HEAT: THE CAUSE OF BURNS

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ABSTRACT" *Understanding the concept of HEAT maybe challenging and difficult to us. This research study aims to get an in-depth knowledge and understanding on what students know and perceive regarding HEAT in their daily life and how these students give value to these daily experiences. Out of the nine (9) BS Physics third year students in the program, three (3) were chosen using purposive sampling to participate in the study. The research study was carried out by doing an open-ended interview to each participant. Data from the interviews were explicated, transcribed, formulated meanings, and summarized. The researcher was able to identify four (4) categories/themes, these are 1.) heat as an invisible energy 2.) origins of heat 3.) hotness and 4.) effects of heat. The result of the study somehow contradicted to the findings of previous research done regarding students' perception of heat, but further studies regarding student's conception regarding heat is highly recommended.*

1. INTRODUCTION

One aspect of education is the curriculum, it includes the different processes and contents in teaching and learning. Knowledge development involves students' experiences which may influence their understanding of the many concepts, theories, principles, and laws. Curriculum also requires and demands that the teacher is able to arrange instructional activities that interlinking science content and science process skills. In achieving such demands teachers must learn and understand students' experiences since there must always be an interplay among all contributors.

Heat and thermodynamics are important topics in learning physics because they are fundamental concepts for modern Physics areas such as energy and mechanics and they are applicable in many fields of Physics and Chemistry. Thermodynamics has a wide-ranging impact as demonstrated in the number of different fields in which it plays a fundamental role in both practices and in instruction [1]. Thermodynamics is the study of heat and its transformation into mechanical energy. It is important to point out that matter does not contain heat. Matter contains molecular kinetic energy and possibly potential energy, not heat. Heat is energy in transit or transfer from a higher temperature to one of a lower temperature. While temperature is defined as the quantity that indicates how warm or called an object is with respect to some standard [3].

One of the challenges in teaching physics is to help students develop a scientifically compatible understanding of heat phenomena based on their existing ideas, beliefs, and experiences. According to Lewis and Linn [21], many students face difficulties in understanding concepts of heat and thermodynamics. Trends in International Mathematics and Science Study (TIMSS) made a very crucial and critical report regarding the low-performance result of the Philippines in 2003, which poses challenges to all stakeholders in the field of education.

The intention of this study was to get an in-depth understanding of the lived experiences of university students regarding heat phenomena. Specifically, I explored how students experience heat in their daily life. And how do students give value to these experiences? In other words, this study concerns life-world experiences from the student's perspective and interpretations of a certain phenomenon. Von Eckartsebrg [14] and Moustakas [11] advocate that phenomenology, which is a qualitative research methodology reflects the life-world experiences of the learners.

Answering these research questions, and more specifically being able to explore the lived experiences of the students provided information and eventually insights into the prior knowledge of the students about geometrical optics. This is because according to Dochy and Alexander [8], prior knowledge, which includes explicit, inferred knowledge, metacognitive and conceptual knowledge are derived from the individual's daily experiences, beliefs, and cultural backgrounds.

The results of this study are significant since they will provide a clear understanding of how students' lived experiences, which may be considered prior knowledge, affect their concept of heat and how students describe their experiences of heat offering information useful to physics education researchers and teachers.

By using an in-depth interview and open-ended questions, this phenomenological study allowed students to relate their stories about the heat. Thus, the result of the study fills the gap in physics education literature by relating the stories of the students lived experiences.

The manner of in-depth interview was centered only on student participants and was limited to their lived experiences only about the heat. Another limitation was purposive sampling which is a non-probabilistic technique that does not allow the researcher to generalize data from other students who had not participated in the study.

Creswell [4] mentioned that, in conducting qualitative research, personal views are generally attached to the interpretations of data. As a teacher, who teaches physics subjects such as thermodynamics, my notion of the participants and their experiences of the heat may have been influenced by these past experiences. Because of my background, I acknowledge the biases as follows:

- I am a college instructor and I discuss the concepts of heat and thermodynamics in class
- I have a strong belief regarding the need to explore the students' lived experiences so as to address conceptual change
- I suppose that all college instructors have the responsibility to teach for the remediation of students' preconceptions in order for the students to reconstruct their own conceptual understanding.

2. METHODOLOGY

In qualitative research, a researcher seeks to explore the story of the students and be able to tell this story. The researcher opted to use a phenomenological methodology research design was employed to address the research problems of the study. Phenomenology is defined as, "an approach to philosophy that takes the intuitive experience of a phenomenon as its starting point & tries to extract from it the essential features of experiences & the essence of what we experience" and attempts to understand people's perceptions, perspectives, and understandings of a particular situation Giorgi [9]; Welton [10]; Moustakas [11]; van Manen [12]. Phenomenological research design is further recommended for a study that aims to understand and discover the foresight of the students [15].

This approach was chosen because phenomenology emphasizes the importance of precognition of the learners, including their sense of feeling, which is different from conceptual cognition [2] and phenomenological methodology is effective at bringing to the fore these experiences and perceptions of the students from their own point of view. Furthermore, as mentioned by Lester [6], this method is strongest when it is used to understand subjective experiences. Lin [7] recommends a phenomenological methodology for a study that aims to understand and explore the precognition of students.

According to Creswell [5], phenomenological research considers only the building of understanding of the experiences from the point of view of the participants, instead of focusing the specific theoretical orientations. Creswell [5] also emphasized that phenomenological research questions must be descriptive and be able to surface the meanings of the phenomenon in the experience of the participants.

Purposive sampling was used since it is considered to be the most important non-probabilistic procedure to identify the participants [13]. To bring out this sampling technique, two criteria were set to identify the representative participants. These criteria are 1) participants must have lived experiences regarding heat on a daily basis, and 2) students must have taken the subject thermodynamics in the classroom as part of their curriculum.

Using the first criterion as a basis, I approached the Head of the Physics Department of Western Mindanao State University, considering that he manages BS Physics degree programs and has access to all students within the department. Furthermore, the said physics department is very much accessible to me.

Through the gatekeeper, I met the 26 students, who were referred to me by the department head. Satisfying the second criterion, I interviewed the students to whether they had experiences with the phenomenon of heat. With affirmative reply, the students have met the two qualifications.

Students, who have met the selection criteria, are incidentally third-year BS Physics majors. Although there are nine (9) third-year students enrolled in the BS Physics degree program only three (3) were solicited and interviewed in the study due to time constraints. Two interview sessions were carried out to reach saturation. The data were collected during the first semester of the school year 2014-2015.

Due to his hectic schedule, the department head found it difficult for me to contact him during the time of the investigation. So, he designated other faculty members to assist me in conducting the study. He is the adviser of the Physics Society whose members are all BS physics of the said department. This faculty member was my gatekeeper.

Since the students are under the Physics Department of WMSU where I also belong, I talked personally to the Department Head informing him of the conduct and nature of my study. Physics Department's approval was obtained. Prior to collecting data, students were given written instructions and notified of their voluntary participation in the research and right to refusal as reflected in the consent form.

Confidentiality was observed and maintained by calling the participants as student1, student2, and so on, instead of their real names. Each participant signed the consent form with provisions about the research study and their freedom not to continue participating in the study at any time without prejudice to them in terms of their academic grades, school performance, and relation to the school where they enrolled. All recorded data were kept in my possession and will be made available only to a group of educational researchers who will conduct similar phenomenological research in the future.

Before doing an in-depth interview, participants were asked to do an essay regarding all possible existing understanding they have regarding heat. This was done to give rise to probable questions to be asked during the in-depth interview.

In-depth face-to-face interviews were conducted in order to gather the lived experiences of the students about the heat in its entirety as a phenomenon. Participants were encouraged to talk freely and to tell stories using their own words and dialect. I conducted all the interviews.

Open-ended questions were asked to the students in order to understand how participants experience heat in their daily life. Such as, "What concepts do you have regarding heat?" Follow-up questions were also asked regarding their previous answers as well as clarificatory questions to ensure that answers are really in accordance with the students' concepts and ideas. This allowed me to capture rich descriptions and settings of the phenomenon.

With the consent of the participants, I recorded all the interviews using digital recorders. Each interview was assigned a code, for example, "Student1, 1st Interview, July 28, 2014". Each interview and every interview of the participants were recorded.

At the end of the interview, I reminded the participants about my need for subsequent contact with them to discuss the study findings and to make sure that the study findings reflect their own experiences.

I converted the audio recording into a text-based form by listening to the recorded voice, writing them on paper, and typing them verbatim in Microsoft word. These make the audio data as transcripts of all of the words that the participants of the study said, including pauses they made during the interview.

In this study, I also used memo-writing as another important data source. It is my notes recording what I heard, saw, felt, experienced, and thought in the course of collecting the data.

All the memos are dated so that I could easily correlate them with the data from the interview.

I used my Samsung digital phone as a recording device. To safeguard the recordings, I created two backup copies- one copy of the digital recording was saved electronically on my phone and the other one in my laptop.

During data explicitation, I bracketed my own understanding and interpretations of the data. I introduced measures to enhance the validity of the explicitation. Going through the following steps helped me systematically process the qualitative data:

I divided first each working space in landscape format into three columns. The first column is for the transcript, the second for the message units, and the last column for the codes and categories.

I read and re-read each transcription in order to get a sense of the whole content. For each transcript, I delineated significant ideas (second step). Statements in a form of message units that are seen to answer the research questions were extracted. These message units were separated and recorded in the second column, after the transcripts. Meanings were formulated from these significant message units.

Third, the formulated meanings were grouped into categories that reflect the unique cluster of themes. Thereafter, the distinctive construct of theme, which reflects a particular participant's experience was formed by identifying the significant topics and several clusters that include related formulated meanings.

Fourth, to provide holistic context, I summarized each transcript, which is related to the themes, for every participant. At this step, when all emergent themes were defined, and the whole structure of the phenomenon had been extracted, I presented the findings to my peers for review and confirmation in terms of their richness to provide sufficient descriptions of participants' experiences with heat as a phenomenon.

Fifth, when all the above-mentioned steps were completed for all the interviews, I looked for the central theme that captures the entirety of the phenomenon. Finally, I concluded the explicitation procedures by writing a compound summary reflecting the contextual materialization of the themes.

I returned to the participants for "member checking" in order to determine whether the meanings and interpretations of the transcripts correctly captured their experiences. Suggestions and comments from the participants, which are deemed necessary, were incorporated into the set of data as a form of modification. This was done as the last step in data gathering.

Validity and Ethical Considerations

In a way to augment the dependability of the study, I applied repeated readings on the transcripts and rechecking of the themes as recommended by Krefting [22]. Dependability was also addressed through detailed descriptions of the analysis and results. I also continuously reflected on my personal engagement and contributions to the study and constantly consulted our understanding professor who is an expert in qualitative research to ensure the conformability of the study.

Lastly, I interpreted the data and drew an understanding of the students lived experiences regarding heat. Overall understanding is revealed through this collection of stories, instances, and themes.

3. RESULTS AND DISCUSSIONS

Data Explicitation

The transcripts were read and re-read over and over to achieve a desirable and concrete understanding of the whole contents. At the same time, all of my thoughts, feelings, and ideas that impulsively surfaced due to my previous experiences as a teacher were all bracketed. This helped me explore the phenomenon as experienced by the participants themselves.

The researcher identified four particular categories/themes regarding the central phenomenon which is heat. These categories are as follows: 1.) *Heat as an Invisible Energy*, 2.) *Origins of Heat*, 3.) *Hotness*, and 4.) *Effects of Heat*. These categories and central phenomena were achieved after doing the axial coding.

Heat as an Invisible Energy

When all of the participants of the study was about what idea and concepts they have about heat, each one of them answered that heat is a form of energy. The participant provided even a more precise answer by saying:

"Heat is a transitory form of energy"

"When you say to heat it is a form of transfer of energy from hotter to the colder body" "Heat, transfer of energy and energy cannot be created nor destroyed"

Based on the answers of these students, student 1, considered heat to be a form of energy even providing information that heat can be transferred from one body to another saying that it is transitory, student 2, mentioned that heat will always flow from hotter (higher temperature) to colder (lower temperature), thus obeying the second law of thermodynamics. Lastly, student 3, gave an insight that heat also obeys the law of conservation of energy.

The information and definition of the students provided agree with how Puskin [20] and Sisko & Dykstra [19], both defined heat as transmitted energy due to temperature differences.

Origin of Heat

The participants also provide ideas and concepts that sources of heat can be from many forms one student mentioned that "*When cooking, heat originates from its source like gas stove", another stated that, "example our source of heat is the sun, the sun radiates heat*" and another also argued that "*our body radiates heat, so it is being dispersed to the surroundings".*

The students provided correct information regarding many different probable sources of heat, which proves further that the students were able to understand and retain many of the things that have been taught and discussed to them by their teacher when they were enrolled in heat and thermodynamics class.

Hotness

As the participants provided more answers and ideas as to what they understand and know about heat, they came to mention how heat can be transferred from one object to

another and they provided three (3) specific methods:

*"When we put the spoon to the boiling water, the transfer of energy is what we call **conduction"***

*"if we put our hands above the boiling water that type of energy transfer or energy heat transfer is what we call **convection"***

*"the other one radiates hotness, it is a **radiation** process of heat transfer, example in a campfire, circling that fire you can feel the heat radiating to you."*

Their understanding of heat appears to be excellent since the participants were able to explain the different methods of heat transfer with some sort of clarity, as per discussed by Hewitt [3]. This proves more that their experiences on the discussion of heat inside a classroom are correct and worth noting.

Effects of Heat

Students' acquisition of many different concepts of heat, it provided them with a better understanding also of many different possible effects of heat. These were their answers and insights regarding the effects of heat:

"Heat also causes expansion, for example in our roads we put some kind of gap to give way to the expansion of the material. It can be either linear or volume expansion".

"Water changes the phase from liquid to gas, but its boiling point is 100°C, so at that point, the water turns into its gaseous phase but it does not change its temperature, it's still 100°C".

"I think sir when we put objects like water in a refrigerator or freezer, the temperature of the object or substance decreases until it will reach its freezing point and starts to solidify or change its phase"

Again, the ideas provided by the students (participants) are correct conceptions regarding what possible effects of heat one can observe and explain. And this can only be possible if they have a spot-on understanding of what heat is all about.

Summary per Interviewee with Validation

With all the ideas, concepts, and understanding the participants have regarding heat, the researcher asked the participants what lived experiences they have regarding heat, and these were their responses:

Student 1: "Fire is used to boil water and even melt objects"….We perspire if the sun is really hot even if we are not in direct contact with it. I also have experienced sunburns when going to beaches if the sun is hot. I use fire to be able to cook my food."

Student 2: "Yes sir, when I was cooking and accidentally touched the cover of the "kaldero" (cooking pot), I got a burn on my fingertips, I also got burned when my leg was in contact with the "tambucho" (muffler) of my motorcycle. I also noticed a change in color in my complexion if I drive my motorcycle without using a jacket or protection to my arms"

Student 3: "My experience sir regarding heat is, when I bought ice cream, it melted very quickly when I went outside the store because the sun was so hot…And I can remember using Bunsen burner to increase the temperature and boil substances in our chemistry laboratory subject when we exposed the test tube to the fire for a very long period of time the substance evaporated"

Student 1 response was clear that she was able to relate that due to the radiation of heat, the environment absorbs this heat eventually turning the atmosphere warmer. Thus our body reacts to it by perspiring, also that heat from the sun causes sunburn when we are in direct contact or exposed to it. Lastly, she even mentioned being able to cook food using fire which she considers a source of heat.

Student 2 response clearly demonstrates that he relates that in cooking, heat from the source is being transferred to the material in contact, and burns can be caused by too much absorption of heat, thus also resulting in to increase in the temperature of the materials. He even provided insights that too much exposure to sunlight. And lastly, he was certain that heat can cause a change in our skin complexion or discoloration of things.

Student 3 was aware of the idea that when materials such as ice cream absorb heat even from the environment, this heat can actually change the phase of substances or things. He also shared his experience with the heat when doing his laboratory experiment in chemistry class, when he was able to notice, observe and explain why the substance inside the test tube evaporated.

Students' responses regarding their lived experiences are evidence of students' understanding of the different concepts and phenomena of heat. The responses provided evidence that would help us assess if the students are equipped with the correct information or if are they misled with a wrong understanding of the concepts of heat.

4. GENERAL SUMMARY

This study was purposely done to be able to gain an in-depth understanding of the lived experiences of third-year BS Physics students of Western Mindanao State University who have enrolled and taken the subject of heat and thermodynamics and be able to provide ideas regarding their lived experiences about the heat.

Considering that this is qualitative research, one may attest that the results of this study are not generalizable to larger populations. However, the uniqueness of the experiences described provides rich stories for those individuals who would like to understand the lived experiences of university students regarding heat. The participants' experiences, as told in their own words and interpreted according to themes were used to answer the research questions.

After doing the axial coding, four themes emerged with heat as the central phenomenon as shown in figure 1. This concept map was generated based on the ideas provided by the students.

Heat is said to be considered a form of energy that can be transferred from one body to another through the process of conduction, convection, and radiation. The transfer of heat is due to temperature differences between and among substances or materials.

Results of the study showed that the students were able to relate to and understand heat based on their lived experiences, and this was evident when they provided correct concepts and ideas.

The results of the study contradicted the findings of Kesidou and Duit [16] since students were able to clearly identify and differentiated the concept of heat and temperature. However, none of the participants was able to mention thermal equilibrium and considered that objects in the same surroundings have the same temperature as reported by Tiberghien [15], Thomas, et al. [17], and Clark & Jorde [18]. The research study also failed to further validate that confusion is not reinforced by the contrast between the cold sensation generated by touching a good and a poor conductor of heat.

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