*THE INTERNATIONAL JOURNAL OF HUMANITIES & SOCIAL STUDIES*

# Students' Conception of Heat Energy in Senior Secondary School Physics

**Nduji, Chukwuebuka Christopher**
Postgraduate Student, Department of Science Education,
University of Nigeria, Nsukka, Nigeria
**Onuya Clement Chizoba**
Postgraduate Student, Department of Science Education,
University of Nigeria, Nsukka, Nigeria
**Madu, Barnabas Chidi**
Senior Lecturer, Department of Science Education,
University of Nigeria, Nsukka, Nigeria
**Okeke, Ugochi MaryJane**
Postgraduate Student, Department of Science Education,
University of Nigeria, Nsukka, Nigeria

***Abstract:***
*The purpose of the study was to determine students' conceptions of heat energy in senior secondary school physics. Three research questions and two null hypotheses guided the study. Ex-post facto research design was adopted for the study. The population of the study consisted of 6,270 senior secondary school two (SSS2) physics students in all the government owned educational secondary schools in Onitsha Education Zone in Nigeria. The sample size of the study comprised of 357 senior secondary two (SS2) students drawn from the population using multi-stage sampling procedure. Heat Energy Conception Test (HECT) which consists of 16 essay items was used as instrument for data collection. The reliability coefficient of 0.747 for the instrument was ascertained using Cronbach Alpha. Frequency and percentage were used to answer research question one and students' responses were described based on research question two. Chi-square was used in testing the two null hypotheses of the study at 0.05 level of significance. The findings of the study showed that the level of students' conception is low; only 5.6% have Sound Conception, 6.7% have Partial Conception, 13.7% have Alternative Conception while 74% have No Conception. Based on the findings of the study, recommendations were made.*

***Keywords:*** *Students' conception, heat energy, sound conception, partial conception*

## 1. Introduction

Physics is viewed as the study of matter, energy and their mutual relationships. This implies that physics is concerned with the acquisition of knowledge on the relationship between energy and matter. Energy as a component of physics was first used by Thomas Young to help generalize the product of the mass of an object and its velocity squared (kinetic energy), which was an earlier proposed idea of Gottfreid Leibniz called living force (Smith, 2008). The amount of energy in a system is to an extent relates to the system ability to perform certain tasks, called work. Thus, energy is the ability of a physical system to do work. Energy can exist in various forms such as potential energy, kinetic energy, mechanical energy, chemical energy, heat energy and other forms of energy (Britannica, 2018). Out of all the forms of energy, students do not show the required conception towards heat energy as outlined by West Africa Examinations Council (WAEC) Chief Examiners Report, specifically both in May/June 2015, 2016 and 2017, and November/December 2015 and 2016 examinations. The summary of the report include; majority of the candidates avoided question on heat capacity; the few candidates that attempted the question on heat capacity performed on an average; very few candidates were able to correctly solve the problem of heat energy. These situations could be as a result of not having the right conception about heat energy. Similarly, many students have difficulty in relating knowledge gotten from relative humidity and dew point, and applying such knowledge into the mechanism of air conditioner (Batanero & Sanchez, 2015). In the same light, faults and errors to some extent exist on students' abilities to name and draw a simple air conditioner. This could be as a result of how students imagine or perceive the working principle(s) of air conditioner. Hence, it implies that students' conception can either be for constructing personal understanding (i.e., students' belief) or for changing personal understanding (i.e., shift in students' belief) (Weimer, 2018). Heat is a form of energy, called thermal energy. Heat is normally transferred from one body to another as a result of temperature differences between the two bodies (Okeke, Okeke & Akande, 2011). Heat energy is the result of the movement of tiny particle called atoms, molecules or ions in solids, liquid and gases (https://www.sciencelearninghub.org.nz). Heat energy is caused by the internal motion of molecules of

matter (Ohio State University [OSU], 2009). Anyakoha (2011) opined that, the direction of heat energy flow when placed with another object depends on the property of that object. This implies that, heat is the measure of the total internal energy of a body.

To this effect, poor achievement here could be as a result of students not having the require conception of a concept, particularly on heat energy which has large content as contained in the SS2 physics curriculum. The inability of a student in possessing the required conception puts such student in naive state. For instance, when students talk about heat energy, they often talk about 'using heat energy' or 'losing heat energy'. The students imagine that something has lots of energy, and then as the object functions, it uses up heat energy until it runs out. Based on this idea, the students move further defining heat energy as the temperature of an object (Fries-Gaither, 2009). Students also believe that heat and cold are different, and that 'cold' is transferred from one object to another (https://www.sciencelearninghub.org.nz).

The Senior Secondary School Physics Curriculum by the Federal Republic of Nigeria (FRN, 2008) listed the contents of heat energy to include the concept of specific heat capacity, latent heat, application of latent heat, evaporation, boiling and sublimation, relative humidity and dew point. Despite the above outlined contents of heat energy, the curriculum takes no cognizance of the way students conceive some ideas which result to lapses in the curriculum (Gosling, 2014). As a result of such lapses in the physics curriculum, many students exhibit inability to possess the required scientific (or sound) conception. To this effect, students conceive some of these concepts from their own personal experiences due to their day-to-day interaction with the environment. Students' daily activities with the environment affect their thoughts about the world. These thoughts differ from the way adult thinks as narrated by Piaget (1972).

To better understand students' conception, Piaget explained four (4) factors that influence how children learn and grow, which include schema, assimilation, accommodation and equilibration. Piaget describes schema as both the mental and physical actions involved in understanding and knowing. Schemas are categories of knowledge that help us understand the world. Secondly assimilation is viewed as the process of taking new information into our already existing schemas. When existing ideas or schemas are modified as a result of new information or new experience, Piaget called it accommodation (Piaget, 1977). Fourthly, equilibration is believed to occur when children strike a balance between assimilation and accommodation. The striking balance is geared towards assimilation of information to suit an individual's own existing mental schemas and adaptation of thoughts so as to accommodate information. This implies that equilibration takes place so as to direct and guide the prior knowledge student came to class with.

Students' preconception can be said to be all knowledge or understanding a student has about a concept to be taught. According to Seel (2012), students' preconception can be defined as 'opinion or conception formed in advance of true knowledge or experience of a concept.' This implies that students' preconception indicates biases or prejudices in forming scientific concepts. Some studies have indicated that preconception held by students in physics has influence on their achievement (Aguirre, 2008; Heuvelen, 2009; Clement, 2012). The findings in these studies support the fact that students' preconception contribute to their poor achievement in physics. However, preconception a student developed on his own before entering the class can be corrected, since students can move from naive conception to sound or scientific conception.

However, a student may either have scientific (sound) conception (SC) or partial understanding (PU) or alternative conception (AC) or naive conception (NC) about a concept (Orji, 2013). Scientific conception indicates that the student has sound or right conception about the concept. It can also be attributed to correct or competent information about a topic. Partial understanding shows learners' incomplete or biased knowledge about a concept. Predictions are been made either with confidence or no confidence based on the explanation the student can construct about the concept (Alwan, 2011). This implies that ideas are not integrated in verbal form but understanding is evident to some extent. Alternative conception represents learners' ideas which are inconsistent with right conception. For instance, many students thought that heating an object always increase the temperature of that object been heated (Yeo & Zadnik, 2001). Such student may answer questions in a test correctly in a formal setting but usually fall back to their alternative conception. This is as a result of substance-based conception which may occur due to linear explanation of a concept rather than see number of factors responsible for the concept (Alwan, 2011). Naive conception deduces the wrong or no idea about the concept. Naive conception also implies limited or inappropriate proposition hierarchy (Helm & Novak, 2008). This implies the failure of a student to formulate an answer. Students at this level admit that they have some exposure about the concept but could not assess or remember it (Amaechi, 2013).

However, students' conception or understanding of idea(s) about a concept or a process, are common and can be experienced in any field or discipline (Savion, 2009). In the aspect of physics, previous studies have revealed that physics students hold incomplete or inaccurate conception in some physics concepts like; force and motion (Ugwuanyi, 2012), real and virtual experimentation on electric circuit (Zacharia, 2017), electric resistance (Tao, Sanjun, Jingying & Yongjun, 2018), electricity and magnetism (Bekele, Jeanne & Temesgen, 2013; Demirci & Cirkinoglu, 2004) and elasticity as investigated by Agumuoh (2010). Thus, there comes the need to investigate on students' conception, specifically on heat energy since other studies are on different physics concept. Every segment of educational institution operates on a written statutory document called curriculum. It is therefore expected that when leaners are exposed to any concept in the curriculum, that the objectives of the planned curriculum are achieved, but physics curriculum takes no cognizance of the way students conceive some concepts. Thus, many students exhibit inability to possess the required scientific conception specifically on heat energy. The inability of the physics students to have sound conception of heat energy may impede their desired growth, understanding and achievement in physics. Hence, the purpose of the study was to determine students' conception of heat energy in senior secondary school physics in Nigeria. Specifically, the study was to:

- Determine the level of students' conception of heat energy in senior secondary school physics, and,

- Describe how the students conceive the heat energy concepts.

*1.1. Research Questions*

The current study clears students' conception of heat energy in senior secondary school physics. Therefore, two research questions were examined:

- What is the level of students' conception of heat energy in senior secondary school physics?
- How did the physics students conceive the concepts in heat energy concepts?

**2. Method**

The design of the study was Ex-post facto design. According to Nworgu (2015), Ex-post facto design is a research design which is used to study the influence of variables that cannot be manipulated such as gender, school location etc. Hence, the researchers employed this design to identify the students' conception of heat energy since data for the study was collected after the event or phenomenon under investigation has taken place. This study was carried out in Onitsha Education Zone of Anambra State. Onitsha Education Zone is made up of three Local Government Areas with total number of thirty-two (32) government owned co-educational senior secondary schools viz: Onitsha-North local government (16), Onitsha South Local Government (10) and Ogbaru Local Government (6) (Post Primary School Service Commission Onitsha [PPSSCO] 2018). The population of the study comprised of 6,270 senior secondary school two (SSS2) physics students in all the government owned educational secondary schools in Onitsha Education Zone during 2018/2019 academic session.

The sample size of the study was 357 senior secondary two (SS2) students drawn from the population. The sample size was determined using confidence level of 95 per cent based on the population size as opined by Cohen, Manion and Morrison (2011).Multi-stage sampling procedure was used in composing the sample. At the initial stage, purposive sampling technique was used to select twenty (20) co-educational schools from the thirty-two (32) schools in the three local government areas (LGAs) that were used for the study. The reason for the choice of purposive sampling was because the three (3) LGAs have co-educational schools at the end, the following number of schools emerged namely; 7- Onitsha North, 3- Onitsha South, 10- Ogbaru. This gave a total of 20 schools. In the second stage, simple random sampling technique of balloting with replacement was used to draw three (3) schools from each LGA. Thirdly, proportionate stratified random sampling was used to draw number of students to be studied in each school that was sampled from each LGA resulting to the total number of 357 students.

The instrument used for the study was Heat Energy Conception Test (HECT) to measure students' conception of heat energy. This instrument was originally developed by Yeo and Zadnik (2001) and adapted by the researchers. The original instrument was initially developed to measure Thermal Concept Evaluation (TCE). However, the researchers made some modifications on the items by adding more items measuring heat and discarding those items measuring temperature. This was aimed at ensuring consistency in measuring students' conception of heat energy. Also, the adapted instrument was modified from TCE which had objective questions to HECT which is theory-based questions. HECT had 16 items with a marking guide. The researchers got marking guide for the instrument from four (2) physics experts in physics and astronomy, two (2) physics educators and one (1) physics teacher all in the University of Nigeria, Nsukka, except the physics teacher who teaches at University Staff Secondary School, Nsukka. In the marking guide, each item was arranged and scored in four-point scale (i.e., 3, 2, 1 and 0). However, 3 were assigned to scientific conception; 2 were assigned to partial understanding; while 1 and 0 were assigned to alternative conception and no conception respectively. Scientific conception shows the most accepted understanding. Partial understanding indicates learners' abandonment of his/her naïve conception. Alternative conception represents naïve conception proper. HECT has an answer that would expose the learner's alternative or scientific conception. The instrument was specifically adapted to evaluate students' conception for heat energy.

The instrument was validated by three experts from the Department of Science Education, University of Nigeria, Nsukka. Two of the validators are purely measurement and evaluation specialists while the third validator is from Physics Education. The items of the instrument were properly modified based on the observations of these experts. The trial testing was done using twenty-four (24) physics students from Urban secondary school Nkpor in Idemili North LGA in Ogidi Education Zone, Anambra State. However, the school used was outside the study area, but has similarities to some extent that are necessary for the study such as same class, same co-educational school and curriculum. Cronbach Alpha formula ($\alpha$) was used to estimate the internal consistency reliability of the HECT. The choice of this reliability estimate was because HECT was polytomously scored. With this formula, the internal consistency index of the instrument was calculated to be 0.747.The data for this study was collected through the use of HECT. The data obtained were used to determine students' conception on heat energy. Prior to the proper commencement of the study, the researchers briefed the teachers (assistant researchers) on the purpose of the study. Also, the researchers visited the sampled schools to collect the data for the study. At the course of the visit, the copies of the instrument were administered to the students through the assistance of the physics teachers in the respective sampled schools. The administration of the instrument was done once and retrieval of the instrument was on the spot. Frequency and percentage were used to answer the research question one while students' responses were described for research question two. The item wise analysis was done to determine the students' conceptions that might have taken place.

**3. Results**

What are the levels of students' conception of heat energy in senior secondary school physics?

| Item No. | SC f(%) | PU f(%) | AC f(%) | NC f(%) | Total f(%) |
|---|---|---|---|---|---|
| 1 | 163(45.7) | 63(17.6) | 67(18.8) | 64(17.9) | 357(100) |
| 2 | 7(2.0) | 25(7.0) | 63(17.6) | 262(73.3) | 357(100) |
| 3 | 10(2.8) | 12(3.4) | 22(6.2) | 313(87.7) | 357(100) |
| 4 | 68(19.0) | 19(5.3) | 55(15.4) | 215(60.2) | 357(100) |
| 5 | 2(0.6) | 21(5.6) | 57(16.0) | 277(77.6) | 357(100) |
| 6 | 4(1.1) | 12(3.4) | 89(24.9) | 252(70.6) | 357(100) |
| 7 | 3(0.8) | 15(4.2) | 56(15.7) | 283(79.3) | 357(100) |
| 8 | 6(1.7) | 46(12.9) | 69(19.3) | 236(66.1) | 357(100) |
| 9 | 14(3.9) | 14(3.9) | 26(7.3) | 303(84.9) | 357(100) |
| 10 | 1(0.3) | 9(2.5) | 42(11.8) | 305(85.4) | 357(100) |
| 11 | 1(0.3) | 21(5.9) | 49(13.7) | 286(80.1) | 357(100) |
| 12 | 3(0.8) | 12(3.4) | 47(13.2) | 295(82.6) | 357(100) |
| 13 | 5(1.4) | 39(10.9) | 56(15.7) | 257(72.0) | 357(100) |
| 14 | 0(0) | 6(1.7) | 43(12.0) | 308(86.3) | 357(100) |
| 15 | 33(9.2) | 38(10.6) | 24(6.7) | 262(73.4) | 357(100) |
| 16 | 1(0.3) | 28(7.8) | 21(5.9) | 307(86.0) | 357(100) |
| Overall No. of student | 20(5.6) | 24(6.7) | 49(13.7) | 264(74) | 357(100) |

*Table 1: Frequency and Percentage Analysis of Levels of Students' Conception of Heat Energy in Senior Secondary School Physics*
*NC= No Conception, AC= Alternative Conception, PU= Partial Understanding, SC= Sound/Scientific Conception, f= Frequency, %= Percentage*

*Table 1* above shows that in item1 of Heat Energy Conception Test (HECT) instrument, 163 students have scientific/sound conception (SC) and 63 students have partial understanding (PU) whereas 67 students have alternative conception (AC) and 64 students have no conception (NC) of item1. Also, in item2, 7 students have SC and 25 students have PU while 63 students have AC and 262 students have NC of item2. In item3, 10 students have SC and 12 students have PU while 22 students have AC and 313 students have no conception of item3. In item4, 68 students have SC and 19 students have PU while 55 students have AC and 215 students have NC of item4. In item5, 2 students have SC and 21 students have PU while 57 students have AC and 277 students have NC of item4. In item6, 4 students have SC and 12 students have PU while 89 students have AC and 252 students have NC of item6. In item7, 3 students have SC and 15 students have PU while 56 students have AC and 283 students have NC of item7. In item8, 6 students have SC and 46 students have PU while 69 students have AC and 236 students have NC of item8. In item9, 14 students have SC and 14 students have PU while 26 students have AC and 303 students have NC of item9.

In item10, 1 student has SC and 9 students have PU while 42 students have AC and 305 students have NC of item10. In item11, 1 student has SC and 21 students have PU while 49 students have AC and 286 students have NC of item11. In item12, 3 students have SC and 12 students have PU while 47 students have AC and 295 students have NC of item12. In item13, 5 students have SC and 39 students have PU while 56 students have AC and 257 students have NC of item13. In item14, no student has SC and 6 students have PU while 43 students have AC and 308 students have NC of item14. In item 15, 33 students have SC and 38 students have PU while 24 students have AC and 262 students have NC of item15. In item16, 1 student has SC and 28 students have PU while 21 students have AC and 307 students have NC of item16.

The above discussion indicates that items1, 4 and 15 have highest number of students with SC compared to other items. This reveal students' conception of heat energy is dependent on the nature of question in each item. However, from the summation of students' response across all items of HECT, it indicates that 264(74%) students have NC while students with AC are 49(13.7%); and students with PU across all item is 24(6.7%) whereas students with SC have 20(5.6%). This implies that students with NC of heat energy are higher since it has the highest frequency and percentage values. Also, students with SC have the lowest frequency and percentage values. These are students that can respond to heat energy question no matter how twisted the questions may appear.

**4. Discussion**

The findings of the study showed that most students had no conception of heat energy while very few students had alternative conceptions, partial understanding, and scientific/sound conception respectively. This indicates that small fraction of students possesses the correct understanding of heat energy. This finding is in agreement with the findings of Orji (2013) who discovered that there is significant relative effect of cognitive strategy and conceptual change pedagogy on students' levels of understanding of heat and temperature in favour of group taught with cognitive conflict strategy. Also, the study by Alwan (2011) whose findings revealed that most students have alternative conception of heat and temperature and some students still regard 'heat and temperature' as the same. This finding is in consonance with the

present study. Ugwuanyi (2012) whose study unveiled that the level of conceptual understanding of the students is low since only 15% have adequate conceptual understanding, 61% have inadequate or partial conceptual understanding while 24% have little or no conceptual understanding. This finding is in agreement with the findings of the present study. This finding is also in agreement with the finding of Amaechi (2013) whose study showed that the number of students that shifted from no conception to partial or sound conception is dependent of the instructional method used. This implies that many students possess no conception or alternative conception about a concept. On the contrary, Demirci and Cirkinoglu (2004) study disagreed with the present study. The student conception of electricity and magnetism concepts showed that there is significant difference in students' conception in electricity and magnetism concepts. However, the difference between the findings of both studies may be attributed to different design and method of data analysis. Demirci and Cirkinoglu (2004) used ANOVA, mean and standard deviation for data analysis and descriptive design while the present study used chi-square, frequency and percentage for data analysis, and ex-post facto. The statistical analysis of the students' responses is further explained in the description of their responses as shown

*4.1. Qualitative Description of Students' Response*

The focus of the discussion is not just to compare students' performance or point out those items in which students indicated the correct conception or the items they did not show the correct conception. But to further discus on the students' response based on; how they responded to the questions; why they responded that way; and what made them respond in that way. However, the discussion was organized into four categories. They include the following: specific heat; application of heat transfer through conduction and radiation; effect of pressure on boiling and melting point; relative humidity and dew point.

*4.2. Specific Heat*

To understand specific heat properly, one must be able to know what heat is (i.e., latent heat, specific latent heat and specific heat capacity) (Brilliant, 2019). However, in this study some students who attempted the questions were able to show the SC of specific latent heat of fusion which is the amount of heat required to change the unit mass of ice at melting point to its liquid without change in temperature which is $3.4 \times 10^5$ J/Kg. Meanwhile, most students have PU, AC and NC about what specific latent heat of fusion of ice is. Some of the students understanding are stipulated as follows; the quantity of heat supplied to a body which is proportional to its mass i.e. H= m*l*; the quantity of heat required to carry an ice which is $3.4 \times 10^5$ J/Kg in one Kelvin; the quantity of heat to melt an ice within a specific period of time in Celsius temperature which is $3.4 \times 10^5$ J/Kg ; hidden amount of heat energy required to raise the unit mass of an ice; the heat required to convert ice from its solid state to gaseous state without change in temperature of the ice; hidden heat which cannot be detected by thermometer; the heat required to overcome force which holds molecules of solid in bondage. This incorrect conception could be from students thought that specific latent heat is a particular hidden heat of a body or time function of melting point of ice which could be the reason for the above response. However, in students' day to day activities, heat is been encountered which shapes their explanations based on daily experiences.

Also, most of the students who responded to specific heat capacity failed to understand the sound/scientific meaning of the concept. Thus, they conceive specific heat as; the amount of energy required to raise the temperature of the unit; the amount of energy required to change a body or substance; the amount of heat exerted on an object; the amount of heat required to change a unit mass of a substance from one point to another neglecting air pressure; the amount of energy required to raise the latent heat of temperature; the amount of energy required to change one mole of substance; the amount of specific heat raise in temperature; the energy required to raise the latent heat of temperature; the heat supplied to a body which is proportional to its mass and change in temperature. However, few students took into consideration that specific heat capacity can be viewed as the heat required to raise a unit mass of the substance through $1^o$ temperature which shows SC of specific heat capacity. The reason behind few students out of many having SC of specific heat capacity could be attributed to their literal understanding of heat capacity and inability to denote the differences between heat and temperature.

*4.3. Application of Heat Transfer*

For proper understanding of application of heat transfer through conduction and radiation, one must be able to conceptualize the various medium of heat transfer (i.e., conduction, convection and radiation) (Pathare, 2010). However, few students who attempted this part gave the correct understanding here (i.e., SC). For instance, the phenomenon behind methylated spirit having cooling effect when poured on the skin, many students conceived the cooling effect of methylated spirit as caused due to; evaporation which causes cooling; alcohol element that supports combustion in the methylated spirit; heat transfer and body temperature. However, most students have PU, AC and NC here. These students see the phenomenon here as been caused by; the low temperature of the methylated spirit which overcomes the warmness of the skin; latent heat of vaporization; methylated spirit has hydrogen and oxygen; the temperature of the liquid is lower and the cover deflects heat and make it cold. Also, to some students, cooling effect of methylated spirit occurs because; the wound on the body is open and methylated spirit cools the blood rushing out of the wound; there is evaporation of heat from the body thereby making it have cooling effect which undergoes endothermic reaction with other compounds. These wrong conceptions of students could be attributed to their day-to-day use of methylated spirit and teachers' failure in given in-depth illustrations. The inability of the teachers to use substance like methylated spirit to explain heat transfer could be what made students give their answers in this way.

In denoting the reason why earthen pot is preferred in storing cold drinking water in hot climate, many students gave the wrong consideration (i.e., PU, AC, NC) of earthen pot been preferred to glass pot for storing water in hot climate. Respondents gave their reasons as follows; earthen pot has latent heat stored in it which makes it possible for the water to be cool; earthen pot surface is cold at all moment while the glass pot surface is not; evaporation passes the tiny hole of the pot and the water becomes cool; earthen pot has vacuum which makes the water cool; earthen pot absorbs heat out of the water to make it cold; earthen pot is a good conductor of heat while the glass pot is not; earthen pot is made of clay material which is porous in nature. Students with the above response see earthen pot as a vacuum with good absorber which made them give their answers in such way. However, these students fail to understand that earthen pot is made of small hole through which the water inside evaporates. To evaporate, the water needs to absorb heat from the liquid within the pot itself. This process is continuous and, in few hours, the water becomes cool. But glass pot does not have any small holes and so the water placed inside cannot evaporate. Hence, the water inside remains as it is which indicates the correct understanding (i.e., SC).

Also, students do not take into consideration that metal block gains more heat energy on hitting the ground through collision and as a result of collision, heat transfer which is caused by the internal motion of molecules of matter from high moving molecules to low moving molecules makes metal block X becomes slightly warmer after hitting the ground (i.e., SC). However, many students explained that metal block X becomes slightly warmer after hitting the ground since; the metal hits the ground with a great force; heat energy took place when metal block x dropped from a height to the ground; there is no collision difference between the metal and the ground; frictional force occurred between the ground and the metal block; the ground is warmed. To some respondents, metal block x is slightly warmed because the sun temperature is too high and changes the metal; the ground is warmed and the metal block gains from heat transferred. The reason for these wrong conceptions could be linked to the students' weak understanding of conduction in solid (i.e., metal).

Respondents to Ada's comment on why her doll wrapped in the blanket did not warm up, wrongly gave these explanations as follows, thus; the doll is warmed up whenever it's been wrapped with blanket; because of heat of conduction in the atmosphere and the colour of the blanket; the doll is not a good conductor; because of low pressure in cold season; because Ada's body has been in contact with the doll and the blanket; the doll is not a good conductor of heat. These incorrect conceptions could be bored out of students' failure to understand that the blanket used in wrapping the doll is made of fur properties which are insulated materials. Insulators keep energy such as heat from easy transfer through them. Thus, they are not good conductors of heat. For this reason, the doll would not warm up.

*4.4. Effect of Pressure on Boiling and Melting Point*

For proper understanding or SC of effect of pressure on boiling and melting point, the student must be able to conceptualize the meaning of pressure, boiling and melting point. Besides, most students who responded on this part failed to show that they possess SC here. For instance, many students' view the fastness of pressure cooker as when compared with normal saucepan as follows; the temperature in the pressure cooker is higher than that of saucepan; saucepan heat escape while in pressure cooker heat is trapped in, this makes the food to boil faster; the pressure cooker has cover and the saucepan does not have; high pressure causes decrease in volume of content in the pressure cooker. The wrong conception could be linked with the fact that students failed to conceptualize that the trapped steam in the pressure cooker causes increase in atmospheric pressure thus, creating an interior pressure greater than the pressure outside the pressure cooker. For this reason, pressure cooker boils faster than normal saucepan.

Students, who responded to reason behind a thin wire with heavy weight attached to its ends which can cut through an ice block without breaking the ice block, wrongly interpreted the phenomenon. Most students gave PU, AC and NC reason for this phenomenon which are as follows, thus because; of force exerted on the ice cube; the wire is thin; the wire is heavier than the volume of the ice block; the pressure mounted on the ice; the block is strong enough that the thin wire can pass through it without breaking it; the surface tension of the ice; the weight attached to the tin wire puts pressure on it; the thin metal is a good conductor. However, students failed to understand that increase in pressure lowers the melting point of ice or freezing point of water. Thus, when we subject ice to higher pressure it melts, but when this pressure is removed, the ice re-freezes.

*4.5. Relative Humidity and Dew Point*

To have the SC of relative humidity and dew point, one must understand the pressure and saturation of water vapour in the air (Mersereau, 2017). However, many students who attempted this part gave the incorrect understanding (i.e., PU, AC, NC). For instance, in explaining the concept of relative humidity, many students explained the concept as the; amount of water vapor in the atmosphere; saturated water vapour; moisture level of a substance; amount of temperature required to raise the state of heat; saturation of atmospheric pressure acting on substance; amount of humidity in the air. The reason for these incorrect conceptions could be as a result of students' failure to understand that relative humidity is actually the ratio of mass of water vapor in a certain volume of air to the mass of water vapour required to saturate the same volume of air at the same temperature.

However, students who attempted to explaining the concept of absolute zero failed to understand that it is the temperature at which atomic motion of all kinds stops which implies that no atomic motion is going to be warmer than $0^{o}K$, $-273.15^{o}C$, and $-459.67^{o}F$. Most of the students defined absolute zero as follows; the point that atomic reaction takes place; constant or original temperature; decrease in pressure; the melting point of ice; zero number that is not significant;

pressure decreases to zero; the low level of an element; the freezing point temperature; the point at which substance freezes or solidifies; the point at which a substance is normal; the standard for measuring heat and temperature.

Students who responded to explaining dew point failed to understand that dew point is the temperature at which the water vapour presents in the air is just sufficient to saturate it. However, many students viewed dew point as follows; ice coming down from heaven in the morning; the process whereby the earth releases dew; the same as relative humidity; a situation where there is lot of water in the atmosphere leading to little drop of water from the atmosphere; the structure of water vapour in the atmosphere; dew occurs because the atmosphere has different temperature; the acceleration of water vapour in the air; this is the cool weather that occur in the early morning; the point of a temperature. These incorrect conceptions of students could be attributed to their experience on early morning droplet of water vapour from the atmosphere.

## 5. Conclusion

Based on the discussion of the findings, the following conclusions were made, thus; the level of students' conception is low since 5.6% of the students have SC, 6.7% have PU, 13.7% have AC while 74% have NC; students' conception level is determined by the nature of item; there is no significant influence between students conception of heat energy in senior secondary school physics and gender; there is no significant influence between students conception of heat energy in senior secondary school physics and school location.

## 6. Recommendations

Based on the findings, the researchers made the following recommendations, thus;

- Physics teachers should endeavour to possess the required scientific conception about heat energy. This will help bring students to sound conception level.
- Physics teachers should be careful on the way items on heat energy are structured since nature of item influences students' conception.
- Curriculum planners should ensure that the way students conceive a concept is considered and included in the physics curriculum.

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