Research on Humanities and Social Sciences
ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)
Vol.4, No.4, 2014

Ghanaian Senior High School Students' Perceptions of Energy

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Abstract
This study used descriptive survey design to find out Senior High School students' perceptions of energy and examined influences of gender, geographical location and academic programme on students' perceptions of energy. Questionnaire on seven frameworks of energy was used to collect data from 720 students in 18 Senior High Schools in Ghana. Data were analysed using frequencies and percentages. The study showed that Senior High School students in Ghana perceive energy as anthropocentric, depository, an ingredient, an activity, a product of processes, functional and flow. In the teaching of energy, rather than simply contradicting students' perceptions, a better strategy is to build on what students perceive of energy and try to help them modify their perceptions appropriately.
Keywords: senior high school, perception of energy, 'depository' model of energy, alternative conceptual framework of energy, seven frameworks of energy.

1.0 Background of the study

Energy is one of the scientific concepts which is central in school science and is often perceived alternatively and scientifically by students. As a core concept, energy covers about 20% of Integrated Science syllabus in Senior High School (SHS) in Ghana (Ministry of Education, Youth and Sports [(MOEYS)], 2012). Noticeably, energy both from the SHS Integrated Science syllabus and in the classroom is presented in the Physics perspective. In the syllabus for instance, emphasis of energy is placed on definitions, forms and mathematical formulation. Little is related to students' perceptions about the energy. This makes it difficult for students to learn and apply energy in their "everyday" living. The current mode of teaching energy in science is basically base on mathematical formulations and definitions as a result students learn energy as mathematical formulations; memorize the definitions for the classroom and examination purpose. Outside the classroom, students perceive energy differently from those definitions and most often do not apply the mathematical formulations in their daily lives. For instance, in the students' everyday language, we hear of 'the country is having energy crises, the energy supplied by the motor; I need some rest to gain lost energy, burning energy, used up energy, waste energy, and save energy. It however, appears that students do not appreciate the scientific perspective of energy. Despite the fact that energy is a fundamental concept of science, moves towards proper instruction of energy seem to remain inappreciably low. An attempt in assisting students to develop their perceptive about energy into refined perspectives that are useful for making sense of their experiences may have to start with students' own perceptions of energy.

1.1 Statement of the problem

Research has pointed out that students' perceptions are essential considerations to the learning of science (Fraser, 2000; McInnis, 2003). However, in Ghana students learn energy in science with little considerations to their perceptions. The SHS teaching syllabus which serves as a guide in the learning of science, including energy, does not show any reflection on students' perceptions of energy. Energy in the syllabus is presented basically in simple definitions and mathematical formulations. A major limitation is that Ghanaian teachers appear to know nothing about the perceptions of energy their students hold and how these can be integrated to promote students learning of energy. More profoundly, the current mode of teaching energy in science where the focus is basically on mathematical formulations and definitions does not promote meaningful learning. As a result students find energy in school science abstract and cannot apply it to their daily lives. The study of students' perceptions is based upon the assumption that if students' perceptions of energy are to develop into more refined perceptive of the scientist then we must first ascertain what perceptions of energy they may hold. Therefore a timely study of students' perceptions of energy is indispensable.

1.2 Research Question

The following research question guided the study: What perceptions do Ghanaian senior high school students have about energy?

2.0 Students' perceptions of energy

There has been much study interested in the area of energy in education owing to its occurrence across every fields of science. From the research works of Corney (2000), Dawson (1997), Driver (1985), Osborne and

Freyberg (1985) and Tytler (2002), some recurring themes about students' prior knowledge of science related topics can be made. These themes are: students bring to their studies their own ideas about science and environmental concepts; these pre-conceived ideas are formed through prior experiences and they are very persistent; and, the pre-conceived ideas are difficult to change. Because of its abstract nature and associated concepts, a number of studies have focused on energy in diverse views: energy conversion (Ebenezer & Fraser, 2001; Liu, Ebenezer & Fraser, 2002), heat and temperature (Sözbilir, 2003), photosynthesis (Özay & Öztaş, 2003; Çepni, Taş & Köse, 2006), energy and its description (Diakidoy, Kendeou & Ioannides, 2003), Scientific and technological questions related to energy supply, distribution, and storage (e.g., Davis, 2011), energy challenges (Hegedus & Temple, 2011), individual and household energy consumption behaviour (Southwell, Murphy, DeWaters & LeBaron, 2012), solar energy and photovoltaic cells (Kishore &Kisiel, 2013) . These studies confirm that students can conceptualize the experiences they encountered in a different manner rather than conventional scientific perspectives. Notably, students would rely on various knowledge fundamentals stored in memory in order to solve a problem involving physical phenomena. They would also attempt to retrieve these fundamentals, and apply them without much further reasoning rather than rely on general laws or concepts. A large number of researchers such as (Diakidoy *et al*., 2003; Hirca, Calik & Akdeiniz 2008; Nordine, 2007) have reported on the ideas students hold with respect to energy.

Watts (1983) talked about alternative views on energy in a study which was established within seven frameworks on how students perceive energy. These frameworks are:

- ❖ Human centered energy, a situation where energy is seen to be connected principally with persons, or regard as objects as if they had human attributes;
- ❖ A 'depository' model of energy- with this view energy is perceived as an object that is rechargeable, some as having need of energy and simply use it up what they get and yet others as neutral. Energy, then, is a causal agent, a source of activity based or stored within certain objects;
- ❖ Energy is an 'ingredient' - a dormant constituent within objects or situations that needs some 'trigger' to release it;
- ❖ Energy is an obvious activity – from this view it is not seen as the cause of the action, but as the occurrence itself;
- ❖ Energy is a product - here it is treated as a relatively short-lived product that is generated, its active for some time and then disappears or fades;
- ❖ Energy is functional - firstly energy is more or less restricted to technical appliances and secondly is not essential to all processes but is mainly associated with those that make life more comfortable; and
- ❖ Energy as a flow – in this way energy is seen as being 'put in', 'given' 'transported', 'conducted' and so on.

Trumper and Gorsky (1993) also in their study stated nine discrete conceptual frameworks designed for discussing perceptions about energy. Features of these extensive conceptions are as follows.

- ➢ Energy is associated with people;
- ➢ Things possess and expend energy;
- ➢ Energy causes things to happen;
- ➢ Energy is an ingredient in things and can be released by a trigger;
- ➢ Energy is associated with activity;
- ➢ Energy is created by certain processes;
- ➢ Energy is a generalized kind of fuel associated with making life comfortable;
- ➢ Energy is a kind of fluid which is transferred in some processes; and
- ➢ A scientific conception in which energy is transferred from one system to another

Liu and McKeough (2005) studied United States students' responses to selected items in the TIMSS database. They classified items in order of the type of conception that the items represented and came up with the following categories:

- activity/work - energy is associated with activities;
- source/form - energy is stored in a variety of sources and can be present in different forms;
- transfer - energy can be transferred;
- degradation - energy is "lost" during transformations; and
- conservation - the total energy in a closed system must be constant.

Hirca *et al*, (2008) studied students' conceptions of energy and related concepts with 171 grade 8 students. Among other results, Hirca *et al*., (2008) reported to have found that 50% of the grade 8 student understood the abstract structure of energy, 26% of them could take into account the relationship between 'work' and 'energy' concept, between 65% and70% of the student were able to apply theoretical knowledge to novel situation. Regarding energy conversion, 72% could apply energy conversion to different cases. Seventy-four percent (74%) of the student failed to comprehend the relationship between types of energy and its conversion while 64% failed to comprehend the relationship between types of energy and its conversion and applying it to novel situation.

The findings of such study show that perceptions held by students do certainly weaken their ability to learn and apply energy concepts formally presented to them in science lessons. This could contribute to students' poor performance in science.

2.1 Confusion of terms within energy among students

Watts (1983) discussed the fact that students need to be taught force and work before energy. According to Watts, this would reduce the problem of confusing these ***three*** terms. One possible reason for this confusion arises from the everyday observations involving these concepts where they all are linked in some way to energy and observations of their effects are similar to those of energy. This may be the everyday use of many of these terms. For example, we do not say turn on the energy to light a bulb in your room, but rather we say turn on the power, where power and electrical energy appear to be synonymous to them. More materials may perhaps have been taught in such a method as to not treat the same aspect of the concept. Evaporation is an example. In chemistry, it is taught as a separation method and in another, as process to water molecule movement as a liquid boils. It is rare that the cooling effect of evaporation is focused on in formal circumstances and even less regularly that the cooling effect is associated to body temperature regulation and sweating. Further, researchers since then have reported on learner confusion between a variety of terms and energy (Barak, Gorodetsky, & Chipman,1997; Harrison, Grayson & Treagust, 1999).

2.2 Energy and the duality of meaning

The duality of language that students face along with the perception associated with each word's usage can and does generate inconsistency within the individual. More often, the students will forget or reject the scientific meaning of the term and revert to the common language meaning, especially over time when the former meaning is not frequently used. It is more convenient and less stressful to use the common meaning as it is part of everyday life and as such this meaning is continually reinforced by society. This confusion due to multiple meanings of terminology is especially relevant in science classes dealing with energy where energy is often introduced to students with the definition of "Energy" equals "Work done". The use of this definition assumes the learner to have a scientific meaning of work, which is highly unlikely due to its common language use and meaning. At the same time, many science teachers especially in the past have assumed learners have scientifically acceptable understanding of energy and proceed to teach energy based on this assumption (Linjse 1990).

2.3 Energy and activity as a dual meaning of terms

The perception that energy is activity or is only present when activity occurs is a commonly reported phenomenon and is found in all age groups (Jennison & Reiss, 1991; Lijnse, 1990; Nicholls & Ogborn, 1993). This energy and activity link is not the acceptable perception that activity requires energy; rather that energy is only present when activity or change occurs. This confusion could arise in a similar manner to that of the conservation of energy and other held conception on energy sources. Observations of situations involving energy all have some form of activity or change present. For a human to be active requires the expenditure of energy and leads to a decrease or loss of useful energy. So to the young learner, when other objects undergo change, energy must be involved (as a form of activity to cause the change) and so it is as well since energy needs to be continually supplied to the situation. With these discoveries of the poor understanding of the scientific conception of energy across a range of ages and countries, it is of little surprise that a number of researchers advocate teaching energy with both a real life focus starting from primary to senior high school level.

Methodology

3.1 Research design

Descriptive survey research design was used in this study. The researchers used descriptive survey because it allows for standardization and uniformity of questions asked, and easier comparison and contrasting of answers by respondent groups can be made (Kumekpor, 2002). It is also an efficient and accurate means of determining relatively inexpensive, quicker and reliable information about a given population. Again, findings related to perception are noted to be reliable if data are drawn from wider and representative sample which is a typical characteristic of survey design. Since the purpose of this study is to obtain large data on perception of energy to describe Ghanaian students' views about energy, the researchers found descriptive survey appropriate.

3.2 Population and area of study

The population was all students enrolled at the Senior High Schools in the ten regions of Ghana. These students are all required by the Integrated Science Curriculum to study scientific concepts including energy which are considered core in daily life. However, in order to collect reliable data from students who have a well-formed concept about energy, second year students were selected for the study. Third year students were not selected because they had written their final West African Senior Secondary Certificate Examination (WASSCE) and were not available in schools at the time of this study. The students (both males and females) are located in schools with rural, semi-urban and urban settlements. Also, the students either offered science programmes

(Science, Home Economics, Agriculture and Technical) or non-science (Arts and Business).

3.3 Sample and sampling procedures

Out of the ten regions in Ghana, lottery method was used to select three regions for the study. The regions were labeled on pieces of paper, folded and drawn out at random and Volta, Eastern and Central Regions were selected. The three regions represent 30% of the regions in Ghana. After selecting the regions, next was the choice of location of schools. This was done based on settlements considered urban, semi-urban and rural. Two schools each were purposively chosen from the regions to reflect the three types of settlements (urban, semi-urban and rural) considered in the population. All the schools selected were made up of male and female students; hence no single sex school was used in the study. In the schools, stratified random sampling was used to select students from SHS 2 which was considered most appropriate category that possessed well-formed perception of energy. This sampling procedure was used to ensure there was increase chance of representativeness of gender and programmes since the sample were not of the same size (Fraenkel & Wallen 2003). For example, it was found that some programmes had high number of males than females and vice versa. Stratifying the sample by gender therefore enhanced the proportion of male and females. With assistance from teachers, stratified random samplings of programmes followed by instant random selection of male and female students were done to arrive at 40 students from each school visited. Ten students were selected from each of the four programmes namely science, arts, business and home economics/technical to include perception by programmes. However, under each programme, male to female proportions were calculated to obtain ten students.

3.4 Research instrument

Questionnaire was used to survey students' perception of energy in line with seven frameworks. It was adopted from Trumper and Gorsky (1993) and Watts (1983) distinct conceptual framework of energy and modified to determine the students' perception of energy in the Ghanaian setting. It was made up of two main sections; Section A and Section B. Section A focused on the biographic data of the respondents that included class and sex. Section B was made up 21 items put into three scales of true, partly true and not true. Likert scale from which respondents choose one option that best aligns with their view. Three of the 21 items were framed to illustrate instances of each of the seven frameworks of energy perception by Watts. Watts's (1983) seven (7) frameworks, which were later substantiated by Gilbert and Pope (1986) and Trumper (1990a & b) and are consistent with Trumper and Gorsky's (1993) nine distinct conceptual frameworks for energy, are categorized as follows:

1. Anthropocentric - which finds out how a student perceive energy to be associated with human beings;
2. Depository – which finds out how the student perceives that some objects have energy and some, needs it;
3. Ingredient - the focus here is on whether the student is able to perceive energy as dominant within some objects and can be released by some trigger.
4. Activity -this deal with energy being identified by overt displays, and the display itself is actually called energy;
5. Product - whether the student does perceive energy as a by-product of some situation and is relatively short lived;
6. Functional - whether the student thinks about energy as a very general kind of fuel or less restricted technical devices and not essential to all processes;
7. Flow transfer – energy is some sort of physical fluid that is transferred in certain processes.

The items described each of these seven frameworks and took into consideration common use of energy in everyday life in Ghana.

3.5 Data collection procedure/ethical consideration

A total of six weeks was used to collect data from the three regions. In each school the researcher visited, a teacher was assigned by the head or assistant headmaster to assist in identifying the required male and female proportions and select the 10 students each from the four programmes needed for the questionnaire administration. The selected students were often conveyed to one classroom and briefed on the purpose of the study. Each student was told to opt out if s/he did not want to be involved in answering the questionnaire. Students were given the opportunity to ask questions to clarify issues that were not clear to them. In order to ensure independent responses, students also consented to complete the questionnaire before leaving the classroom. A maximum of 15 minutes were used by students to answer the items in the questionnaire in all the 18 schools visited. The return rate was 100%.

3.6 Reliability and validity

A pilot test was carried out on forty (40) SHS 2 students in one Senior High School in the Western Region of Ghana. The sample was made up of twenty (20) students offering Home Economics programme, ten (10) students offering Business and ten (10) students offering Arts programme. From the pilot test, the researcher realized that 5 of the 21 statements used to illustrate the frameworks were too long and could affect students' understanding and the duration to complete the questionnaire. The items were therefore reconstructed into

Research on Humanities and Social Sciences www.iiste.org
ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)
Vol.4, No.4, 2014

shorter statements to ensure better understanding and easy responses. To address the reliability of the questionnaire, data from the pilot test were fed into SPSS computer software and reliability coefficients computed at 0.05 level of significance. The reliability coefficients ranging from 0.728 - 0.770 were found for the 21 items addressing students' perception of energy (see Appendix A). The results show that the items were internally consistent.

3.7 Data analysis procedure

Data analysis was done after the collection of the administered questionnaire. The questionnaire items were arranged serially. Under each item, code numbers were assigned to the Likert scale as follows: not true (1), partly true (2) and true (3). Based on these codes, data were then fed into SPSS for processing into tables of frequencies and percentages. This was done to ensure clear description of gender, location, programmes and perception of the students by frequency and percentages. Table of frequencies and percentages obtained from SPSS analysis was therefore used to answer the research question.

4.0 Results and discussions

The research question sought to find out the perceptions Ghanaian students in the SHS have of energy. To answer this research question, the responses of the students to the 21 items on the seven frameworks on energy were analysed. Frequencies and percentages of students' responses are shown in Figure 1.

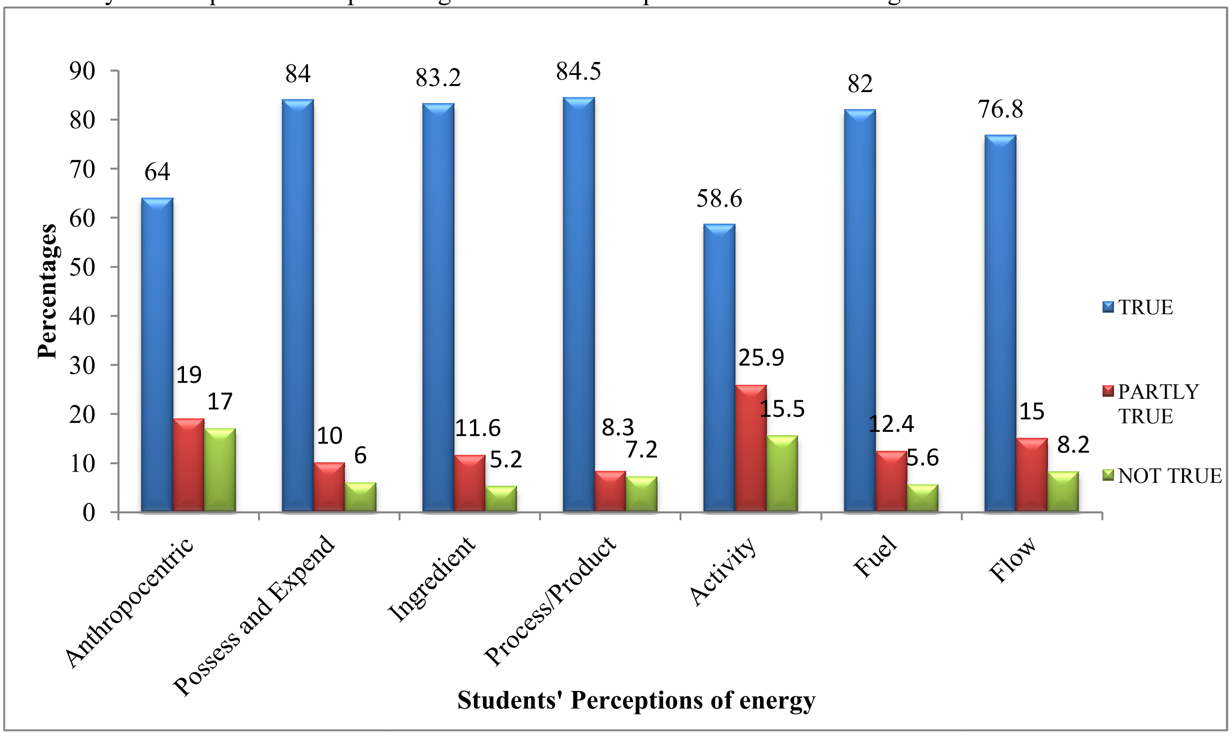

Figure 1: Perceptions of students about the concept of energy

Items 1-3 sought to find out the students anthropocentric perception of energy. An average of 64.0% of the students indicated true to energy being associated with people (human centered). Also, on the average 19.0% of the students indicated partly true while 17.0% did not perceive energy as human centered. This implied that majority of SHS students in Ghana perceive energy to be associated with people. This finding is in accordance with the studies of Watts, (1983) and Trumper and Gorsky (1993) that students perceive energy as a human centered conceptual framework.

Items 4-6 which sought to find out students' perception of things as possessing and expending energy ('depository' model of energy). Averagely, a higher percentage (84.0%) of students perceive that things posses and expend energy. Only an average of 6.0% of the students indicated not true to this model while 10.0% partly perceive that things possess and uses up energy. This suggests that majority of Ghanaian Senior High School students perceives energy as being possess and used up by things. This has confirmed the findings of Trumper and Gorsky, (1993) and Watts, (1983) which led to the identification of 'depository' model of energy in the conceptual framework of energy.

Items 7-9 were intended to find out students perception of energy as an ingredient in things. True to this perception was indicated by a high percentage (83.2%) of the students. In contrast, 5.2% of the students specified not true while 11.6% said it is partly true. This finding reveals that high percentage of Ghana SHS students perceive that energy is an ingredient in things and can be released by a prompt. This finding has been report by

studies outside Ghana (Lijnse, 1990; Trumper & Gorsky, 1993; Watts, 1983).
Items 10-12 were framed to determine if Ghanaian SHS students perceived energy as being produced by certain processes. This framework has been identified by Trumper and Gorsky, (1993) and Watts (1983) as a conceptual framework which describe perceptions about energy. As shown in Figure 1, in the fourth framework, majority of the students in the selected schools specified true to these items. It therefore implies that just as reported in literature, Ghanaian students also perceive energy as being produced by some processes.
Items 13-15 sought to find out whether students perceived energy as being associated with activity. A high percentage (58.6%) of the students said true. On the contrary, 25.8% said not true and 15.5% of the students said partly true to the perception that energy is associated with activity. This result reveals that with respect to the three items students perceive energy as connected with activity. Hence most Ghanaian students' view of energy is that it is associated with activity.
Items 16-18 describe the perception of energy as generalised kind of fuel associated in making life easy. In this regard, it is clear from Figure 4.3 that 82.0% indicated true to this perception. In contrasting, 5.6% of students indicated not true, while 12.4% chose partly true to this perception. A very high number of the students therefore perceive that energy is functional. This implies therefore that SHS student in Ghana have the perception that energy is a sort of fuel connected with making life easy. This finding is in accordance with the studies by Trumper and Gorsky (1993) and Watts (1983), in which students' view of energy was that it is functional.
Items 19-21 was meant to find out whether the students perceive energy as a type of fluid which is transferred through some processes. Majority (76.8%) of the students specify true to these items. A minority (8.2%) said not true and 15.0% chose partly true to these descriptions. Other studies confirmed the perception of energy as some sort of fluid that flows in some processes (Driver, Squires, Rushworth, & Wood-Robinson, 1994b; Duit, Roth, Komorek, & Wilbers, 1994; Leach, Driver, Scott & Wood – Robinson, 1995).

5.0 Conclusion

The study revealed that Ghanaian students have alternative perceptions of energy. The perceptions held by Ghanaian students are in accordance with alternative ideas of energy held by other students elsewhere in the world. The perception of energy held by the students are consistent with the alternative conceptual frameworks of energy as classified by Watts (1983) and Trumper and Gorsky (1993). Hence Ghanaian students in the SHS have their perceptions about energy. The students' perceptions of energy is that energy is human centered (anthropocentric); possessed and expended; an ingredient in things; an activity; a process/product; fuel and a fluid that flows. These perceptions are in accordance with conventional distinct alternative conceptual framework of energy by Trumper and Gorsky (1993) and Watts (1983).

6.0 Implications for classroom practice

The underlying message from this research suggest that classroom teachers draw attention to
how important it is for them to establish what students do know, do not know, and partially know about science concepts as the first step in quality teaching practices. Therefore teachers must design their teaching and learning lessons in ways that will build from what the students know and provide opportunities to engage in experiential learning practices that will lead to students developing new and deeper understandings of the science concepts. It is very important that teachers should be aware of the ways the students talk and think about energy. The focus of teaching therefore is not to replace students' perceptions with more sophisticated ones, rather, it is to fit them into a broad consistent framework in which the most explanatory and general perceptions are given a high cuing preference in appropriate contexts. If students develop consistent perceptive, they are able to relate their scientific ideas to make sense of experiences and observations and to explain new situations. Hence, in the teaching of energy, rather than simply contradicting students' perceptions, a better strategy is to build on what the students perceive and try to help them modify their perceptions in appropriate manner.

7.0 Recommendation

It is recommended that the *energy* aspect of the Ghanaian *Integrated Science Syllabus* at the primary to the senior high school levels, should be developed in such a way that concepts of energy are real to students by way of their everyday experiences. This may aid their development of a more acceptable conception of energy. The end of such a unit of study, be it one course or a series of smaller sub-courses, should be the ability to use energy terminologies in the appropriate way in any situation which would most likely be similar to the experts' use of multiple languages where each use is appropriate to the situation (Warren *et al.* 2001).

References

Barak, J., Gorodetsky, M., & Chipman, D. (1997). Understanding of energy conceptions in Biology. *International Journal of Science Education. 19* (1), 21-30.
Çepni, S., Taş, E., & Köse, S. (2006). The effects of computer-assisted material on students'cognitive levels,

misconceptions and attitudes towards science. *Computers & Education*, 46 (2),192-205.

Corney, G. (2000). Student geography teachers' pre-conceptions about teaching environmental topics. *Environmental Education Research*, *6*(4), 313-329.

Davis, J. L. (2011). Nanomaterials open new frontiers in energy storage. *Electroindustry, 17* (9), 7–8.

Dawson, C. (1997). *Science teaching in the secondary schools*. Sydney: Longmans.

Diakidoy, I. A. N., Kendeou, P., & Ioannides, C. (2003). Reading about energy: The effects of text structure in science learning and conceptual change. *Contemporary Educational Psychology*,28(3), 335-356

Driver, R. (1985). *Research into Childrens' Ideas Book 2*. London: Routledge.

Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (1994b). *Making sense of secondary science: Supporting materials for teachers*. London: Routledge.

Duit, R., Roth, W., Komorek, M., & Wilbers, J. (1994) Conceptual change cum discourse analysis to understand cognition in a unit on chaotic systems: Towards an integrative perspective on learning in science. *International Journal of Science Education. 20,* 1059 -1073.

Ebenezer, J. V. & Fraser, M. D. (2001). First year chemical engineering students' conception of energy in solution processes: Phenomenographic categories for common knowledge construction. *Science Education*, 85, 509-535.

Fraenkel, J. R., & Wallen, N. E. (2003). *How to design and evaluate research in education. (5th ed)*. New York, NY: McGraw-Hill.

Fraser, B. J. (2000). *Improving research on learning environments through international cooperation.* Paper presented at the second international conference on science, mathematics and technology education, Taiwan, R.O.C.

Gilbert, J., & Pope, M. (1986). Small group discussions about conceptions in science: A case study. *Studies in Science Education, 10*, 61-98.

Harrison, A. G., Grayson, D. J., & Treagust, D. F. (1999). Investigating a grade 11 student's evolving conceptions of heat and temperature. *Journal of Research in Science Teaching, 36,* 55-87.

Hegedus, L. L., & Temple, D. S. (Eds.) (2011). *Viewing America's energy future in three dimensions.* RTI Press Publication No. BK-0006-1106. Research Triangle Park, NC: RTI Press. doi:10.3768 /rtipress.2011.bk.0006.1106

Hirca, N., Calik, M. & Akdeiniz, F. (2008). Investigating grade 8 students conceptions of 'energy' and related concepts. *Journal of Turkish Science Education*, 5 (1) 75-87.

Jennison, B., & Reiss, M. J. (1991). Does anyone know what energy is? *Journal of Biological Education, 25,* 173 176.

Kishore, P., & Kisiel, J. (2013). Exploring high school students' perceptions of solar energy and solar cells. *International Journal of Environmental and Science Education*, 8, 521-534. doi: 10.12973/ijese.2013.216a.

Kumekpor, K.B. (2002). *Research methods and technique of social science*. Accra: SonLife Press and Services.

Leach, J., Driver, R., Scott, P., & Wood-Robinson, C. (1995). Children's ideas about ecology 1: Theoretical background, design and methodology. *International Journal of Science Education,17,* 721 -732.

Lijnse, P., (1990) "Energy between the life-world of pupils and the world of physics" *Science Education, 74* (5), 571-583.

Liu, X., Ebenezer, J., & Fraser, D. M. (2002). Structural characteristics of university engineering students' conceptions of energy. *Journal of Research in Science Teaching*, 39(5), 423-441.

Liu, X., & McKeough, A. (2005). Developmental growth in students' concept of energy: Analysis of selected items from the TIMSS database. *Journal of Research in Science Teaching,42*(5), 493-517.

McInnis, C. (2003). *New Realities of the Student Experience: How should Universities respond?*Paper presented at the 25th Annual conference of the European Association for Institutional Research

Ministry of Education, Youth and Sports, (MOEYS) (2012). *Teaching syllabus for (SHS 1-4),*
Accra, Ghana: Curriculum Research and Development Division (CRDD).

Nicholls, G. & Ogborn, J. (1993). Dimension of children's conceptions of energy. *International Journal of Science Education, 15,* 73 – 81.

Nordine, J. (2007). *Supporting Middle School Students' Development of an Accurate and Applicable Energy Concept*. Paper presented at the Knowledge Sharing Institute, University of Michigan, Washingon DC.

Osborne, R. &Freyberg, P. (1985). *Learning in Science: The implications of children's science.* Melbourne: Heinemann.

Özay, E., & Öztaş, H. (2003). Secondary students' interpretations of photosynthesis and plantnutrition. *Journal of Biological Education*, *37*(2), 68-70.

Southwell, B. G., Murphy, J. J., DeWaters, J. E., & LeBaron, P. A. (2012). *Americans' perceived andactual understanding of energy* (RTI Press publication No. RR-0018-1208). Research Triangle Park, NC:
RTI Press. Retrieved from http://www.rti.org/rtipress.

Sözbilir, M. (2003). A review of selected literature on students' misconceptions of heat andtemperature. *Boğaziçi University Journal of Education*, 20(1), 25-41.
Trumper, R. (1990a). Being constructive: an alternative approach to the teaching of the energy concept - part one. *International Journal of Science Education, 12* (4), 343-354.
Trumper, R. (1990b). Energy and a constructivist way of teaching. *Physics Education*, *25* (4),208-212.
Trumper, R., & Gorsky, P. (1993). Learning about energy:The influence of alternative frameworks, cognitive level, and closed mindedness. *Journal of Research in Science Teaching,30* (7), 637-648.
Tytler, R. (2002). Teaching for understanding in science: student conceptions research and changing views of learning. *Australian Science Teachers' Journal, 48*(3),14-21.
Warren, B., Ballenger, C., Ogonnowki, M., Rosebury, A. S., & Hudicourt- Barnes, J. (2001).
Rethinking diversity in learning science: The logic of everyday sense-making. *Journal of Research in Science Teaching, 38* (5), 529-552.
Watts, D. M. (1983) "Some alternative views of energy" *Physics Education,* 18, 213 -216.

Appendices

Appendix A: Students' Questionnaire on Perceptions of Energy

This questionnaire is part of a study on "Ghanaian senior high school students' perceptions of energy". The information you provide will help to determine Ghanaian students' perception of energy. The information will be used for the purpose of this study. I would be grateful if you could respond to the items as appropriately as possible. Your anonymity is assured. Thank you for your co-operation.

Energy concept

Perceptions	True	Partly True	Not True
1. A box has no energy because a person pushing it upwards is doing all the work. If the box has energy, it can help the person to push it upward.	[ ]	[ ]	[ ]
2. You have to have energy and store it and then use it up. You get energy from oil, petrol and the sun or anything that possesses energy.	[ ]	[ ]	[ ]
3. Food has energy in it. When we eat food energy is released to the body.	[ ]	[ ]	[ ]
4. After a hard days work, one needs to sleep/rest to gain energy.	[ ]	[ ]	[ ]
5. When wood burns, it releases energy.	[ ]	[ ]	[ ]
6. Energy is what makes something work. Electricity would make a tape recorder work, so energy is fuel.	[ ]	[ ]	[ ]
7. In the body, blood flows and carries energy to all part of the body.	[ ]	[ ]	[ ]
8. Two reacting chemicals have energy in them. Although they don't talk to things, they' have got energy in them like humans do. However, in their own way they are living.	[ ]	[ ]	[ ]
9. If we don't have water, we can't survive. If we drink water, we get energy. Water also has got something to do with power station like Akosombo dam, it gives electrical energy. Therefore, water is a source of energy.	[ ]	[ ]	[ ]
10. Energy is not stored in charcoal but when it is burnt, it produces energy for cooking.	[ ]	[ ]	[ ]
11. A boy running fast is displaying energy.	[ ]	[ ]	[ ]
12. When ice melts it will give off heat. So it produces heat energy.	[ ]	[ ]	[ ]
13. Energy is provided to our bodies from its chemical reaction with the oxygen we breathe.	[ ]	[ ]	[ ]
14. In electricity, energy flows into television to make it work.	[ ]	[ ]	[ ]
15. A student has a lot of energy because he/she can push a desk from the right to the left end of the classroom. Once the desk is there it cannot do anything so the desk definitely has not got energy. Meanwhile, the student can walk away back to the right end of the classroom. So energy is associated with people.	[ ]	[ ]	[ ]
16. A battery has got energy, the bulb needs it to give light and the wires carry the energy to the bulb. That is things possess and expend energy.	[ ]	[ ]	[ ]
17. There is energy in things. It is there but it needs another form of energy to make it come out. Like a seed, it has energy inside it to grow but it needs the sunlight.	[ ]	[ ]	[ ]
18. The hammer is creating energy by hitting fast on the nail. That is energy is associated with activity.	[ ]	[ ]	[ ]
19. In a chemical change, some energy is released to produce heat. This means energy is created by certain processes.	[ ]	[ ]	[ ]
20. Energy is something that can make things work. For instance, petrol would make a vehicle to move.	[ ]	[ ]	[ ]
21. In a circuit, energy comes out from the negative end, flows round the circuit, encountering the light bulb on the way, where it can transfer some of the energy, and it goes back to the battery. Thus, energy is some kind of fluid which is transferred during process.	[ ]	[ ]	[ ]

Appendix B: Pilot test results on reliability statistics

Reliability Statistics

Cronbach's Alpha	N of Items
.756	23

Appendix C: Reliability Statistics: Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Students' Perception of Energy				
A box has no energy (anthropocentric)	31.81	31.590	.113	.770
Store energy and use it (possess and expend)	32.28	29.635	.432	.738
Food has energy in it (ingredients)	32.56	30.654	.575	.735
Sleep to gain energy (process)	32.47	32.771	.110	.759
Wood burns to release energy (activity)	31.61	29.730	.379	.742
Electricity makes tape work (fuel)	32.22	29.721	.417	.739
Blood flows and carries energy (flow)	32.50	30.714	.588	.735
Reacting chemical has energy in them (anthropocentric)	32.14	30.809	.357	.744
Water gives energy (possess and expend)	32.50	32.257	.270	.750
Energy stored in charcoal (ingredient)	32.44	32.597	.180	.755
Boy running display energy (process)	32.39	30.244	.401	.741
Ice melt to give off energy (activity)	31.78	31.321	.162	.763
Oxygen provides energy to our body (fuel)	32.50	32.257	.333	.749
Energy flows into television (flow)	32.42	30.707	.458	.739
Energy is associated with people (anthropocentric)	32.42	31.107	.391	.743
A battery has got energy	32.44	32.425	.181	.755
Energy is in things but needs another to make it come out (possess/expend)	32.33	31.943	.233	.752
Hammer is creating energy by hitting hard on a nail(process)	32.39	29.444	.601	.728
Some energy is released to produce heat (activity)	32.50	32.143	.360	.747
Energy is something that can make things work (fuel)	32.47	31.913	.277	.750
Energy is some kind of fluid (flow)	32.14	31.494	.237	.753

Appendix D: Frequencies and percentages of students' perceptions about the concept energy

Perceptions based on framework	True F (%)	Partly true F (%)	Not true F (%)	Total F (%)
(A) Anthropocentric				
1. A box has no energy	443 (61.5)	76 (10.6)	201 (27.9)	720 (100.0)
2. Reacting chemical has energy in them	383 (53.2)	215 (29.9)	122 (16.9)	720 (100.0)
3. Energy is associated with people	547 (76.0)	111 (15.4)	61 (8.5)	719 (99.9)
Average	*458 (64.0)*	*134 (19.0)*	*128 (17.0)*	*720 (100.0)*
(B) Possess and expend				
4. Store energy and use it	558 (77.5)	90 (12.5)	72 (10.0)	720 (100.0)
5. Water gives energy	661 (91.8)	39 (5.4)	19 (2.6)	719 (99.9)
6. A battery has got energy	601 (83.5)	89 (12.4)	30 (4.2)	720 (100.0)
Average	*607 (84.0)*	*73 (10.0)*	*40 (6.0)*	*720 (100.0)*
(C) Ingredients				
7. Food has energy in it	691 (96.0)	20 (2.8)	9 (1.2)	720 (100.0)
8. Energy stored in charcoal	560 (77.8)	103 (14.3)	57 (7.9)	720 (100.0)
9. Energy is in things but needs another to make it come out	544 (75.6)	128 (17.8)	47 (6.5)	719 (99.9)
Average	*598 (83.1)*	*84 (11.6)*	*38 (5.2)*	*720 (100)*
(D) Process				
10. Sleep to gain energy	641 (89.0)	49 (6.8)	30 (4.2)	720 (100.0)
11. Boy running display energy	589 (81.8)	57 (7.9)	74 (10.3)	720 (100.0)
12. Hammer is creating energy by hitting hard on a nail	592 (82.2)	74 (10.3)	52 (7.2)	718 (99.7)
Average	*608 (84.4)*	*60 (8.3)*	*52 (7.2)*	*720 (100.0)*
(E) Activity				
13. Wood burns to release energy	387 (53.8)	98 (13.6)	232 (32.2)	717 (99.6)
14. Ice melt to give off energy	306 (42.5)	132 (18.3)	282 (39.2)	720 (100.0)
15. Some energy is released to produce heat	572 (79.4)	105 (14.6)	43 (6.0)	720 (100.0)
Average	*422 (58.6)*	*112 (15.5)*	*186 (25.8)*	*720 (100/0)*
(F) Fuel				
16. Electricity makes tape work	583 (81.0)	83 (11.5)	53 (7.4)	719 (99.9)
17. Oxygen provides energy to our body	556 (77.2)	115 (16.0)	48 (6.7)	719 (99.9)
18. Energy is something that can make things work	630 (87.5)	69 (9.6)	20 (2.8)	719 (99.9)
Average	*590 (82.0)*	*89 (12.4)*	*41 (5.6)*	*720 (100.0)*
(G) Flow				
19. Energy flows into television	629 (87.4)	61 (8.5)	29 (4.0)	719 (99.9)
20. Energy is some kind of fluid	459 (63.8)	162 (22.5)	99 (13.8)	720 (100.0)
21. Blood flows and carries energy	570 (79.2)	100 (13.9)	49 (6.8)	719 (99.9)
Average	*553 (76.8)*	*108 (15.0)*	*59 (8.2)*	*720 (100.0)*

Key: F = Frequency; % = Percentages