could be followed by all students in different fields which covers the basics of energy, its technologies, potentials and global update.

In addition, renewable energy education should be encouraged on social and media networks to enlighten both the students and also all the public at large. Finally, government should support activities such as renewable energy competitions, school projects...etc., where students could have opportunity to participate and reflect their theoretical knowledge to practical applications and therefore to own renewable energy more.

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