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FUNDAMENTAL THERMAL CONCEPTS: AN ASSESSMENT OF UNIVERSITY COLLEGE STUDENTS' CONCEPTUAL UNDERSTANDING OF EVERYDAY PERSPECTIVES

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ABSTRACT

The phenomenon of the basic thermal concept is a challenging topic in the early learning of thermodynamics. This research investigated students' understanding of basic thermal concepts from an everyday perspective. Nineteen open-ended multiple-choice questions equipped with written justifications for the student's answer choices were used in this study. Items based on everyday perspectives avoiding scientific terminology were given to 244 university students of Leyte Normal University Tacloban City, Leyte, Philippines. This study shows that students' written responses are specific alternative conceptions commonly used. Most of the students could not provide correct reasons for their answers. The results of this study imply that the teaching style in junior and secondary schools in the Philippines may be problematic. These results can be used as a guide for developing appropriate teaching strategies in introductory physics courses, especially on heat.

KONSEP DASAR KALOR: PENILAIAN PEMAHAMAN KONSEP MAHASISWA DALAM PERSPEKTIF SEHARI-HARI

Kata Kunci:

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ABSTRAK

Fenomena konsep dasar termal merupakan topik dalam pembelajaran awal termodinamika yang menantang. Penelitian ini dilakukan untuk menyelidiki pemahaman siswa tentang konsep dasar termal dalam perspektif sehari-hari. 19 soal pilihan ganda terbuka yang dilengkapi dengan pembenaran tertulis untuk pilihan jawaban siswa digunakan dalam penelitian ini. Item didasarkan pada perspektif sehari-hari dengan menghindari terminologi ilmiah diberikan kepada 244 mahasiswa universitas Leyte Normal University Tacloban City, Leyte, Filipina. Studi ini menunjukkan bahwa tanggapan tertulis siswa merupakan konsepsi alternatif spesifik yang umum digunakan. Sebagian besar mahasiswa tidak dapat memberikan alasan yang benar untuk jawaban mereka. Hasil penelitian ini menyiratkan gaya mengajar di sekolah menengah pertama dan menengah di Filipina yang mungkin bermasalah. Hasil ini dapat digunakan sebagai panduan untuk mengembangkan strategi pengajaran yang tepat pada mata kuliah pengantar fisika khususnya pada topik konsep dasar kalor.

1. INTRODUCTION

Students' conceptual understanding forms the basis for their transfer of learning from one context, such as their jobs, to another, such as classrooms [1]. Cultivating conceptual understanding is challenged by students' preconceptions based on their prior experiences [2]. Despite the diversity of these preconceptions and theories, different researchers have repeatedly reported similar results and patterns across age groups. It is also generally agreed that the traditional teaching method that does not consider the existing beliefs of students is mostly ineffective in changing their naïve ideas. Many students drop out of school (and even university) with their misconception that physics understandings are unaffected or exist alongside more accepted scientific interpretations [3]-[5].

The previous studies [6] involving university students enrolled in a bridging program have indicated that students experienced problems in making connections between their everyday life experiences and scientific concepts. Also, learners could not apply scientific concepts from different perspectives even though the same scientific theories were involved [6]. It is essential to elicit the students' alternative conceptions that prevent them from applying the same scientific concepts from different everyday perspectives [7]. To elicit the students' preconceptions is considered a relevant approach given the growing emphasis in several sciences on the relevance of contextualized science at elementary, high school, and college levels.

The concept of heat and temperature are considered together in science, which is somewhat related but not alike. The ideas are prevalent due to their full usage in our day-to-day life. Heat and temperature concepts are found throughout senior high school and college science curricula [8]. Students were confused about the concepts of heat and temperature and could not explain the differences between heat and temperature [9], [10]. Some students still regard the words "heat" and "temperature" as the same. It has also been found that students hold a variety of alternative conceptions [11], [12]. There are five alternative conceptions about heat and temperature, repeatedly established in the literature [12], subsequently labeled as "conceptual themes" (p. S2G-1) [10]. These themes included ideas in the equivalency of heat and temperature; the temperature measures how cold or hot something feels, and heat application always makes a body warmer. Also, through condensed educational literature, learners at various grade levels frequently think that temperature is a good measure of the energy in a system [13]. Several studies have documented that engineering students have difficulty understanding heat and temperature [14]. Based on the result, some recurrent areas where engineering students have had difficulty and alternative conceptions include rate versus the amount of heat transfer, temperature versus perceptions of hot and cold, temperature versus energy, and the effects of surface properties on heat transfer by radiation [14], [15]. For time versus amount of heat transfer, several students conflate factors impacting the heat transfer rate with the amount of heat transferred [14]. Learners exhibiting this alternative conception have responded that any condition that made a glass of water cold faster would also cool it to a lower temperature.

Different studies use 26 multiple-choice items of Thermal Conceptual Evaluation (TCE) to assess how learners have attained systematically acceptable understandings of basic thermal concepts like temperature, heat, phase changes, and heat conduction [16]. The TCE was used as a pre-test and post-test to explore the effectiveness of cognitive conflict-based physics instruction over the traditional method of physics instruction on primary school teachers' perception of thermal physics [17]. No specific types of alternative concepts and factors hindered students' conceptual understanding of thermal concepts because TCE contained typical multiple-choice items [18]. So in this study, 19 of the TCE items were adapted, needing students to require reasons for the student's choice of responses, and the instrument was renamed the Thermal Conceptual Survey (TCS).

Many studies related to understanding the concept of thermodynamics have been carried out, including improving understanding of the concept of thermodynamics [19], determining the level of understanding of the concept of thermodynamics [20], and evaluating instrument understanding of the concept of thermodynamics [21]. Nevertheless, a different approach was used in the design of the questionnaire and the data analysis in this study; initially, students' open-ended explanations for their answers to 19 multiple-choice items were categorized into four conceptual groups. Alternative conceptions from the open-ended reasons were next identified to determine the factors that hindered students' conceptual understanding and their capability to apply the same thermal physics concepts in not the same contexts. The primary goal of this research was to investigate first-year college students' understanding of thermal concepts associated with their everyday life experiences and to categorize alternative conceptions that were believed by the students established on a questionnaire (the TCQ) [16].

2. METHODS

Leyte Normal University faculty and students conducting research with or about students, teachers, their data, or specimens must apply for ethics approval. Approval of the University's Human Research Ethics Committees before conducting the research with respondents or their data. Moreover, this study has applied to the ethics committees for exemption from human research ethics review since the study uses only existing collections of data that contain only non-identifiable data about human beings and is of negligible risk, was exempt from the review.

Two hundred forty-four (244) university college students at Leyte Normal University participated in this research. They were studying physics (Force, Motion, and Energy) and had previously achieved passing grades in physics ranging from 79% - 85%. Thermal physics concepts taught in junior and senior high school involve the microscopic view, the heat capacity of thermodynamics, and molecular motion caused by heat energy.

The Thermal Conceptual Survey (TCS) is a paper-and-pencil test consisting of 19 multiple-choice items assessing thermal conceptions. The distractors represent common alternative conceptions. The test requires explanations for every answer selected. The students gave reasons to reveal or confirm their alternative conceptions. Items involving topics in basic thermal concepts of heat transfer, temperature change, thermal conductivity, and equilibrium are based on previously developed questionnaires and from students' alternative conceptions obtained from the research literature. Items strictly based on everyday perspectives and avoiding scientific terminology were given to 244 university students at Leyte Normal University Tacloban City, Leyte, Philippines. Such an instrument was evaluated in terms of its content validity. Content validity focused on the relevancy and clarity of each item. Relevancy of the item refers to how each item is relevant to the thermal physics concepts. While clarity refers to the structure of the items if it is well constructed and can be understood by the respondents. Five physics education teachers evaluated the instrument using the scale indicated in the determining content validity index. The entire instrument generated a relevancy index of 0.9895 and a clarity index of 0.9789; both were interpreted as acceptable. This result justifies the utilization of the instrument in the conduct of the study. Figure 1 illustrates an example of one of these items.

1. What is the most likely temperature of ice cubes stored in a refrigerator's freezer compartment?
   a. −10°C
   b. 0°C
   c. 5°C
   d. It depends on the size of the ice cubes.

   The reason for my answer:

____
____
____
____
____

Figure 1. An Example of a Thermal Conceptual Survey (TCS)

The items were categorized into four conceptual groups specifically, (1) temperature changes and heat transfer, (2) boiling, (3) heat equilibrium and heat conductivity, and (4) Freezing (see Table 1).

Table 1. Depiction of Items in The Four Conceptual Groups

No	Conceptual Group	Item Number	Item Description
1	Heat transfer and temperature changes	4	Predicting the direction of heat energy transfer
		6	Evaluating the temperature of a cold can of soda with the temperature of the countertop beneath the can
		7	Finding the direction of heat transfer
		9	Finding the direction of heat transfer of egg from boiling into a bowl of cold water
		12	Predicting room temperature based on the cooling effect of bottles wrapped with wet and dry washcloths.
		17	Wearing a coat in cold weather
		14	Predicting the temperature inside the oven
		15	Comparing the temperatures of our skin and sweat lying on our skin
		16	Finding the direction of heat energy transfer
2	Boiling	2	Predicting the initial temperature of boiling water
		3	Predicting the temperature of continuously boiling water
		8	Predicting the bubbles that form in the boiling water
3	Heat conductivity and equilibrium	5	Evaluating the temperature of a plastic soda bottle with the temperature of the drink in the plastic bottle
		10	Evaluating the "warmness" and "coldness" of plastic and metal chair
		18	Evaluating temperatures of the wooden and ice parts of a popsicle
		11	Evaluating the "warmness" and "coldness" of plastic and wooden ruler
		13	Comparing the "warmness" and "coldness" of cartons of chocolate milk
		19	Measuring the temperature of toy dolls enclosed in blankets
4	Freezing	1	Predicting the temperature of the ice cubes stored in a refrigerator's freezer compartment

Students'correct and incorrect responses were coded 1 and 0, respectively, for the multiple-choice items, along with when their justifications were taken into account. The explanation was considered correct when it coincided with the scientific view. Furthermore, each idea in students' responses in the explanation part was identified. Similar ideas were grouped or classified according to their dominant characteristics, e.g., tautomerism and direct observation. The classification was further verified by two physics education specialists from the University. Frequencies of ideas were also recorded. This analysis will provide percentages of students' correct responses to each of the 19 items separately and in the justification of the four conceptual groups. Qualitative and quantitative analyses were done on their multiple-choice questions and explanations.

3. RESULT AND DISCUSSION

In the following discussion, the results are presented in groups according to the four conceptual groups for which the survey instrument consists of a 19-item open-ended alternative conceptions test is used. The categorization of alternative conceptions gathered was limited to the situations included in the survey and to the student's written responses. The following results were obtained after a thorough collection, tabulation, and analysis of students' responses.

In the multiple-choice items, 244 or 100% of the respondents provided their answers on all of the items. But among these items, only a few respondents explained. With the number of respondents who provided explanations, only a few got the correct explanations. Item number 1 had the most (14%) respondents who tried to explain the concept of boiling, while item number 18 had the smallest (16%) respondents with explanations.

Table 2. Distribution of Respondents Who Provided Explanations on the Different Items (n = 244)

Items	Frequency (Provide Correct answers)	Frequency (Provide Answers)	Percentage
1	18	130	14
2	11	121	9
3	8	110	7
4	15	112	13
5	10	103	10
6	5	76	7
7	3	79	4
8	2	78	3
9	2	92	2
10	10	51	20
11	6	49	12
12	5	26	19
13		35	0
14	12	25	48
15	9	18	50
16	3	25	12
17	5	36	14
18	4	25	16
19	2	26	18

On the test about thermal concepts, questions 2, 3, and 8 involve the concept of boiling. Table 3 below shows the number of students who got the correct answer to questions about boiling. It is in item 2 that more than half of the students (90 or 68.7%) could apply the correct concept of boiling to a particular situation. Unfortunately, in questions 3 and 8 (30 or 22.9% and 37 or 28.2%), students encountered confusion and identified a wrong answer in some situations. These results manifest that most of the students could not understand the application of the concept of boiling.

Table 3. Frequency Distribution of Respondents who got the Correct Answer to the Questions about Boiling in the Four Conceptual Groups (n=244)

Questions	Frequency (Correct Answer)	Percentage
Question 2: (On the stove is a kettle full of water. The water has started to boil rapidly. The most likely temperature of the water is about:)	90	68.7%
Question 3: (Five minutes later, the water in the kettle is still boiling. The most likely temperature of the water now is about:)	30	22.9%
Question 8: (Mel is boiling water in a saucepan on the stovetop. What do you think is in the bubbles that form in the boiling water?)	37	28.2%

Questions 4, 6, 7, 9, 12, 17, 14, 15, and 16 deal with heat transfer and temperature change. Among these situations, question 4 obtained the highest percentage, 105 or 46.3% of the students. And questions 6, 9, 12, and 17 reflect the low proportion of the students who got correct answers. These items attained 22.5%, 16.7%, 21.1%, and 15.4%, respectively. But, questions 9, and 17 involved situations in that only a small proportion of respondents could get the correct answer. It means that few students cannot understand the concept of heat transfer and temperature change. Students' correct responses in multiple-choice were considered and summarized in Table 4.

Table 4. Frequency Distribution of Respondents who got the Correct Answer to the Questions about Heat Transfer and Temperature Change (n=244)

Questions	Frequency (Correct Answer)	Percentage
Question 4: (James takes two cups of water at 40°C and mixes them with one cup of water at 10°C. What is the most likely temperature of the mixture?)	105	46.3%
Question 6: (A few minutes later, Alfredo picks up the cola can and then tells everyone that the countertop underneath it feels colder than the rest of the counter.)	51	22.5%
Question 7: (Pamela asks one group of friends: "If I put 100 grams of ice at 0°C and 100 grams of water at 0°C into a freezer, which one will eventually lose the greatest heat?)	69	30.4%
Question 9: (After cooking some eggs in the boiling water, Mel cools them by putting them into a bowl of cold water. Which of the following explains the cooling process?)	38	16.7%
Question 12: (Amy wrapped two glass bottles containing water at 20°C in washcloths. One of the washcloths was wet, and the other was dry. Twenty minutes later, she measured the water temperature in each. The water in the water with the wet washcloth was 18°C, and the water in the dry washcloth was 22°C. The most likely room temperature during this experiment was:)	48	21.1%
Question 17: (Why do we wear sweaters in cold weather?)	35	15.4%
Question 14: (Pat believes her Dad cooks cakes on the top shelf inside the electric oven because it is hotter at the top than at the bottom.)	73	32.2%
Question 15: (Ben is reading a multiple-choice question from a textbook: “Sweating cools you down because the	77	33.9%

sweat lying on your skin:)		
Question 16: (When Zack uses a bicycle pump to pump up his bike tires, he notices that the pump becomes quite hot. Which explanation below seems the best?)	70	30.8%

Table 5 shows that the thermal physics conceptual understanding test had questions 5, 10, 18, 11, 13, and 19 for heat conductivity. Questions 10 and 13 appear to be situations where students could not comprehend the correct concept of heat conductivity. These questions reflect very low proportions among the number of students. Though questions 5, 18, 11, and 19 still obtained low percentages on understanding the concepts but seem higher than the other items on heat conductivity.

Table 5. Frequency Distribution of Respondents who got Correct Answers on the Questions about Heat Conductivity (n=244)

Questions	Frequency (Correct Answer)	Percentage
Question 5: (Sam takes a can of cola and a plastic bottle from the refrigerator, where they have been overnight. He quickly puts a thermometer in the cola in the can. The temperature is 7°C. What are the most likely temperatures of the plastic bottle and cola?)	66	35.5%
Question 10: (Jane announces that she does not like sitting on the metal chairs in the room because "they are colder than the plastic ones.")	22	11.8%
Question 18: (Vic takes some Popsicles from the freezer, where he had placed them the day before, and tells everyone that the wooden sticks are at a higher temperature than the ice part.)	43	23.1%
Question 11: (Kim takes a metal ruler and a wooden ruler from his pencil case. He announces that the metal one feels colder than the wooden one. What is your preferred explanation?)	55	29.6%
Question 13: (Dan simultaneously picks up two cartons of chocolate milk, a cold one from the refrigerator and a warm one sitting on the countertop for some time. Why do you think the carton from the refrigerator feels colder than the one from the countertop? Compared with the warm carton, the cold carton)	29	15.6%
Question 19: (Four students were discussing things they did as kids. The following conversation was heard: Ami: "I used to wrap my dolls in blankets but could never understand why they didn't warm up.")	64	34.4%

There is only 1 question that involves the concept of freezing (21 correct answers = 20.9%). Such a question reflects a deficient proportion of students who could get the correct answer. Empirically, only 18 of the students got the correct answer. This implies further that students do not have a grasp of knowledge in applying the concept of freezing.

The heat transfer conceptual group consisted of two sub-categories, Heat transfer and temperature changes. There were 59 students who provided the correct response for the temperature change sub-category, the open-ended justification in Items 2, 4, 6, 7, 9, 14, 15, 16, and 17. Students' correct responses when their justifications were considered are summarized in Table 6.

Table 6. Students' Correct Responses to their Justification were considered in the Four Conceptual Groups.

Conceptual Group	Item Number	Correct Responses	Percentage of Correct Responses
		Heat transfer and temperature changes	
Heat transfer	4	When two objects at different temperatures are in contact, heat energy flows from a region of higher temperature to an area of lower temperature until the thermal equilibrium has been achieved.	13
	6	When two objects at different temperatures are in contact, the heat energy flow from a region of higher temperature to an area of lower temperature; hence heat energy is transferred from the counter to the cola.	7
	7	Since ice is still present in a mixture of water and ice, the temperature of the ice should be the same (thermal equilibrium) as the temperature of the water, which is at 0°C.	4
	9	The direction of heat energy transfer is always in one direction: from hot to cold and never from cold to hot. Coldness then cannot be transferred.	2
	12	The room would have to be quite dry. Water evaporates and cools down one bottle; the other bottle tends towards thermal equilibrium, which occurs at 26°C.	19
Temperature change	14	When fluid, such as air, is heated and then travels away from the source, it carries the thermal energy. The fluid above a hot surface expands less dense and rises.	48
	15	When sweat evaporates, it needs energy to convert it from a liquid state to a vapor state. This energy is drawn from the skin. Since the skin losses heat energy, the skin feels cold.	50
	16	When pumping air inside a bicycle and performing mechanical work on the air; hence, the internal energy of air increases, which increases the temperature in the pump.	12
	17	An insulator delays the heat energy transfer rate from a higher temperature region to a lower temperature region. So, the coat delays the heat transfer process of the man as heat energy from the body takes longer to reach the surroundings.	14
		Heat conductivity	
	5	Different objects made from different materials feel different because the rate of heat energy transfer is different for different materials, although their temperature is the same or equal.	10
	10	If placed long enough in a particular environment, all materials will acquire the same temperature, which is the temperature of that environment. Thermal equilibrium has been achieved.	20
	11	Different objects made from different materials feel different because the heat transfer rate is different for different materials, although their temperatures are the same.	12
	18	If placed long enough in a specific environment, all materials will acquire the same temperature:	16

	the environment's temperature.	
19	Different objects made from different materials feel different because the rate of heat energy transfer is different for different materials, although their temperatures are the same.	8
	Boiling	
2	The most likely temperature of water boiling in a kettle is 98°C. The boiling point of water is 100°C only at sea level. Any location above the sea level will have lower pressure.	9
3	The boiling point of water remains constant during boiling as there is no change in pressure> If water is boiling at 98°C, then its boiling point will stay the same five minutes later.	7
8	These bubbles are Air. Liquid water undergoes a phase conversion (called boiling) at 373K = 100°C to steam (water in the vapor, or gaseous state of matter); this is because of the water pressure of the steam = the pressure of the earth's atmosphere (mainly containing Nitrogen and Oxygen gases) at 100°C. When this happens, a tiny gas bubble "nucleases" spontaneously within the liquid water, and the bubble grows and rises in the liquid until it pops out 1 bar of water vapor pressure.	3
	Freezing	
1	The ideal temperature range of the freezer compartment is -18°C or below	14

Responses from University college students (n=244) were analyzed to identify students' alternative conceptions of thermal concepts.

3.1 Heat Transfer and Temperature Changes the Conceptual Group

Table 7 shows categories from students' incorrect open-ended responses in temperature changes and heat transfer conceptual groups. The alternative conception, "cold and hot as the ends of the continuum," keep appearing in all items in Heat Transfer and Temperature Change conceptual group. Also, 74% of students understood heat energy could be easily transferred from one object to another because of their everyday experiences.

Table 7. Percentage of Incorrect Students' Open-Ended Justifications in Categories of the Heat Transfer and Temperature Changes Conceptual Group (N=244)

Categories	**Examples of Students' Open-Ended Justifications**	**Item Number in HT**					**Item Numbers in TC**			
		4	**6**	**7**	**9**	**12**	**14**	**15**	**16**	**17**
The nature of the material	The sweater can generate heat and reduce heat loss									10
Temperature movement	Temperature attracted from higher object to lower object				3		9			
Considering cold and hot at the ends of a continuum	Cold is transferred	5	2		3		5	5		
	The heat energy absorbed from the skin					5			8	7
Everyday observation	In the canteen, there was no difference.		4	5				10	55	

	I read it in my high school science textbook.									
Other Categories	Question/choice reiteration	68	80	70	74	55	60	40	20	75
	The answer cannot be understood	20	10	15	13	25	20	15	10	5
	No choice and no explanation	7	4	10	7	15	6	30	7	3

Item number in TC & HT: Item numbers in Heat Transfer and Temperature Changes sub-conceptual group

3.2 Boiling Conceptual Group

Table 8 shows the categories drawn from students' incorrect open-ended justifications in the boiling conceptual group. Most students (83%) believed that the boiling point of water is always stable (100°C) without considering the location. If it is above the sea level will have lower pressure. Except for two students, a student could not make a connection between the boiling point of water in an everyday context and water's boiling point under atmospheric pressure.

Table 8. Percentage of Incorrect Students' Open-Ended Justifications in the Categories of the Boiling Conceptual Group (N=244)

Categories	**Examples of Students' Open-Ended Justifications**	**Item Number in BW (Boiling Water)**		
		2	**3**	**8**
Constant Boiling point	The boiling point of water is always 100°C The boiling point of water exceeds 100 °C after 5 minutes.	65	83	
Occurrence of impurities	In the water, some impurities turn it into gas. Hot water has substances that make it hot. Something is going out of the hot water.			25
Other Categories	No choice and no explanation	20	10	56
	Question/choice reiteration	10	4	9
	The answer cannot be understood	5	3	10

3.3 Heat Conductivity and Conceptual Equilibrium Group

Table 9 shows categories from university students' incorrect open-ended explanations in the heat conductivity and equilibrium conceptual group. Students' alternative conception that "we feel some objects colder than other objects at the same temperature because of the properties of materials" kept repeated in items 5, 10, 11, 13, 18, and 19. In item 10, about comparing metal and plastic chairs, 80% of students showed these alternative conceptions.

Table 9. Percentage of Incorrect Students' Open-Ended Justifications in The Categories of Heat Conductivity and Equilibrium Conceptual Group (N=244)

Categories	**Examples of Students' Open-Ended Justifications**	**Item Number**					
		5	**10**	**11**	**13**	**18**	**19**
Heat gained/lost from surroundings	Heat gained from surroundings Heat lost from surroundings.			6			
Intrinsic properties of the material	Metal is a good conductor Plastic is a good insulator. Insulating properties of the blanket Heat-transferring properties of the blanket	57	80	76	43	87	78
Different amounts/volumes	Different amounts of coke result in different heat capacity	7					
Other Categories	No choice and no explanation	26	8	6	45	8	15
	Question/choice reiteration	5	10	9	7	2	4
	The answer cannot be understood	5	2	3	5	3	3

3.4 Freezing Conceptual group

Table 10 shows the categories drawn from students' incorrect open-ended justifications in the Freezing conceptual group. Seventy-five percent of students in Item 1 suggested that the temperature inside the freezer was the same as in ice inside the freezer.

Table 10. Percentage of Incorrect Students' Open-Ended Responses in the Categories of Melting Conceptual Group (N= 244)

Categories	Examples of Students' Open-Ended Justifications	Item 1
Thermal equilibrium	Ice and freezer temperature is not in thermal equilibrium	75
	Ice and freezer temperature is in thermal equilibrium at 5°C because ice cannot be at 0°C	15
Other Categories	No choice and no explanation	3
	Question/choice reiteration	4
	The answer cannot be understood	3

Most university students had alternative conceptions of basic thermal concepts, such as the boiling concept, heat transfer during the cooling process, and freezing concept. Students mentioned scientific concepts with theoretical explanations in their open-ended reasons, but learners could not make associations with the everyday contexts of the items. For example, learners knew that evaporation resulted in a cooling process, but students could not justify the energy (heat) transfer from the skin to the sweat. Similarly, students knew that the boiling point of water is measured under standard conditions (1-atmosphere pressure at sea level). Still, students could not use this scientific concept in an everyday context.

The results of this study have some implications for classroom instruction as well as for future research. Chances for students to make connections between their knowledge have to be provided. In learning physics, the teacher must provide opportunities for students to make connections between the knowledge to be learned and previous knowledge [22]. Also, this implies that teachers must elicit students' alternative conceptions before teaching a particular concept. In this sense, they can address students' alternative conceptions during instruction. Furthermore, the metacognitive process to make students think about what they know, what they don't know, and why they don't know should be provided through these everyday test items.

If the students are not made aware that whatever they learned in the past will have some relevance, they will have difficulty integrating new knowledge and an existing alternative conception. If this continues to be implemented, there will be misconceptions among students [23]-[25]. Furthermore, the patterns of understanding show that students' alternative conceptions and the degree to which conceptual change occurs are important aspects in assessing the endpoints of instruction. If addressing the students' alternative conceptions is to be used by teachers in assessing students' understanding, it is the quality of the change in scientific conceptions that should matter.

4. CONCLUSION

Addressing students' alternative conceptions attracts conceptual changes that lead to the quality of the learning process. The phenomenon of the basic thermal concept is a challenging topic in the early learning of thermodynamics. Physically adequate thermal concepts are essential to understand the underlying processes from an everyday perspective. The study showed that students' written responses have some common specific alternative conceptions. Most of the students could not offer a correct reason for their answers. The results of this study may imply the teaching style in Philippine junior and senior high schools that may be problematic. Also, the students' alternative conceptions could be used as a guide for developing proper teaching strategies in the introductory physics course, especially on fundamental thermal concepts.

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