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Conceptual Comprehension of Pre-Service Physics Teachers Towards 1st Law of Thermodynamics

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ABSTRACT

This research is a qualitative study conducted to determine pre-service physics teachers' conceptual comprehension of the first law of thermodynamics. In this study, which was conducted with the participation of 25 students, case study pattern was used, and a holistic single case pattern was adopted. Five open-ended questions which include drawings and explanations were used as data collection tool. In order to support the obtained findings, semi-constructed interviews were done with 20% of pre-service physics teachers. As a result of the findings obtained from content analysis, it was seen that pre-service teachers represent energy mostly as object with potential energy, electric energy, and vibration energy; and it was seen that they think of the world as an insulated place and thus think that there is confined transformational energy within it. When findings of the study are taken into consideration, it is believed that the first law of thermodynamics should be explained by drawing examples from daily life.

Keywords: Physics Education; Pre-Service Teachers; First Law of Thermodynamics; Conceptual Comprehension.

INTRODUCTION

Raising creative and productive individuals who follows latest developments and innovations in technology is possible with education. It is necessary raise individuals who can think analytically, do research and can apply theory into practice in order to meet the needs and demands of people in a world of improved technology (Kayhan, 2009). Thanks to science education, things that happen in nature can be understood, observed, and interpreted by technology (İşman, Baytekin, Balkan, Horzum & Kıyıcı, 2002). In science education, the aim is enable students to have problem solving and scientific skills, to use concepts in relation to daily life and also to train individuals who are science-literate and sensitive to their environment (Ausubel, 1968; Eisen & Stavy, 1988; Tatar & Oktay, 2008). Science-literate individuals can reach information faster, they contribute to the development of technology by generating knowledge, and can use new systems efficiently and productively (Yaşar, 1998). A sub branch of science that examines universal events and approaches them with a fundamental perspective is "physics" (Karakuyu, 2006). A sub branch of physics that focuses on energy, conservation of energy, and transformations of energy is "Thermodynamics." Thermodynamics is a branch of science which examines energy, energy transformations and

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how energy transforms from one kind to another (Çengel & Boles, 1996; Çetinkaya, 1999; Jones & Dugan, 2003; Serway & Beichner, 2008; Yamankaradeniz, 2004). Due to its vast application area and its interdisciplinary nature as well as the fact that it is based on natural phenomena makes thermodynamics a highly significant branch of science. Thermodynamics course is predominantly part of the curricula of science and engineering departments, and it is also part of the curricula of such departments as biochemistry and pharmacy. However, studies show that teaching thermodynamics has not been given enough precedence (Meltzer, 2002; Kirtak, 2010). The first law of thermodynamics which explains the conservation of energy principle is expressed as follows: "Energy cannot be created out of nothing, only different forms can transform into one another" (Bueche & Jerde, 2003; Cebe, 1992). Energy can change form but it can never disappear. For instance, let's take a body of water at a certain altitude; during the flow of this water, the existing potential energy turns into Kinetic energy. The water still has energy; but only the potential energy is said to turn into Kinetic energy. The fact that the first law of thermodynamics explains many events in our lives shows its importance (Çengel & Boles, 2008). One of the topics students find difficult to comprehend is energy, which also covers the first law of thermodynamics (Hırça, 2004; Özmen, Dumanoğlu & Ayas, 2000; Stylianidou, Ormerod, & Ogborn, 2002). Energy can be defined as the ability to do things as well as the ability to move or to generate movement (Selici, 2006). Additionally, the concept of energy, which is the basis of such topics as force, movement, power, is used as wind energy, electric energy, solar energy, chemical energy, binding energy, and mechanical energy (Ellse, 1988). The concept of energy denotes different things in daily language. As energy does not have a simple or concrete definition, everyone uses it differently (Martinas, 2005; Sefton, 2004). In the studies about energy, it was determined that students usually have misconceptions which are defined as knowledge that contradicts with scientific facts especially about energy, energy transformation and energy conservation (Ellse, 1988; Konuk & Kılıç, 1999; Ogborn, 1990; Solomon, 1982; Stylianidou 1997; Stylianidou, Ormerod, & Ogborn, 2002; Trumper, 1998). In many studies on energy, it was seen that students find it difficult to comprehend the concepts related to energy, and that they have misconceptions (Aydoğan, Güneş & Gülçiçek, 2003; Başer & Çataloğlu, 2005; Carlton, 2000; Çoban, Aktamış & Ergin, 2007; Harrison, Grayson, & Treagust, 1999; Sözbilir, 2002). Students' misconceptions and misunderstandings affect their comprehension in the following stages, and they resist change (Hewson & Hewson, 1983). Bearing this in mind, students' misconceptions and misunderstandings constitute the main problem for teachers, researchers, educators, and of course students. When literature on energy is examined, it is seen that another reason for students' difficulty in comprehending energy is the fact that this topic is not paid enough attention to. To have an effective teaching of energy, these studies argue that students' misconceptions and imperfect knowledge should be determined, and then the definition of energy, energy transformation, conservation and transfer should be emphasized and examined for a meaningful teaching (Benzer, Bayrak, Eren & Gürdal, 2014; Çoban, Aktamış & Ergin, 2007; Yürümezoğlu, Ayaz & Çökelez, 2009; White & Gunstone, 1992; Aykutlu & Şen, 2012).

The concept of energy, which is part of the first law of thermodynamics and which has an important place in daily life, is used in movement, heating, and illumination; it is felt and measured by such agents as voice, heat, and light; and it has such kinds as Kinetic, potential, electric, heat, and nuclear energy (Şahan & Tekin, 2007). When literature on energy is examined, it can be seen that many of the misconceptions related to energy are about energy conservation, transmission, transformation, storage, necessity, as well as about abstractness of energy, and the definition of energy (Ellse, 1988; Konuk & Kılıç, 1999; Ogborn, 1990; Solomon, 1982; Stylianidou, 1997; Stylianidou, Ormerod, & Ogborn, 2002; Trumper, 1998). In the studies conducted about students' perception of energy and energy-related concepts, it

was determines that they cannot comprehend the difference between different forms of energy and the source of energy, and that they perceive of energy as light, electricity, the sun, technological applications, a characteristic of living beings, and as a means of making life easier, and that there are deficiencies in their mental constructions of energy, source of energy, the form of energy, transformation of energy, and the transference of energy (Çoban, Aktamış & Ergin, 2007; Kaper, & Goedhart, 2002; Kırtak, 2010; Töman & Çimer, 2012; Yürümezoğlu, Ayaz & Çökelez, 2009). In addition to all these, it was revealed in other studies that energy, conservation of energy, and transformation of energy are among the concepts that should be taught to students in a world where science and technology advances rapidly (Benzer, Bayrak, Eren & Gürdal, 2014; Çoban, Aktamış & Ergin, 2007; Yürümezoğlu, Ayaz & Çökelez, 2009). Taking its cue from this, this study aims to determine the conceptual comprehension of pre-service physics teachers, who have taken thermodynamics course. When the importance of teaching the first law of thermodynamics, which is an indispensible part of daily life, is taken into consideration, although very little attention is paid to a detailed analysis of the first law of thermodynamics, it is thought that it is highly important to determine pre-service teachers' conceptual comprehension of the first law of thermodynamics, and it is also believed that such a study would be a significant part of literature. Moreover, it is believed that the study will be effective in exploring the ways that lead to misconceptions about the first law of thermodynamics. In accordance with the aim and significance of the study, an answer was sought for the following question:

1. What is the conceptual comprehension of pre-service physics teachers, who have taken thermodynamics course, of the first law of thermodynamics?

METHODOLOGY

The study was conducted as a qualitative one, and case study pattern, which is one of the qualitative research methods, was used. Case study is a research method which makes it possible to examine an issue in detail so as to answer "why and how" (Yin, 2009; Yıldırım & Şimşek, 2013). Case study refers to a thorough analysis by way of determining in detail the place and time of one or more events, individuals, or groups (McMillan, 2004). In case studies, basic aim is to describe an event. To this end, as the aim is to describe an event out of a real event, whatever is expressed constitutes a meaning and view related to that particular event for the reader (Gall, Gall, & Borg, 1999). Moreover, a holistic single case pattern was adopted in the study. In the holistic single case pattern, there is a single analysis unit such as an institution or a class. This pattern is utilized in studying particular cases (Yıldırım & Şimşek, 2013). In this study the case is pre-service physics teachers' conceptual comprehension of the first law of thermodynamics who have taken thermodynamics course and are juniors.

a) Study Group

Usually, participants in case studies are a group that consists of people who share the same environment and who know each other. For studies conducted in the field of education, students in a class environment are a good example (McMillan, 2004). The participants of this study consists of 25 pre-service teachers who are seniors taking the thermodynamics course during the fall semester of 2014-2015 academic year. Demographic characteristics of pre-service teachers are given in Table 1.

Table 1. *Demographic Characteristics of Pre-service Teachers*

Pre-Service Teachers'	Age	Class	Gender
Ayşe (PT1)	23	3	Female
Ali (PT2)	23	3	Male
Berrin (PT3)	22	3	Female
Hilal (PT4)	23	3	Female
Samet (PT5)	24	3	Male
Ömer (PT6)	23	3	Male
Aynur (PT7)	27	3	Female
Nurdan (PT8)	23	3	Female
Cenk (PT9)	23	3	Male
Burak (PT10)	22	3	Male
Fatma (PT11)	22	3	Female
Deniz (PT12)	23	3	Female
Merve (PT13)	23	3	Female
Betül (PT14)	23	3	Female
Emrah (PT15)	22	3	Male
Selda (PT16)	23	3	Female
Gökçe (PT17)	23	3	Female
Nazlı (PT18)	23	3	Female
Erkan (PT19)	22	3	Male
Cemre (PT20)	24	3	Female
Zeynep (PT21)	24	3	Female
Gizem (PT22)	22	3	Female
Murat (PT23)	23	3	Male
Suna (PT24)	23	3	Female
Berk (PT25)	23	3	Male

In determining the participants, criterion sampling method, which is one of the purposeful sampling methods, was used (Yıldırım & Şimşek, 2013). Criterion sampling is a method the participants are determined so as to meet a series of criteria pre-determined or constructed by the researcher (Patton, 2002). To this end, junior pre-service physics teachers, who meet the criterion by the fact that they have taken thermodynamics course, were selected in accordance with the aim of the study.

b) Data Collection Tool

In this study which was realized by qualitative research methods, an energy concept form which consists of five open-ended questions with drawings and explanations was used as data collection tool in order to determine pre-service physics teachers' conceptual comprehension of the first law of thermodynamics. This energy concept form that consists of open-ended questions was preferred because it is effective in obtaining in-depth information about pre-service physics teachers' views on the topic without being under the influence of anything else (White & Gustone, 1992). Before designing the form, studies which were conducted in Turkey and abroad related directly or indirectly to the topic of this study were researched. After the literature review, and with the views of three experts – one with a PhD in physics and two with PhDs in physics education – it was decided that five questions should be in the form (Yürümezoğlu, Ayaz & Çökelez, 2009; Tekbıyık, 2010; Aydın & Balım, 2005; Töman & Çimer, 2012). While literature was consulted in the design of the questions in the form, some questions were altered partially by the researcher and three experts were consulted

as to whether the questions in the form have content validity. Taking its final shape after expert consultation, the form was applied to 20 junior pre-service teachers, who have taken thermodynamics course, as a pilot study during the fall semester of 2013-2014 academic year. Data obtained in the pilot study were analyzed with content analysis method. It was determined that pre-service teachers express energy most frequenly as transformational energy and under the movement theme, and that they have incomplete and incorrect knowledge about the preservation, transformation, and transfer of energy. As a result of the pilot study, it was determined that pre-service teachers have incorrect or incomplete knowledge about the first law of thermodynamics, which is the research problem of this study. In this respect, data gathering tool, which was developed in accordance with expert views, was determined to be acceptable and sufficient in revealing pre-service physics teachers' conceptual understanding of the first law of thermodynamics. Questions in the energy concepts form are given below:

1. How would you illustrate energy?
2. Can we claim that our world is an insulated system? Why? Explain.
3. Can energy be transferred without transformation? Explain by giving examples.
4. How would you explain the melting of ice cubes that rub against one another?
5. How is the energy transformation during the power generation at a dam?

c) Procedure

The form which was distributed to the pre-service teachers after teaching them the first law of thermodynamics was applied to them during class hours by giving them 20-25 minutes to complete it. Analysis of the questions in the form was done by entering data to the files opened for each question separately. Moreover, in order to support the findings, semi-constructed interviews were conducted with 20% (five pre-service physics teachers) of the pre-service physics teachers. Interviews conducted with pre-service physics teachers were done by the reserachers in an empty classroom, and the aim was to obtain data of different quality and depth. Pre-service teachers to be interviewed were determined through the data obtained from energy concepts form and among pre-service teachers with different views. When the views of pre-service teachers are taken into consideration, a total of five pre-service teachers were selected among those with correct (one pre-service teacher), incorrect (two pre-service teachers), and incomplete (two pre-service teachers) knowledge about the first law of thermodynamics. Since the scope of the study focuses on determining as to how the first law of thermodynamics is conceptually comprehended, having the views of pre-service teachers with differing views is necessary. Interviews with pre-service teachers were realized a week after the application was completed in an empty classroom, and one interview took 25-30 minutes. Moreover, willingness of the pre-service teacher to give an interview was also taken into consideration in selecting the participants. Data obtained from these interviews were recorded with a voice recorder and them they were transcribed into files in electronic media.

d) Data Analysis

Data obtained in the study were analyzed by content analysis method. Content analysis refers to the interpretation of data by arranging them in a coherent way by putting similar data together according to certain themes and concepts (Yıldırım & Şimşek, 2013). Moreover, content analysis is a technique in which words in a certain text are categorized and systematically summarized via certain codifications (Büyüköztürk, Çakmak, Akgün, Karadeniz & Demirel, 2009). In the study, analysis process started after data collection process. After the completion of data collection process, qualitative data were re-read, and a

code list was prepared for each question with inductive analyses. It is thought that pre-service teachers' answers reflect the real situation because of this. In addition, objectivity was sustained in forming and evaluating the data. Then, qualitative data were entered to the code list, which was prepared in accordance with inductive analysis (Miles & Huberman, 1994). During analysis, some additions to the code lists and some alterations in some of the codifications were done; some codifications which were thought to have a relationship were put together. Then, codifications were grouped among each other under certain themes. At the same time, percentages and frequencies of codes under these themes were calculated. All data obtained and transformed to forms were given to another expert, who has a PhD degree in physics education and teaches thermodynamics, in order to see whether the data were under the correct themes and codings in terms of internal validity. Data entries were revised again at different times by the researcher and the expert separately and the consistency between results of the revision were compared with each other. Comparison was done by looking at the similarities (agreement) and differences (disagreement) in the data entries realized by the researcher and the expert. Then, after applying the reliability calculation formula suggested by Miles and Huberman (1994) ($R_{reliability}$ = (Agreement / (Agreement + Disagreement)) x 100), it was determined that consistency between the researcher and the expert is 82%. The fact that the consistency is higher than 70% shows that reliability of research findings is established (Miles & Huberman, 1994). Moreover, the difference was minimized by re-working on the answers given by the researcher and the expert and arriving at a consensus. In Table 2, an example related to the data analysis of the question "If you were to draw energy as a picture or to express it with an image, how would you do it. Explain." was given.

Table 2. *Example Related to Data Analysis*

Themes / Frequency (%)	Codes / Frequency (%)	Explanations
Movement 9 (36%)	Moving particles 3 (12%)	• Energy is a moving particle that has very little matter in it. • Several moving particles move as a knot with a bigger energy as they keep colliding with one another
	Moving car 2 (8%)	• A car has kinetic energy because of its movement.
	Running dog 2 (8%)	• Energy is the movement of an object with a certain mass and velocity from one place to another.
	Moving person 2 (8%)	• Energy is a conservable entity (we can call it an entity). It travels like a constrantly moving person, but it never gets lost and it has a highly developed sense of direction.

During the analysis, special attention was paid to whether especially direct quotations reflect the related code and theme. Moreover, obtained data were supported by semi-constructed interviews conducted in an empty classroom with pre-service teachers. In order to improve internal reliability and validity, views of pre-service teachers were also given. When the interviews were transcribed, pre-service teachers were called PT#1, PT#2, PT#3, PT#4, and PT#5 in accordance with the order they were interviewed. In the interviews, in order to more thoroughly evaluate pre-service teachers' answers to the questions in energy concept form, questions in the form were asked to the pre-service teachers one more time. In line with the answers, additional questions within the boundaries of the research were asked. These additional questions were determined in paralel to the questions about the first law of thermodynamics in the form. At the same time, most of the questions asked in the semi-constructed interviews were designed by the researcher, and in the formation of some

literature was consulted (Kırtak, 2010). In order to increase the internal realibility and validity of findings, views of pre-service teachers were taken and the questions asked to them were evaluated by the same experts, and it was decided that questions should be part of the application. Pre-service teachers were given ample time to answer the questions so that they do not get scared or anxious thereby providing internal validity of questions. Moreover, in constructing and evaluating the data, objectivity was sustained, and direct quotations were used. Certain parts of one of the semi-constructed interviews can be found below (R: Researcher):

Researcher: Can we say that our world is an insulated system? What do you think?
Student4: When a house is insulated, all heat is confined within. If the world were not insulated it would take all the heat of the Sun. By the way insulated means protector. In conclusion I think the world is an insulated system.
R: Do you think so because not all heat of the Sun can penetrate the earth? (This question was asked to the pre-service teachers as an additional question).
S4: Yes. Actually, there is a protective belt around the earth which functions as a shield for the harmful rays that could come from without. The fact that not only heat but also harmful rays cannot penetrate the earth and the fact that no effect goes out means that the earth is an insulated system.
R: So, what do you think of the reason of using double-glazed windows? (This question was asked to the pre-service teachers as an additional question).
S4: It prevents the air from going out. I mean, double-glazed windows prevent heat transfer. Moreover, when the windows are closed, the treshold to hear the voices outside is decreased by the glazed windows.

In the external validity of the study, each step of data collection and analysis was indicated in detail. Lastly, obtained data were preserved so that they could be examined by another researcher, and the aim of the study as explained in detail so that the research process could be compared to other studies.

FINDINGS

In the study, data obtained from the form with open-ended questions which also include drawings and explanations about the problem question "How is the conceptual comprehension of pre-service physics teachers who take thermodynamics course?" and from the semi-constructed interviews done to support the data. In this study, it was determined that pre-service teachers have correct and imperfect knowledge about energy and that they have misconceptions. Data and pre-service teachers' explanations and views are given in below in detail.

First question asked to pre-service teachers in the study was "How would you illustrate energy?" Answers of pre-service teachers were gathered under following themes: transformational energy (40%), movement (36%), impact dispersing from the source (16%), wave (16%), and entity (8%). It was seen that pre-service teachers mostly depict energy as an object that has potential energy, electric energy, and vibration energy, all of which are under the transformational energy theme. Codes and expressions obtained from the answers of pre-service teachers were given in Table 3 in detail.

Table 3. *Pre-service Teachers' Views On The Expression Of Energy*

Themes / Frequency (%)	Codes / Frequency (%)	Explanations
Transformational Energy 10 (40%)	An object that has potential energy 4 (16%)	• The object has potential energy, and when it is let down, its potential energy turns into kinetic energy. • Energy is equal to the sum of both potential and kinetic energy. Energy and energy transformation of an object with a height of h and a mass of m, moving at the velocity v is calculated. • I visualize a child sliding. In the beginning, the child has mgh potential energy, and then he moves on by turning his/her energy to $1/2mv^2$ Kinetic energy.
	Electric energy 2 (8%)	• Electric energy moves over resistance. Some of this energy turns into thermal energy over resistance.
	Vibration movement 2 (8%)	• A hanging mass constantly moves to and fro when it has the velocity v. In a scenario where air friction is disregarded, maximum kinetic energy is transformed to potential energy. This transformation keeps occurring. • Energy is the ability to do things. In the representation given in the figure, potential energy turns into Kinetic energy because the spring gives velocity to the object. We see suh energy transformations in many areas of daily life.
	Windmill 1 (4%)	• It is the method of getting energy from wind.
	Total energy graphic representation 1 (4%)	• However energy is transformed, the fact that total energy is conserved within a syste can be expressed through mathematical representations.
Movement 9 (%36)	Moving particles 3 (12%)	• Energy is a moving particle with very little matter in it. • Several moving particles move as a knot with a bigger energy as they keep colliding with one another
	Moving car 2 (8%)	• A car has kinetic energy because of its movement.
	Running Dog 2 (8%)	• Energy is the movement of an object with a certain mass and velocity from one place to another.
	Moving person 2 (%8)	• Energy is a conservable entity (we can call it an entity). It travels like a constrantly moving person, but it never gets lost and it has a highly developed sense of direction.
An Effect that Disperses from a Source 4 (%16)	Lightning 1 (4%)	• I can say that energy disperses from a source such as lightning.
	Light 1 (4%)	• Impact never vanishes nor can it come into being out of nothing. I can only say that energy disperses from a source just like light.
	Scintillant globes 1 (4%)	• Energy disperses around just like a scintillant globe.
	The Sun 1 (4%)	• The Sun is our principle source of energy.
Wave 4 (%16)	Waves 4 (16%)	• It comes out from a source, it does not have a certain direction, and it is not stable. It can expand and change shape. • It can be thought of as a case created by the waves. For example, if kinetic energy occurs in a moving object, energy waves can be thought to come into being during the object's movement.

Table 3. *Continued..*

Entity 2 (%8)	Human being 1 (4%)	• When somebody says "representation of energy," I visualize a muscular and vibrant child. The reason for this is, he/she must have spent a lot of energy to build those muscles. All that energy he/she spent did not go to waste but instead made him/her a strong person. This physical power is reflected in his/her vibrant smile, I mean in his/her self-confidence.
	Thinking man 1 (4%)	• Life is a constant energy cycle, and it moves within its transformation. There is energy in everything everywhere. In the simplest term, the pressure created by my hand and pen, and the friction between the pen and the paper, the movements of my muscles, blood circulation while I write these sentences all happen with energy.

When the same question was asked during the semi-constructed interviews in order to support the data of the study, pre-service teachers answered it as follows:

PT#2: "I think of energy as a moving particle. These particles come together and they get stronger and create a very big impact."
PT#3: "Energy is an impact that disperses from the source."
PT#4: "Energy is everywhere. I do not think of it merely as mechanical. You can get energy from an electric circuit as well."

Pre-service teachers depict energy as an impact that disperses from the source, as electric energy, and as a moving particle. However, it was seen that most of pre-service teachers think of energy as a moving object or a transformational energy form, and that they try to depict it through objects which they think have the impact and energy that disperses from the source. In other words, it is obvious that pre-service teachers try to depict energy via solid situations. Moreover, when pre-service students were asked "What can be done with energy" they gave answers such as the following: "Anything can be done. We can maintain the existence of something. We can observe the transformation and impact of energy," "We spend energy even when we talk, write, and think," "Plants, for example, live by the sun's energy. We move due to certain energies and we maintain our lives with oxygen," "Anything can be done. We can ride down the slide in a theme park because of energy," "Various energy types come to my mind such as wind power, hydroelectric energy. When I think of the types of energy one by one, [I can say that] technology advances due to energy." Another finding of the study is that pre-service teachers think anything can be done with energy, that technology advances and lives are maintained due to energy.

Second question they were asked was "Can we claim that our world is an insulated system? Why? Explain." While the answers of those who expressed that the world is insulated were grouped under the theme closed system (60%), the answers of those who did not think so were grouped under the theme open system (40%) within the interaction code. Pre-service teachers' views concerning this question can be found in Table 4.

Tablo 4. *Pre-Service Teachers' View On Whether Or Not The Earth Is An Insulated System*

Themes / Frequency (%)	Codes / Frequency (%)	Explanation / Frequency (%)
Closed system 15 (60%)	Confined energy 13 (52%)	• The earth is an insulated system. One cannot talk abou energy entry or exit. • Because there is no energy loss, I mean because energy never ends, we can call it an insulated system. • Non-conducting quality of the earth is more predominant. Moreover, as human body and the air contact with each other, our charges become balanced, and there is no loss of energy on earth. • Because there are atmospheric spheres, it can be claimed that the earth is an insulated system. • If it weren't an insulated system, one should be able to hear all sounds made by stars and planets. We don't hear it thanks to insulation. There is no energy entry or exit on earth. • Because the earth is an insulated system, harmful rays cannot reach the earth. There is no energy entry
	Transformational energy 2 (8%)	• Because there is a certain amount of energy within the earth and it constantly transforms. For example, if a vase falls from a table and breaks, potential energy turns to audio and thermal energy. • Because energy cannot be destroyed and cannot be created out of nothing. Energy transformation occurs only on earth.
Open system 10 (40%)	Interaction 10 (40%)	• Whole universe is in harmony. Our earth is in the universe. • We cannot say it is insulated, I mean, we can influence the Moon with gravitational force. Likewise, the movements of the Moon affect the earth (e.g. lunar tide). The whole universe is in harmony. We cannot isolate ourselves; our Earth is part of that system. • There are many energy resources on earth and they are influenced by energy resources that exist within the system. • If it were an insulated system, our clothes, even our hair affects the system during, say, Coulomb law experiment, it would result in miscalculations. • Since sun rays, meteors, and matters enter [the atmosphere of] the earth, it is not insulated.

Supportive expressions taken from the semi-constructed interviews are as follows:

Researcher: Can we say that our world is an insulated system? What do you think?
Student4: When a house is insulated, all heat is confined within. If the world were not insulated it would take all the heat of the Sun. By the way insulated means protector. In conclusion I think the world is an insulated system.
R: Do you think so because not all heat of the Sun can penetrate the earth?
S4: Yes. Actually, there is a protective belt around the earth which functions as a shield for the harmful rays that could come from without. The fact that not only heat but also harmful rays cannot penetrate the earth and the fact that no effect goes out means that the earth is an insulated system.
R: So, what do you think of the reason of using double-glazed windows?
S4: It prevents the air from going out. I mean, double-glazed windows prevent heat transfer. Moreover, when the windows are closed, the treshold to hear the voices outside is decreased by the glazed windows.
R: Then, do you used the word "insulated" in the same sense in both cases?
S4: Yes, in both cases, I used it to mean blocking an effect that comes from without and not letting an effect from going out.
R: So, what do you think is the basis of life on earth?

S4: The first basis of life on earth is water because it is the major component of our bodies. Then it is the Sun. Also the basis of energy on earth is gravitational energy. Life goes on with the energy between the earth and the universe.
R: You mention the universe; is there an energy transfer between the earth and the universe?
S4: Of course there is, but it is very little, scarcely any.
R: So, you say that the Sun is the basis of life on earth and that the earth is an insulated system. In this case, how do the sun rays reach the earth if it is insulated?
S4: the earth blocks harmful rays and the sounds in the universe, it just gets few sunlight and heat, but it is very limited, hardly any. Thus, I can still claim that the earth is insulated. By the way, another basis for life on earth is the human body. Our cells have energy. That's how there is atp synthesis and energy is got.
R: What does the expression "Total energy in the universe is constant" mean to you? Can you explain it?
S4: I don't think the total energy in the universe is constant. Since the earth is part of the universe, let me think about the earth, energy is spent on earth, and this energy is transformed, and here there is energy loss. An example to this would be getting electric power from water in hydroelectric power plants, because there you cannot get 100% efficiency from water.
R: If the total energy on earth is not constant, then what happens to that lost energy?
S4: I don't know about that. We just disregard it in solving the problems anyway. In fact, it is just assumed that the total energy on earth is constant.
R: What do you know about the conservation of energy?
S4: In order for energy to be conserved, there should be an insulated and frictionless environment. Actually this is impossible in reality because friction is everywhere but we disregard this. Hence, the earth is assumed to be insulated. Therefore, we can talk about conservation of energy on earth.

Content of the interview with another pre-service teacher is as follows:

R: Can we say that our world is an insulated system? What do you think?
S2: We are not in an insulated environment even now. The earth is affected by various things such as gravity, the moon and the sun. That is to say the earth cannot be insulated.
R: Can you give an example of an insulated system?
S2: The earth is in the universe and cannot be an insulated system. The earth is affected by the sun and the gravitational pull of the planets. However, I can call the universe an insulated system.
R: What do you think the double-glazed windows are for?
S2: Double-glazed windows are used as a means of heat insulation in houses. We would like our houses to be cooler during the summer; we would like to decrease the effect of the thermal situation outside. I mean, they are used to prevent hot air from going outside. Double-glazed windows prevent energy transfer.
R: What do you think is the basis of life on earth?
S2: Energy. Even the earth was created after a big bang. Moreover, energy is not only available on earth but also in the universe. Energies in the universe affect the earth. Even our breathing is due to energy. In fact, if I should name a certain source of energy, I could say water and oxygen.
R: You also said that the universe has an effect on the energy sources on earth, right?
S2: Yes. Absolutely.
R: So, what does the expression "Total energy in the universe is constant" mean to you?
S2: Energy cannot be created out of nothing, and it cannot disappear. There is a constant transformation. Energy of the earth is constant. Logically, if the energy in the universe is constant, then it is so on earth, too, because the universe and the earth are connected. Thus, the earth's trade with the outside is constant.
R: Can you explain this with the conservation of energy?

S2: Due to the conservation of energy, we breathe, use it, and exhale. Energy on earth is constantly transformed. Energies transform into something else but never disappear. In other words, an object has a potential energy and its potential energy transforms into Kinetic energy when released. Thus, because the existing energy is transformed, total energy is conserved.

It was revealed by the views and explanations of pre-service teachers that many of the pre-service teachers think of the earth as an insulated place and thus it is a transformational energy. Therefore, it was determined that most pre-service teachers have imperfect or incorrect knowledge of the first law of thermodynamics as they disregard the continuous effect of sunrays on earth. Moreover, it was also determined that most pre-service teachers use the word "insulated" to mean "blocking the energy flow," and that they know the meaning of the word "insulated" in the second question. While it was determined that pre-service teachers see energy, water, oxygen, human body, and gravitational force as the basis of life, it was interesting to see that those who claim that the world is insulated also think of the sun and the gravitational force as the basis of life. In addition to these, it was also revealed that most of the pre-service teachers think that the energy of the earth is constant since the energy of the universe is so, and that they explain the conservation of energy with the energy of the universe being constant. However, it was determined that one pre-service teacher thinks that the total energy of the universe is not constant due to energy loss. In this respect, it can be claimed that pre-service teachers have imperfect knowledge about conservation of energy. As far as conservation of energy is concerned, it was seen that most pre-service teachers give correct explanations as they did in the previous question; however, it was thought that they have imperfect knowledge as they explain it as a contained energy circle that happens only within the earth. Additionally, it was also revealed that one pre-service teacher claims that energy is not conserved and that there should be an insulated environment for its conservation. Generally speaking, it was determined that pre-service teachers cannot fully associate the earth with the universe, and that they have imperfect knowledge on such concepts as energy and conservation of energy.

Third question asked to pre-service teachers was "Can energy be transferred without transformation? Explain by giving examples." The answers of those who said that it could be transferred were grouped under the theme "contact" (48%) and the answers of those who said that it could not be transformed were grouped under the theme "transformational" (52%). Because most of the pre-service teachers thought that there should definitely be some sort of transformation, they claimed that energy cannot be tranferred without transformation. Details about the question are given below (Table 5):

In the semi-constructed interviews, it was revealed that 20% of students who had thought that energy could not be transformed also changed their opinions. Their explanations are as follows: "Electronic systems came to my mind. Thus, it [energy] cannot be transferred without transformation. Energy transference is energy transition between objects. Or I change my mind, it can be transferred. I remember the saying 'Cold air entered [the room] when you opened the door, close it' and here there is transference of energy without transformation. Or, someone who feels cold can get heat standing across the stove;" "It can be transferred. For instance in the Coulomb law experiment, when the balls touch they are charged with electricity and energy is transferred without transformation. I can transfer my own energry to you by heat transfer;" and "It can. If I hit the table, for example, energy is transferred without transformation." As such, it was determined that most pre-service teachers thought that energy can be transferred without transformation. It can be claimed that those who expressed that energy cannot be transferred without transformation also have imperfect and incorrect knowledge about energy transference.

Table 5. *Pre-service Teachers' Views On Whether Or Not Energy Can Be Transmitted Without Transformation*

Themes / Frequency (%)	Codes / Frequency (%)	Explanations
Contact 12 (48%)	Transfer with Transmission 6 (24%)	• Heat is energy. It may not transform during transmission. For example, when boiling water, heat coming from the stove is transmitted without transformation. • It can be. Thermal energy from hot water to cold water is transferred without transformation. • It can be transferred. An example for this would be the heat exchange of two matters with different temperatures. • We can give heat as an example. Let's think of two masses with different temperatures. There would be heat exchange between masses. As heat is also a form of energy, it is transferred without transformation. • It can be transferred. For example the radiator.
	Transmission through action-reaction 6 (24%)	• It can be transferred. For example; if a car with Kinetic energy hits an unmoving car at the velocity v_o, with this energy transfer the unmoving car has Kinetic energy and can move. • It can be transferred. For example, colliding balls. When balls hit, Kinetic energy of one ball is transferred to the other without being transformed. • It can be transferred. For example, when I punch a wall, it is transferred due to the action-reaction principle. • It can be transferred. Heat can be transferred within a system. Energy that came into life through movement can provide movement to a different system. • It can be transferred. For example, when two cars with a certain velocity collide, they would move again due to the collision. • There is always an exchange in energy. I mean, in order to transfer energy you have to get it.
Transformational energy 13 (52%)	Transformation 13 (52%)	• Energy cannot be transferred without transformation. There is always transformation. • It cannot be transferred. To put it simply, if we want to get energy from the win, we use windmills. We turn it into energy and enrgy cannot be transferred without transformation, because the received and sent energy should be equal to one another. • Energy cannot be transferred without transformation. For example, we cannot get electricity and transmit it to our houses from the solar power, thermal energy or wind power without transforming their energy. • Energy cannot be transferred without transformation. There is potential energy in an unmoving object. The object moves and potential energy turns into Kinetic energy. For example, generation electricity from wind. Wind turns the baffles, so with the transformation of wind power, electric energy is obtained. • It cannot be transferred. It is transformed. E.g. dams. • It cannot be transferred. For example, in wind turbines, there is transformation when you get electric power from the water vapor.

Fourth question asked to pre-service teachers was "How would you explain the melting of ice cubes that rub against one another?" Pre-service teachers explained the melting of ice cubes that rub against one another under the following themes: friction (80%), pressure (8%), heat (8%), and temperature (4%). Most pre-service teachers indicated that ice melts because of the heat that stems from the friction of ice cubes (Table 6).

Table 6. *Pre-Service Teachers' Views On The Melting Of İce Cubes That Rub Against One Another*

Themes / Frequency (%)	Codes / Frequency (%)	Explanations
Friction 20 (80%)	Heat formation 10 (40%)	• Due to friction, there occurs heat. This heat will be transferred to the ice cubes and cause ice cubes to melt. • Since heat will come into being with friction, ice cubes melt with the movement of molecules. • Due to friction, there occurs warming, and heat comes into being due to the temperature which is transformed from hot environment to the cold one, and ice cubes melt. • As frictional force can happen on any surface, it happens in these ice cubes as well, and thermal energy occurs. Two cubes melt due to the heat after the balance with this energy. • Due to the energy that comes into being because of friction, some of the ice between the rubbed surface will melt and some will erode, and the mass of the ice will decrease. • They lose energy by rubbing against one another. Heat comes into being due to friction, and this causes them to melt. • If two objects with the same temperature rub against one another, heat comes into being due to friction. Electrification may also happen due to this friction. Thus, the object loses heat and starts melting.
	Movement 5 (20%)	• Friction enables movecules and particles to move. Thus, ice starts melting. • In friction, ice heats up due to movement and their temperature changes. Then they start melting.
	Heat exchange 5 (20%)	• There is energy exchange between rubbing ice cubes, because energy transforms. At the friction point energy comes into being and the ice melts. • With friction they exchange heat.
Pressure 2 (8%)	Pressure effect 2 (8%)	• Pressure accelerates melting and decreases melting point. • In my opinion, the main factor is pressure. It is not likely for mechanic energy to become thermal energy by friction.
Heat 2 (8%)	Heat exchange 2 (8%)	• There is direct heat transference. Environmen's energy is transferred to ice, ice transmutes. Heat transfer is from the one with high energy to the one with low energy. • It results from heat exchange between the two.
Temperature 1 (4%)	Increase in temperature 1 (4%)	• When ice cubes rub against one another, molecules start to move due to increase in temperature. Moving molecules gain energy, and ice cubes melt.

In the interviews, pre-service teachers uttered the following sentences which support their explanations: "With friction, there is energy transference, temperature increases and so does energy. Temperature is not energy but I had misstated it in the form, it should have been 'heat increases.'With friction, heat comes into being and melting happens." "With friction, heat energy comes into being. Heat is energy but temperature is a quantity," and "Due to friction, energy is spent, heat comes into being, and that energy melts the ice cubes." Other pre-service teachers indicated that "Due to friction, heat exchange takes place, and melting happens," and "Heat is an energy and with heat transfer comes heat exchange. Thus, ice cubes

melt." In the interviews, it was seen that pre-service teachers realized and corrected their mistakes. Moreover, most of the pre-service teachers have the correct knowledge but some of them have incorrect or imperfect reasons because they have incorrect or imperfect knowledge.

Last question asked to pre-service teachers was "How is the energy transformation during the power generation at a dam?" Answers of pre-service teachers were gathered under the themes electric (80%), thermal (8%), Kinetic (4%), and mechanical (4%). Themes determined by the researcher were formed based on the energy type indicated by the pre-service teachers. As a result of the study, it was determined most of the pre-service teachers think that during power generation at a dam Kinetic energy transforms into electric energy and potential energy transforms into Kinetic energy. Detailed explanations about the question were given in Table 7.

Table 7. *Pre-Service Teachers' Views On Energy Transformations That Take Place During Generation Of Energy at a Dam*

Themes / Frequency (%)	Codes / Frequency (%)	Explanations
Electric 20 (80%)	*Potential → Kinetic → Electric* 7 (28%)	• Water accumulates in dams and this water has lots of potential energy. I mean, potential energy turns into kinetic energy, and kinetic energy turns into electric energy. Thus, light and energies we use in daily life come into being.
	Kinetic → Electric 7 (28%)	• Kinetic energy, due to the movement of water, and water energy, by hitting the turbines, turns into electric energy with the help of hydroelectric plants.
	Mechanical → Electric 3 (12%)	• Due to the flow of water, mechanical energy turns into electric energy.
	Kinetic → Mechanical → Electric 2 (8%)	• There isa need for a source for generating electricity at a dam. Water that comes and accumulated at the dam has kinetic energy. Then, this energy that is used turns into mechanical energy, and finally electric energy is produced.
	Kinetic → Potential → Electric 1 (4%)	• Water has kinetic energy due to its velocity. Kinetic energy of water turns into potential energy after that water reaches a certain height and mileage. Electric energy is got from this potential energy.
Heat 8 (%)	*Potential → Kinetic → Thermal* 2 (8%)	• Energy at dams turns into thermal energy. Potential energy turns into kinetic energy, and kinetic energy turns into thermal energy and thus into the kind of energy we use daily.
Kinetic 2 (8%)	*Potential → Kinetic* 2 (8%)	• Potential energy turns into kinetic energy.
Mechanical 1 (4%)	*Kinetic → Mechanical* 1 (4%)	• Kinetic energy turns into mechanical energy.

In the semi-conducted interviews conducted with the participation of 20% of the pre-service teachers, it was determined that they expressed their views under the theme "electric." Data obtained from the views of some pre-service teachers are as follows:

PT1: "Water stops, hits the panels, and potential energy turns into Kinetic energy, then electricity power is generated."
PT3: "Energy transformation takes place with motional energy, in other words, Kinetic energy, and electricity is generated from Kinetic energy."
PT4: "Mechanical energy turns into electric energy. Mechanical energy is the sum of Kinetic and potential energy."
PT5: "Mechanical energy turns into electric energy. Water that has Kinetic and potential energy hits the wall very fast and thus transformation takes place, and electric power is generated."

By looking at the views and explanations of pre-service teachers, it was determined that they have incorrect or imperfect knowledge about energy transformation because most of them provided correct answers yet incorrect or imperfect reasons in their explanations. Moreover, it can also be claimed that they could not associate energy transformations with daily things nor could they express them properly.

Lastly, pre-service teachers were asked "Do the concepts you have learned at thermodynamics course help you understand daily life events? Explain" during the interviews. Most of the pre-service teachers indicated that those concepts helped them understand daily life events, while one pre-service teacher expressed that he/she could not associate these concepts with daily life as he/she merely focused on things that would be likely in the exam of the course. Views of pre-service teachers are as follows:

PT1: "Yes, definitely. The expression 'Cold air enters [the room] when you open the door, close it' was wrong. I had said when ice cubes rub onto one another temperature increases, but I have learned that it is wrong. I got definite knowledge about energy transformation. I have a better command of energy as a concept now. I can relate the laws of thermodynamics to daily life."
PT2: "Yes, definitely. They say body heat, but it is in fact body temperature. I learned my mistake in this course."
PT3: "I haven't yet related what I have learned in class to daily life. Since I have only studied with the exam in my mind, I can only recall the formulas at the moment."

It was determined that pre-service teachers think that "Thermodynamics" course helped them understand and interpret daily life topics. Moreover, it was revealed through their views that they realized the misconceptions they had had before taking this course and that they reached correct knowledge with the learning they had in this couse.

DISCUSSION, CONCLUSION and SUGGESTIONS

In this study, conceptual comprehension of pre-service physics teachers of a state university about the first law of thermodynamics, which is part of the junior year "Thermodynamics" course, was determined by the energy concept form, which consists of open-ended questions and students'conceptual understanding, drawings and explanations, and semi-constructed interviews conducted to support the data.

As a result of the study, it was determined that pre-service physics teachers depict energy as an object with potential energy, as electric power, and as vibration energy. In addition to these, it was also determined that pre-service teachers explain enrgy as a moving object, an impact that diffuses from a certain source, as wave, and as an entity. Thus, it is evident that pre-service teachers try to explain energy through concrete things. In literature,

energy is known to be depicted as a house, cloud, light, electric circuit, windmill, propeller, computer, car, and the sun (Pastırmacı, 2011; Yürümezoğlu, Ayaz & Çökelez, 2009). In the study, it is believed that teaching should be assisted with experiments, videos, games, and animations in order for students to concretize the concept of energy (Hırça, Çalık & Seven, 2011). Another finding is that pre-service teachers mistakenly thought that insulated as a word means preventing energy transference. Pre-service teachers also think that the earth is insulated and thus there is a confined transformational energy within it. As a result of the study, it was revealed that permanent effect of sunrays on earth is disregarded and hence pre-service teachers have imperfect or incorrect knowledge about the first law of thermodynamics. As for the expression "total energy in the universe is constant," it was determined that pre-service teachers think that the energy of the earth is constant as the energy of the universe is so and that they explain the constancy of energy in the universe by the conservation of energy. Moreover, on a similar vein with the study of Gülçiçek and Yağbasan (2004), this study, too, points at the misconception "the total energy in the universe is not constant due to energy loss." When whether or not the pre-service teachers knew the concept of conservation of energy was examined, it was seen that they depicted conservation of energy as energy transformation and the conservation of total energy, but that they also explained conservation as an energy cycle confined to the earth only. Although it is known that energy transformations and transference take place in the universe since it is a system and it is also known that energy transference does not occur in the universe because it is completely insulated and energy amount is constant (Tekbıyık, 2010), by looking at the results, it is thought that pre-service teachers confuse the characteristics of the earth with those of the universe or that they have difficulty associating the earth with the universe. Then, when they were asked what the basis of life on earth is, it was determined that pre-service teachers used such expressions as energy, the sun, water, oxygen, human body, and gravitational force. Thus, it was revealed that some pre-service teachers confused the characteristics of the earth with the characteristics of the universe by making incorrect explanations and thinking that the earth is in fact not insulated. In addition, it was also determined that pre-service thinkers indicated that energy cannot be transferred without transformation since they believe that tere should definitely be a transformation in energy. This view is also in accordance with Tekbıyık's (2010) study, and it puts forth that pre-service teahers cannot properly differentiate energy transformation and conservation of energy. It is believed that energy transformation and conservation of energy as concepts should be taught in more detail and by relating them to daily life (Çoban, Aktamış & Ergin, 2007). Pre-service teachers who expressed that energy could be transferred without transformation think that this transference takes place through transmission and cause-effect (Tekbıyık, 2010). While there is continuous collision in transfer through cause-effect, there is heat exchange due to temperature difference in transfer through transmission. At the end of the study, it was determined that pre-service teachers cannot properly distinguish related concepts from one another. Same result pops in similar studies, and it was seen that students can easily misuse concepts related to energy interchangeably and that it creates a conceptual problem (Yürümezoğlu, Ayaz & Çökelez, 2009; Amettler & Pinto, 2002). It is believed that this issue stems from the fact that these concepts are not handled in detail during teaching and that this may cause conceptual misunderstandings. Another finding of the study is that pre-service physics teachers believe that pressure, increased temperature and heat transfer are effective in the realization of melting and the formation of heat. As Töman and Çimer (2012) also contend, although pre-service teachers have correct knowledge about energy transformation, they have incorrect or imperfect reasonings when they try to explain things, and it is believed to be stemming from rote learning and from lack of a meaningful learning. Thus, it can be said that they cannot explain daily phenomena. Accordingly, when pre-service teachers'

explanations – Kinetic energy turns into electric energy, and potential energy turns into Kinetic energy which then turns into electric energy – were examined, it was seen that most of them gave the correct answer but that their reasons were different from one another. As a result, it was concluded that pre-service teachers could not properly relate their theoretical knowledge on energy transformation to daily phenomena. It is believed that this problem can be solved by explaining energy transformation over and over through different examples (Töman & Çimer, 2012). In general, it is believed that topics within the first law of thermodynamics, which is the basis of events in nature, should be taught, beginning with primary school, in relation to daily life (Kırtak, 2010).

Finally, in the study it was determined that concepts pre-service teachers learn at thermodynamics course is helpful in understanding daily phenomena, but that some pre-service teachers indicate they cannot relate the topics to the daily things. It is thought to be due to the fact that thermodynamics class is basically taught through the heavy use of mathematical expressions; and it is also believed that pre-service teachers can learn the concepts in a meaningful way only when they are taught by relating to daily life. Moreover, it was determined that pre-service teachers have realized their misstatements which result from daily language such as "When I open the door, cold comes from outside, and the house gets cold, close the door." It was also determined that they believe they have reached correct knowledge. Studies show that pre-service teachers' misconceptions usually stem from spoken language and that these misconceptions affect their later learning negatively (Palmer, 1999; Yılmaz, Tekkaya, Geban & Özden, 1999).

After the completion of the study, it can be said that instructors who teach thermodynamics classes should relate the concepts to daily life, explain them through different examples. Finally, it can be suggested that while teaching such an abstact concept as the first law of thermodynamics, such activities as different animations, experiments, and field trips or new teaching methods should be effectively employed (Kaper, & Goedhart, 2002; Kırtak, 2010).

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