

Energy Conceptions among Science Students for Sustainable Development

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Abstract

The study-energy conception among science students for sustainable development was guided by two research questions and one hypothesis. Descriptive survey was adopted for the study. The study was carried out at Science Education Department, University of Nigeria. Five hundred and sixteen (516) (320 female and 196 males) students formed the population of the study and two hundred and twenty five (225)(86 males and 139 females) students formed the sample size. That is 80 first year students, 88 second year students, 28 third year students, and 29 final year students. The sample size was composed using proportionate stratified random sampling technique to sample the students across levels (100-400 levels). A 15-item instrument titled "Energy Conception Questionnaire" (ECQ) was self developed by the researchers to illicit responses on students' conception of energy concept. The reliability of the instrument was obtained using Kuder-Richardson 20 with reliability index of 0.80 obtained. Four research assistants, with the researchers helped in the distribution and retrieval of the instrument. Frequency and percentages were used to answer the research questions and hypothesis tested using Chi-square. Findings revealed that student's misconceived energy as something tangible or product instead of a process, for instance 90% of the students agreed that energy is like in a man's muscle; energy is something like fuel, and food (90.2%); and when energy is transformed, its amount changes (64.4%). Findings equally revealed that gender has no influence statistically on students' conception of energy among others. Finally, the researchers recommend among others that science teachers should identify students' misconceptions in a particular topic first before going into the teaching proper.

Key words: Sustainable development; energy; and gender

Introduction

Across the globe, development with attendant and multiplicity effects (negative) for the future generation has been overtaking with development predicated upon the need-base theory of the present and future generation. The development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs is called sustainable development (Kates, Parris, and Leiserowitz, 2005). Sustainable development is premised on seventeen (17) goals, with 169 targets and 304 indicators. The seventeen goals include no poverty, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reduced inequality, sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land, peace, justice and strong institutions, and partnerships for goals (Gupta and Geeta, 2015; and Batty, Margaret, 2015).

The most important among the listed goals is quality education, in that quality education drives development of any kind, be it in health, sanitation, poverty, inequality, production etc. Quality education could be seen as a weapon to liberate ignorance, disease and poverty. World over, teaching has been one of the old practices with modern touch in which quality education depends. In science for instance, teaching has gone beyond teacher's centred with attendant rote learning to students centred with meaningful learning. However, meaningful learning occurs only when the previously held ideas and information that conflict with scientific held beliefs are reconciled and repaired (Orji, 2013). During teaching and learning encounter, it is the duty of the teacher to ask questions that will help unravel and unearthed students wrongly held beliefs and thereafter, teach the correct scientifically held belief. Researchers (Madu, 2004, Ugwuanyi, 2012, and Orji, 2013) over the years have beamed their research torch light on students' levels of

understanding and conceptions in science topics and found that students misconceived concept of electricity, motion, heat and temperature. However, no research (in this locality) to the best knowledge of the researcher has been carried out on students' conception in energy and its law of conservation.

Energy concept is one of the unifying concepts that cut across different science subjects like biology, physics, and chemistry. For instance, in biology, energy is treated in area of photosynthesis and respiration, while in chemistry energy is treated as free energy and stored energy in chemicals, whereas in physics energy is handled as a topic in its thermodynamic laws. This unification property of energy has brought conceptual challenges with the concept. In support of this statement, Mann, and Treagust, (2010) posits that the common usage of energy has developed a whole set of meanings in everyday life that are in conflict with the meanings assigned to this word by science for instance people talk about of 'burning energy', 'using up energy', 'conserving energy', 'wasting energy', 'saving energy' and numerous other terms. Also, Azlinah Ispal, Zaki Ishak, and Asri Ispa (2015) showed that there are serious difficulties in understanding of energy and its related concepts among students of all ages. One of the reasons for students' misconception in energy concept could be partly due to the way and manner energy is taught in schools. For example, energy is taught as ability or capacity to do work only, without considering the circumstances and conditions for work done (Azlinah Ispal , Zaki Ishak, and Asri Ispa, 2015). Again, potential energy is defined as energy in position or rest, but work is said to be done when a force move a body through a distance, in the direction of the force. So there is need to explain why potential energy is a form of mechanical energy since a resting body is assumed not to being doing work. Therefore, teachers should explain the role of gravity on potential energy. Finally, of interest to the researcher is gender related issues on students'

conception of energy. Could students' gender influence their conception of energy concept? This research intends to address the question.

Purpose of the Study

This study aims at establishing the science students' conceptions of the concept of energy. Specifically the study intends:

1. Determine the students' conceptions of energy for sustainable development;
2. Determine the influence of gender on students' conception of concept of energy

Research Questions

The following research questions guided the study

1. How do students conceive the concept of energy for sustainable development?
2. What influence does gender has on students' conception of concept of energy?

Hypothesis

Gender is not statistically significant on students' conception of concept of energy

Method

Descriptive survey was adopted for the study. According to Nworgu (2006), descriptive survey is a study aims at collecting data on, and describing in a systematic manner, the characteristics, features or facts about a given population. This design became appropriate for this study because the researchers want to describe students' conceptions of energy concept. The study was carried out at Science Education Department, University of Nigeria as an action research aimed at promoting quality teaching and learning for sustainable development. Five hundred and sixteen (516) (320 female and 196 males) students formed the population of the

study. The break down is 185 first year students, 200 second year students, 64 third year students, and 67 final year students (statistics gotten from Science Education Depart., UNN). Two hundred and twenty five (225) (86 males and 139 females) students formed the sample size. That is 80 first year students, 88 second year students, 28 third year students, and 29 final year students. The sample size was composed with Yamane (1967) formula using the entire population of the students, thereafter; proportionate stratified random sampling was used to sample the students across levels (100-400 levels). A 15-item instrument titled “Energy Conception Questionnaire” (ECQ) was self developed by the researchers to illicit responses on students’ level of conception of energy concept. The instrument has two sections: section A containing the demographic variables of the respondents and Section B containing the items of the instrument. The instrument was face validated by three experts in Science Education. The reliability of the instrument was obtained using Kuder-Richardson 20 because the instrument is dichotomously scored and the reliability index of 0.80 was obtained. Four research assistants, with the researchers helped in the distribution and retrieval of the instrument. Frequency and percentages were used to answer the research questions and hypothesis tested using Chi-square because the data collected fall under nominal data (that is category in-built data).

Results

Research Question 1: How do students conceive the concept of energy for sustainable development?

Table 1: Frequency and percentage of students' conceptions of energy concept for sustainable development

S/N		Freq./Percentage(%) of students that Agree	Freq./Percentage (%) of students that Disagree
1	Energy can be seen like in a man's muscle	203(90.2)	22(9.8)
2	Energy is something like fuel, food etc	195(87.0)	30(13.0)
3	When energy is transformed, its amount changes	145 (64.4)	80(35.6)
4	Energy cannot be transferred from one place to another	113(50.2)	112(49.8)
5	Energy cannot be created	160(71.1)	65(28.9)
6	Energy value cannot change	111(49.3)	114(50.7)
7	If you switch off your electric fan, the energy in it vanishes	107 (47.6)	118(52.4)
8	Energy is the ability to do work only	114 (50.7)	111(49.3)
9	If you switch off all the appliances in the house, energy is conserved	168(74.7)	57(25.3)
10	If you switch on all the appliances in the house which you are not using, you waste energy	156(69.3)	69(30.7)
11	Energy can be renewed by adding another energy to the existing one	179(78.2)	49(21.8)
12	While cooking in a kerosene stove, if the kerosene finishes and the wick grows dim, the energy that cooks the food dies	177(78.7)	48(21.3)
13	Energy at rest cannot do work	184(81.3)	41(18.2)
14	Energy in motion does work	199(88.4)	26(11.6)
15	Energy is force	196(87.1)	29(12.9)

NB: N= Number of respondents; %= percentage and Freq= frequency

Table one revealed that out of 225 students sampled for the study, that 203 (90%) agreed that Energy can be seen like in a man's muscle with only 22 (9.8%) disagreed. Also, 195 (90.2%) agreed that energy is something like fuel, and food with only 30 (13%) disagreed. In item 3, 145 (64.4%) agreed that when energy is transformed, its amount changes, with 80(35.6) disagreed. In item 4, 113 (50.2%) agreed that Energy cannot be transferred from one place to another with 112(49.8%) disagree. In item 5, 160(71.1%) agreed that Energy cannot be created with 65(28.9%) disagreed. In item 6, 111(49.3%) agreed that Energy value cannot change with 114(50.7%) disagreed. In item 7, 107(47.3%) agreed that If one switch off his/her electric fan,

the energy in it vanishes with 118(52.4%) disagreed. In item 8, 114(50.7%) agreed that Energy is the ability to do work only with 111(49.3%) disagreed. In item 9, 168(74.7%) agreed that If you switch off all the appliances in the house, energy is conserved with 57(25.3%) disagreed. In item 10, 156(69.3%) agreed that If you switch on all the appliances in the house which you are not using, you waste energy, with only 69(30.7%) disagreed. In item 11, 179(78.2%) agreed that Energy can be renewed by adding another energy to the existing one, with only 49(21.8%) disagreed. In item 12, 177(78.7%) agreed that while cooking in a kerosene stove, if the kerosene finishes and the wick grows dim, the energy that cooks the food dies, with only 48(21.3%) disagreed. In item 13, 184(81.3%) agreed that Energy at rest cannot do work, with only 41(18.2%) disagreed. In item 14, 199(88.4%) agreed that Energy in motion does work, with only 26(11.6%) disagreed. Finally, in item 15, 196(87.1%) agreed that Energy is force, with only 29(12.9%) disagreed. See the chart below.

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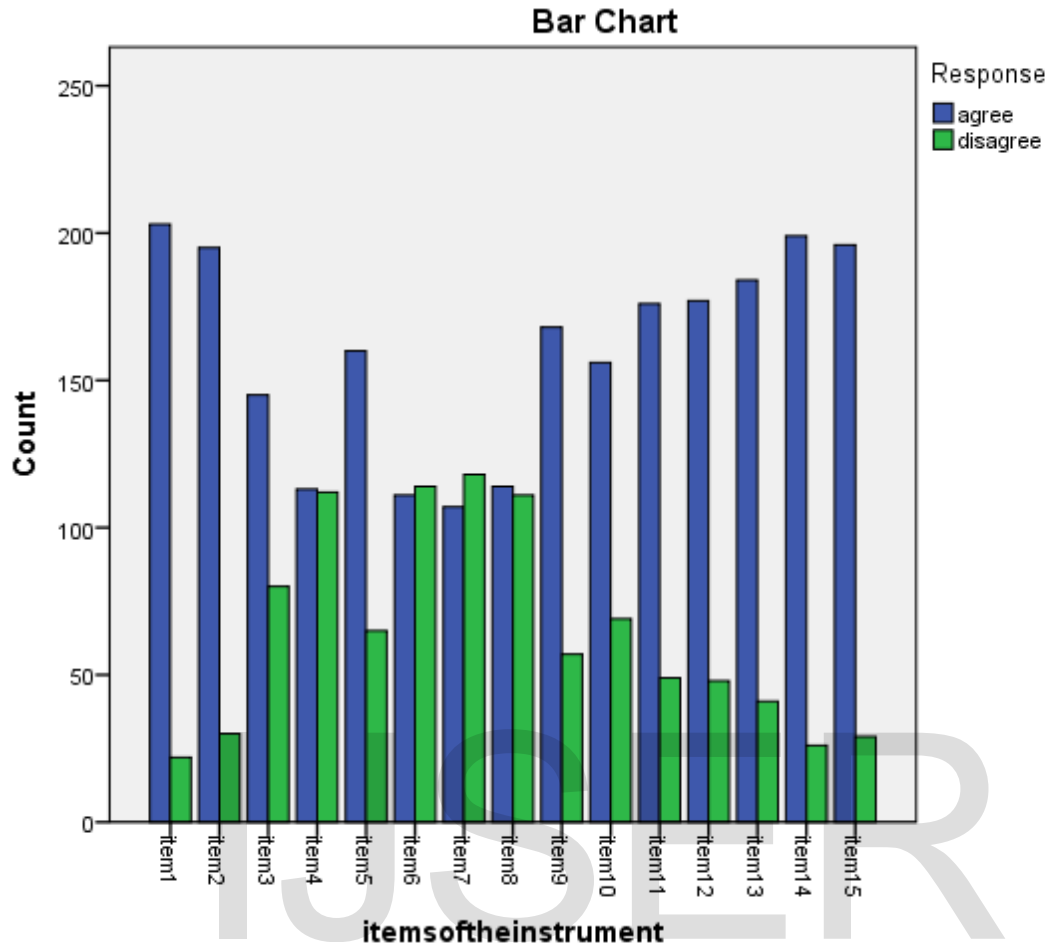


Fig. 1.0: Bar Chart Showing the Response Pattern of Students on their Energy Conception

Figure 1, illustrates the items the students have misconceptions on. It shows that students have misconception on item1, 2, 3, 5, 9, 10, 11, 12, 13, 14, and 15 this is evident by the length of the chart. In these items the majority of the students agreed on them. But in item, 4, 6, 7 and 8, half of the students agreed and half disagreed, showing indecision or undecided.

Research Question 2: What influence does gender has on students’ conception of concept of energy?

Table 2: Frequency and percentage of students’ conceptions of energy concept for sustainable development based on gender

S/N		Male (N=86)		Female (N=139)	
		Percentage(%) of students that Agree	Percentage(%) of students that disagree	Percentage (%) of students that agree	Percentage (%) of students that Disagree
1	Energy can be seen like in a man’s muscle	79(35.1)	7(3.1)	124(55.1)	15(6.7)
2	Energy is something like fuel, food etc	68(30.2)	18(8.0)	127(56.4)	12(5.3)
3	When energy is transformed, its amount changes	60(26.7)	26(11.6)	85(37.7)	54(24.0)
4	Energy cannot be transferred from one place to another	48(21.3)	38(16.9)	65(28.9)	74(32.8)
5	Energy cannot be created	65(28.9)	21(9.3)	95(42.2)	44(19.6)
6	Energy value cannot change	40(17.8)	46(20.4)	71(31.6)	68(30.2)
7	If you switch off your electric fan, the energy in it vanishes	34(15.1)	52(23.1)	73(32.4)	66(29.3)
8	Energy is the ability to do work only	41(18.2)	45(20.0)	73(32.4)	66(29.4)
9	If you switch off all the appliances in the house, energy is conserved	61(27.1)	25(11.1)	107(47.6)	32(3.7)
10	If you switch on all the appliances in the house which you are not using, you waste energy	66(29.3)	20(8.9)	90(40.0)	49(21.8)
11	Energy can be renewed by adding another energy to the existing one	67(29.8)	19(8.4)	109(48.4)	30(13.4)
12	While cooking in a kerosene stove, if the kerosene finishes and the wick grows dim, the energy that cooks the food dies	66(29.4)	20(8.9)	111(49.3)	28(12.4)
13	Energy at rest cannot do work	75(33.3)	11(4.9)	109(48.4)	30(13.3)
14	Energy in motion does work	75(33.3)	11(4.9)	124(55.1)	14(6.7)
15	Energy is force	75(33.3)	11(4.9)	121(53.8)	18(8.0)

Table 2 indicates that male and female students respondents have almost if not the same response pattern, a situation indicating that gender influence on students conception of energy if not noticeable. However, the supportive hypothesis below will explain better.

Research Hypothesis: Gender is not statistically significant on students' conception of concept of energy

Table 3: Chi-square analysis of gender statistically influence on students' conception of concept of energ

S/ N		Male (N=86)		Female (N=139)		P- value	Rema rk
		Percentage (%) of students that Agree	Percentage (%) of students that disagree	Percentage (%) of students that agree	Percent age (%) of student s that Disagre e		
1	Energy can be seen like in a man's muscle	79(35.1)	7(3.1)	124(55.1)	15(6.7)	0.52	NS
2	Energy is something like fuel, food etc	68(30.2)	18(8.0)	127(56.4)	12(5.3)	0.008	S
3	When energy is transformed, its amount changes	60(26.7)	26(11.6)	85(37.7)	54(24.0)	0.19	NS
4	Energy cannot be transferred from one place to another	48(21.3)	38(16.9)	65(28.9)	74(32.8)	0.19	NS
5	Energy cannot be created	65(28.9)	21(9.3)	95(42.2)	44(19.6)	0.25	NS
6	Energy value cannot change	40(17.8)	46(20.4)	71(31.6)	68(30.2)	0.51	
7	If you switch off your electric fan, the energy in it vanishes	34(15.1)	52(23.1)	73(32.4)	66(29.3)	0.06	NS
8	Energy is the ability to do work only	41(18.2)	45(20.0)	73(32.4)	66(29.4)	0.48	NS
9	If you switch off all the appliances in the house, energy is conserved	61(27.1)	25(11.1)	107(47.6)	32(3.7)	0.31	NS
10	If you switch on all the appliances in the house which you are not using, you waste energy	66(29.3)	20(8.9)	90(40.0)	49(21.8)	0.06	NS
11	Energy can be renewed by adding another energy to the	67(29.8)	19(8.4)	109(48.4)	30(13.4)	0.93	NS

	existing one						
12	While cooking in a kerosene stove, if the kerosene finishes and the wick grows dim, the energy that cooks the food dies	66(29.4)	20(8.9)	111(49.3)	28(12.4)	0.58	NS
13	Energy at rest cannot do work	75(33.3)	11(4.9)	109(48.4)	30(13.3)	0.09	NS
14	Energy in motion does work	75(33.3)	11(4.9)	124(55.1)	14(6.7)	0.65	NS
15	Energy is force	75(33.3)	11(4.9)	121(53.8)	18(8.0)	0.97	NS

NB: N= Number of respondents; NS= Not significant; S= Significant; and P-value= Probability value or associate probability

Table 3 above revealed that associate probability (p-value) was greater than the level of significance (0.05) in all the items above (1-15) except in item 2. Hence the alternative hypothesis was upheld. This means that gender is not statistically significant on students' conception of concept of energy.

Summary of the Findings

Findings indicate that students possessed a naïve conception of energy such as:

1. Product conception- here students see energy as something tangible or product instead of a process, e.g. Energy can be seen like in a man's muscle(90%); energy is something like fuel, and food (90.2%); when energy is transformed, its amount changes (64.4%). But the amount of energy cannot change only the value of energy that changes.
2. Conservation conception- here the students demonstrated lack of proper understanding of law of conservation of energy e.g students misconstrued conservation to saving of money for instance, If you switch off all the appliances in the house, energy is conserved (74.7%); If you switch on all the appliances in the house which you are not using, you waste energy (69.3%); and while cooking in a kerosene stove, if the kerosene finishes and the wick grows dim, the energy that

- cooks the food dies (78.7%). But energy from law of conservation of energy cannot be destroyed but can be transformed. This again is a product of every day societal usage of energy concept.
3. Renewable conception- here students misconstrued renewable to mean adding extra energy. For instance, energy can be renewed by adding energy to the existing one (78.2%). But renewable energy means energy that is self sustaining, and replenishable.
 4. Work conception- here again students demonstrated lack of proper understanding of notion of work for instance energy at rest cannot do work(81.3%), only energy in motion does work (88.4%), and that energy is force (87.1%). So students exchange energy with work or force. But energy is not work, but the ability to do the work, this means that energy at rest has the ability to do work, and is conserved.
 5. Finally gender influence on students' conception of energy was found to be statistically insignificant.

Discussion of the Findings

Findings revealed that students' misconceived energy as something tangible or product instead of a process, for instance 90% of the students agreed that energy is like in a man's muscle; energy is something like fuel, and food (90.2%); and when energy is transformed, its amount changes (64.4%). Also, findings indicate that students misconstrued conservation to saving of money for instance, if one switch off all the appliances in the house, energy is conserved (74.7%); if one switch on all the appliances in the house which he/she is not using, you waste energy (69.3%); and while cooking in a kerosene stove, if the kerosene finishes and the wick grows dim, the energy that cooks the food dies (78.7%). But energy from law of

conservation of energy cannot be destroyed but can be transformed. This again is a product of every day societal usage of energy concept. Also, students misconstrued renewable to mean adding extra energy. For instance, energy can be renewed by adding energy to the existing one (78.2%). But renewable energy means energy that is self sustaining, and replenishable. Equally found was that energy at rest cannot do work (81.3%), only energy in motion does work (88.4%), and that energy is force (87.1%). So students exchange energy with work or force. But energy is not work, but the ability to do the work, this means that energy at rest has the ability to do work, and is conserved. For instance a falling body does work, yet it possesses potential energy at certain stage of the height. Again, a student seating down in a classroom and listens to what his/her teacher teaches does work. Finally, the findings show that gender influence on students' conception of energy was found to be statistically insignificant.

These findings are positively in alignment with the findings of Mann, and Treagust, (2010) who found that the common usage of energy has developed a whole set of meanings in everyday life that are in conflict with the meanings assigned to this word by science for instance people talk about of 'burning energy', 'using up energy', 'conserving energy', 'wasting energy', 'saving energy' and numerous other terms. Also, the findings of the study is equally in line with the findings of Azlinah Ispal , Zaki Ishak, and Asri Ispa(2015) who showed that there are serious difficulties in understanding of energy and its related concepts among students of all ages and posits that one of the reasons for students' misconception in energy concept could be partly due to the way and manner energy is taught in schools. For example, energy is taught as ability or capacity to do work only. Also, findings of Dawson-Tunik and Stein (2004) who found that students represent energy in terms of movement , agreed with findings of the present study.

Conclusion

Findings of this study and studies reviewed indicate that students have various degree of misconceptions on concept of energy such as seeing energy as possessing tangible property, and being the same as work and force among others.

Recommendations

Based on the findings of this study, the following recommendations become necessary

1. Instructional Focused- teachers should identify students misconceptions in a particular topic first before going into teaching proper
2. Curriculum design- curriculum designers should build misconceptions' identifications not just previous knowledge into the curriculum

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Instrument for Data Collection

Level: 100 200 300 400

Gender: Male Female

Please indicate your agreeability or not on the items below, no wrong or right answer(s), ok.

S/N		Agree	Disagree
1	Energy can be seen like in a man’s muscle		
2	Energy is something like fuel, food etc		
3	When energy is transformed, its amount changes		
4	Energy cannot be transferred from one place to another		
5	Energy cannot be created		
6	Energy value cannot change		
7	If you switch off your electric fan, the energy in it vanishes		
8	Energy is the ability to do work only		
9	If you switch off all the appliances in the house, energy is conserved		
10	If you switch on all the appliances in the house which you are not using, you waste energy		
11	Energy can be renewed by adding another energy to the existing one		
12	While cooking in a kerosene stove, if the kerosene finishes and the wick grows dim, the energy that cooks the food dies		
13	Energy at rest cannot do work		
14	Energy in motion does work		
15	Energy is force		