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AN INVESTIGATION INTO THE CONCEPTION ENERGY CONSERVATION AT DIFFERENT EDUCATIONAL LEVELS[1]

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Abstract
This paper describes an investigation of the conception and misconception of energy conservation held by students at primary and secondary schools and student teachers at a faculty of education. The study employed developmental research methodology. In order to collect the data, both a conceptual understanding test and semi-structured interviews were used. Before the main study, a pilot study was conducted with 45 students, thereby, some revisions could be done to improve the test's quality. A total of 95 students (35 from primary, 35 from secondary and 25 from university) responded to the test, which consisted of questions that require written answers. In addition, interviews were conducted with 15 students in total. The data from the test and interviews showed that the concept of energy conservation were not fully understood by the students. Misconceptions have been determined at all levels of education. Implications for curriculum and school education are drawn from the results.

Key Words: Energy Conservation, Understanding Levels, Misconceptions.

INTRODUCTION

Students use the terms related to the world they live in while they are trying to explain the events and the contexts in science. However, these terms can not scientifically correspond to the concepts they are related to most of the time. Therefore, it is known that this wrong preliminary knowledge brought to the class environment prevents the new concepts from being learned (Gınns, 1995), so it is required that the preliminary knowledge of the students should be determined before the lesson for an effective learning and the teaching should be organized with respect to this (Dekkers and Thijs, 1998; Osborne and Wittrock, 1983).

The researches in the literature reveal that the students acquire ideas about many concepts in science which are not accepted scientifically and this knowledge is mostly based on inconsistent love, prejudices and the experiences they earned from their daily life (Osborne and Freday, 1985; Gülçiçek and Yağbasan, 2004).

It is stated that the students usually form their misconceptions with the analysis of different kinds of events which they meet in their daily life and before they come to the class and they affect their subsequent learning negatively (Palmer, 1999 and 2001; Yılmaz, Tekkaya, Geban and Özden, 1999).

[1] This study is based on the Ufuk TÖMAN' s master thesis.

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Energy conservation is a concept which appears in different disciplines and it is connected to many concepts directly or indirectly in science. Since this concept is a common, interdisciplinary concept used by many branches of science, it must be dealt with both its physical, chemical and biological dimensions (Gürdal, Bayram and Şahin, 1999; Konuk and Kılıç, 1999; Özmen, Dumanoğlu and Ayas, 2000). The studies conducted mostly investigate energy conservation related to one field only and they address to specific education level. The studies which intend to examine the conceptual change related to this concept that occur in different education levels are quite scarce.

The relations between the concepts will be revealed more explicitly by determining the framework of the concepts with the examination of the changes that occur depending on the education level with the concepts which appear in daily life and in different disciplines about energy conservation as a whole in this study. Moreover, the ways the students understand this concept and the misconceptions which occur depending on it will be determined by forming a meaningful wholeness for this concept. It is thought that this study will make contributions about the renewed adaptation of energy conservation concept to the teaching programs and the teaching of the concept in question.

The purpose of the study is to determine the understanding level of primary education, secondary education , and university students in their final years about energy conservation and reveal the conceptual change between these levels.

METHOD

Developmental research method, one of descriptive researches, were used in this study to determine the education levels of students who study at different levels of education levels about energy conservation concept. The research which aimed at determining the education levels of the energy conservation concept was made up of studies which were carried out at the same time on the sampling which was going to be equivalent of the sampling that will follow it rather than revealing the development level by working on the sampling for a long time. (Çepni, 2009). By this way, the study was completed in the earliest time by studying the samplings in different age groups rather than following the same sampling. When these features of the study are taken into consideration, the study bears the qualities of a cross-sectional study in developmental research method.

This research was carried out in a primary school, a high school and Fatih Education Faculty of Karadeniz Technical University located in the centre of Trabzon. Final year students randomly chosen from each primary school and high school and the teacher candidates in their final years in Biology Teaching Department of Fatih Education Faculty formed the sampling of the study. The distribution of the number of the students who participated in the study and their genders were presented in Table 1.

Table 1: Sampling of the study

Education Level	***Gender***		***Total***
	Female	***Male***	
Primary Education	*21*	*15*	*35*
Secondary Education	*19*	*16*	*35*
University	*17*	*8*	*25*

Data Collection Tools

Conceptual understanding test and individual interviews were used as data collection tools in this study. The features of these data collection tools were stated below.

Conceptual Understanding Test: The research questions of the study were made up of two open ended questions about c energy conservation. While giving the findings obtained from the test data, some abbreviations were used. The explanations of these abbreviations were given below.

For example, TI-1 symbolises the "first primary education student who answered the test".

T: Test, I: Final year student of primary education, O: Final year student of secondary education, U: Final year university student, 1: First student, 2: Second student, 3: Third student, 4: Fourth student, 5: Fifth student

Besides these, the studies conducted by Boyes and Stanisstreet (1991), Köse and et al. (2006) and Yürümezoğlu and et al. (2009) were benefited from while determining the test questions. It was thought that the reliability of the test questions used in these studies was provided. Furthermore, the validity of the test questions were obtained with the expert views, relevant literature, and pilot study. The place of the energy conservation concept in the test and its question numbers were presented in the table.

Interviews: Semi structured interviews which were carried out individually were used in the research. The interviews were carried out with total 15 students (five students from each education level) who were chosen by the teachers according to the criteria determined by the researchers and each interview lasted about 45 or 50 minutes.

While the data obtained from the interviews were being presented, some abbreviations were used. The explanations of these abbreviations were given below. For example, MI-1 represents the "first student of the primary students being interviewed".

A: Researcher (Interviewer), M: Interview, I: Final year student of Primary education,
O: Final year student of Secondary Education, U: Final year undergraduate student, 1: First student, 2: Second student, 3: Third student, 4: Fourth student, 5: Fifth student

Data Analysis

The information about how the data obtained from the interviews and the test used to determine the understanding levels of the students about the concept investigated was given below

Conceptual Understanding Test: In order to evaluate the test which was composed of open ended questions in this study, understanding level categories determined by Abraham and et al. (1992) were used. The categories and their contents were given in Table 2.

Table 2: Categories and their contents used to analyse the items in the test

Understanding Levels	***Grading Criteria***
Clear understanding	• *The answers which include all the aspects of the valid answer*
Partial Understanding	• *The answers which include one aspect of the valid answer but do not include all the aspects*
Partial Understanding with specific misconception	• *The answers which reveal that the concept was understood partially but also include a misconception*
Misconception	• *The answers which are scientifically wrong*
Not understanding	• *The answers which include similar expressions such as "I don't know", "I don't understand" and leaving blank.* • *Reiterating the question* • *The answers which are irrelevant or unclear*

During the analysis, the distribution of the answers given by the students according to these categories were determined in percentages and presented in tables.

Interviews: It was decided in this study that the analysis should be carried out according to the similarities of the answers given by the students around the main questions. Moreover, the authentic answers chosen among the answers related to the questions given by the students were presented directly in order to serve as a model.

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FINDINGS

The findings obtained with the data collected via test and the interviews in the study carried out to determine the understanding level of the students at different education levels about energy conservation concept, identify the possible misconceptions, and reveal the conceptual change between these levels were presented below.

1. Findings Obtained from the Test

The understanding levels of the final year students of primary education, secondary education and university about energy conservation concept were determined with the test prepared. The findings about the concept asked in the test related to the understanding levels of the students at different education levels were presented below.

1.1. Students' Understanding Levels of Energy Conservation

The understanding levels of the 2nd question related to the energy conservation in the test implemented were tried to be determined. According to the data obtained, the primary and secondary education and university students' understanding levels of energy conservation were presented in Table 3.

Table 3: Students' Understanding Levels of Energy Conservation (%)

Question number	***Clear Understanding***			***Partial Understanding***			***Partial Understanding with specific misconception***			***Misconception***			***Not understanding***		
	İ	*O*	*Ü*	*İ*	*O*	*Ü*	*İ*	*O*	*Ü*	*İ*	*O*	*Ü*	*İ*	*O*	*Ü*
1	*37*	*74*	*40*	*14*	*11*	*16*	*6*	*0*	*0*	*34*	*4*	*12*	*9*	*11*	*32*
2	*20*	*37*	*32*	*34*	*43*	*48*	*9*	*3*	*4*	*23*	*3*	*8*	*14*	*14*	*8*
Mean	***29***	***56***	***36***	***24***	***27***	***32***	***8***	***2***	***2***	***29***	***4***	***10***	***12***	***13***	***20***

I: Primary (n=35) O: Secondary (n=35) U: University (n=25)

The 1st question of the test is about energy conservation and it aims at explaining the change in the total energy of the object throughout its movement from one point to another in the figure given. This question aims at determining the students' understanding levels of energy types such as kinetic energy and potential energy which form the total energy but it was asked to determine how much the students understood that the total energy is sum of kinetic and potential energy and what kind of misconceptions they possessed. The efficiency of scientific knowledge stands out while answering this question. As shown in Table 3, total understanding ratio of secondary school final year students (74%) is quite high when compared to primary school and university students. It was determined that total understanding ratio is quite close to each other with primary school and university students (% 37 and % 40 respectively). The students with total understanding stated that potential energy would decrease depending on the increase while kinetic energy increased between the points and therefore energy would not change.

The percentages of student answers in partial understanding category were determined to be quite close to each other in each education level. The students with partial understanding category expressed the energy change between the points correctly, but they could not give the sufficient answers about the change in total energy. The following expressions by the students can be given as examples:

A primary school student (TI-28) stated about this condition "Its potential energy is higher when it is in point A, but while it is moving to the point B, its energy decreases but its kinetic increases. A secondary school (TO-7) said, "Potential energy turns to kinetic energy."

A university student (TU-25) said, "There is only one potential energy in point A, but when it comes to point B, it has got both potential and kinetic energy." Only primary school students are in the partial understanding

with specific misconceptions category (% 6). There are no secondary school and university students in that category. The primary students in partial understanding with specific misconceptions category stated that kinetic energy would increase and this evaluation is partially correct. However, the statement by the students that total energy would increase together with kinetic energy shows they had misconceptions. A statement by a primary school student can be given as an example to this situation: TI-30 stated that while moving from point A to point B, kinetic energy of the object increases together with its mechanical energy. When the misconceptions category was examined, a higher misconception rate was determined with the primary school students than the secondary school and university students (% 34). The misconceptions observed with the secondary school and university students were much lower and close values to each other. Most of the students with misconceptions associated total energy with the speed of matter and they determined that when velocity increases, the energy of matter increases, too. The following answers by the students exemplify the situation mentioned above. A primary school student (TI-9) said, "total energy increases because when the object begins its descent from high altitude, energy and velocity are liberated. A secondary school student (TO-28) stated, "Total energy decreases and ceases on point A and it increases when moving to point B." The highest rate belongs to the university students (% 32) in not understanding category. Senior university students are followed by secondary school students (% 11) and primary school students (% 9). The second question about understanding levels of energy conservation is different from the first question because it relied on the daily activities. The purpose of this question is to determine how much of the knowledge they gained in daily life and the knowledge they obtained scientifically while answering the questions and what kind of misconceptions the students had scientifically and in their daily lives are identified while it is being determined. While the students were explaining energy conservation, they provided answers depending on the examples of energy conversion between some energy types. The most distinctive point with this question is that total understanding rate of each group decreased when compared to the first question where scientific knowledge outweighs. The most distinctive decrease is observed with the secondary school students. This situation reveals that the students at different levels are not able to use "energy conservation principle" which they have obtained scientifically while expressing the simple events in daily life. The students at different education levels with total understanding answered the question with a statement of "Energy does not disappear, but it changes. It was observed that especially secondary school final year students gave detailed answers to this question. For example, a primary school student (TI-6) said, "Energy disappearance is wrong because every object may not have kinetic energy but they may have potential energy. Moreover, energy never disappears but changes. A secondary school student (TO-18) said, "Energy disappearance is wrong because an object which is raised above the ground and moves has energy due to its height. Energy never disappears but it converts into energy. The kinetic energy of an object which it possesses due to its motion turns into heat energy and finally a university student (TU-29) stated, "No, energy disappearance is not true. There is potential energy stored within stationary objects. Energy does not disappear but it converts into energy.

In partial understanding level, while the rates of secondary school students and university students are close to each other, the rate of the primary school students is lower. The highest rate belongs to the partial understanding category between the understanding levels of secondary education and university students. While, the primary school students with partial understanding level expressed some situations and /or some energy conversions with reference to some objects in daily life, the secondary and university students explained them with reference to energy types. However, while using these expressions, they could not tell the change within total energy, so the following answers below were placed in partial understanding category. The following answers can be given as examples: A primary school student (TI-16) said, "Energy disappearance is wrong because coal does not move but it possesses energy. A secondary school student (TO-32) said, "Energy disappearance is wrong because stationary objects possess energy and they do not have to be in motion." A university student (TU-3) said, "Energy disappearance is wrong because stationary objects possess potential energy."

It is understood from Table 3 that the percentage rates of the students in each education level who answered in partial understanding level with specific misconceptions were close to each other. Although the students with different education levels in this category stated with partially correct expressions that energy would be saved at the end of the motion and energy would not disappear, their answers such as "energy would be stored at the end of the motion" revealed that they possessed misconceptions. A primary school student (TI

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12) said, "Energy disappearance is wrong because energy is stored at the end of motion and the existing energy does not disappear." and this answer by a primary student (TI-12) about the position of energy at the end of motion represents the answers suitable to this category. In misconception category, the highest ratio belongs to the primary school students (% 23). Misconception ratio is in lower and close values to each other with secondary and university students (% 3 and % 8 respectively). The misconceptions observed with primary education and secondary education students revealed that the students determined that energy stops when the motion stops where as the university students associated energy with dynamism and they gave misleading answers. The answers below were given to the question above by the students and placed in misconception category. A university student (TI-23) said, "In my opinion, energy disappearance is true because when our motion stops, our energy ceases, too. As a matter of fact, if there is no motion, there is no energy." A secondary education student (TO-11) said, "Energy disappearance is true. As a result of motion, existing energy either decreases or disappears." A university student (TU-21) stated, "Yes, energy disappearance is true. Some creatures are living beings and they aspire, eat, and excrete like human beings. The important thing is its being living or nonliving, not motion."

Students in their final years in primary and secondary education possess (% 14) the same ratio for not understanding category. University students in their final year (% 8) possess lower not understanding ratio than primary and secondary education students.

To summarize, it was determined that secondary education students possessed the highest total understanding rate about energy conservation but primary education students had the lowest total understanding rate about energy conservation. Moreover, primary students possessed the highest misconception rate where as university students possessed the lowest misconception rate.

2. Findings Obtained from the Interviews

The findings obtained from the interviews were categorized according to the similarities between the answers given to the main questions and they were presented below.

2.1. Students' Understanding Levels of Energy Conservation

The students were asked questions about energy conservation during the interviews. The responses were summarized according to the levels of the students in the table given below.

Table 4: Responses of the Students about Energy Conservation

Question	***Categories***	***Education levels***		
		Primary Education	***Secondary Education***	***University***
Does the energy consumed disappear?	*It disappears*	*4*	*0*	*0*
	It does not disappear.	*1*	*5*	*4*
	Don't know	*0*	*0*	*1*
Is it possible for energy to convert into another form when it is in energy conservation phase? If so, please exemplify.	*Light energy- Chemical energy*	*0*	*1*	*1*
	Potential energy- Kinetic energy	*0*	*2*	*2*
	Kinetic energy – Electric energy	*0*	*1*	*0*
	Chemical energy- Light energy	*1*	*1*	*1*
	Don't know	*0*	*0*	*1*

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All the students except the primary education students who answered the question about energy conservation at the end of the energy consumption stated that it disappeared. This misconception shows parallelism with the misconceptions implied in the 2nd question about energy conservation. A primary school pupil who answered that energy did not disappear stated in the second part of the question that energy did not disappear but converted into another form by giving the example of the light bulb which worked with the energy of the battery. To illustrate this, a response of a primary school pupil was given below.
A: Does energy consumed disappear?
MI-4: Yes, energy consumed disappears.
A: How and in what way does the energy consumed disappear? Please, give an example.
MI-4: For example, when the energy in the battery is consumed, it disappears or the energy of the person disappears at the end of an activity.

On the contrary, nearly all of the secondary school students stated that energy did not disappear but changed. The students gave different energy conversion examples to a follow up question. It was determined that mostly students gave examples such as conversion of energy in the battery to electrical and light energy or conversion of energy of water to kinetic and electrical energy as in the "dam" example. Moreover, a secondary school student gave the photosynthesis as an example and explained the conversion between light energy and chemical energy. To illustrate this, a response of a secondary school student was given below.
A: Does energy consumed disappear?
MO-3: No, it doesn't. Energy is not set to zero, it converts into something.
A: If it converts into another form, can you give an example?
MO-3: Energy of water is converted into electricity in dams.

University students except one student gave the answer that energy did not disappear but changed. In the follow up question in the second part, they explained some energy conversion events based on such examples as "battery, dam, and photosynthesis" just like the secondary school students did. To illustrate this, a response of a secondary school student was given below.
A: Does energy consumed disappear?
MU-1: It does not disappear but changes.
A: If it converts into another form, can you give an example?
MU-1: For example, potential energy converts into kinetic energy or light energy converts into chemical energy in plants.

DISCUSSION

In this part of the study, the findings related to the understanding levels of energy conservation at different education levels were discussed with reference to literature.

Students' Understanding Levels of Energy Conservation

Total understanding level about energy conservation at each three level was quite high. The highest total understanding level was determined to be found at secondary education level. Two questions about energy conservation were asked in the study. One of them is about a simple pendulum which is the most specific example given in the courses and the text books about energy conservation. In this question, it was thought that especially the secondary education students' intensions to study for the exams were effective for them to betray a very high total understanding. The ratios of total understanding observed in this question which required theoretical knowledge decreased with the responses given to the 2nd question which asked energy conservation related to a simple event in daily life. This fall was observed in all education levels but it was the most distinctive at secondary school level. As a result, the students who were able to answer the question theoretically fell behind applying and thinking the knowledge.

Energy conservation is not taught as a separate topic in primary education programs and it is given as a student gain in the 8th grade with reference to only energy conversion. It is thought that the studies of the students who started secondary education with lack of knowledge from primary education based on scientific

knowledge and exams in their secondary and university education caused the students to perceive scientific knowledge as a competence to answer some major questions.

When it was evaluated generally, it was found that nearly most of the primary education students were not able to express the energy change in the simple pendulum system. It was determined that the students possessed some misconceptions. For example, while some of these students stated that potential energy is inversely correlated with height, some of them said that the value of kinetic energy decreases when the value in potential energy decreases or does not change. It can be said that although the students having these misconceptions could express the kinetic and potential energy values, they did not realize that total energy value is the sum of kinetic and potential energy values. The study conducted by Gülçiçek and Yağbasan (2004) determined similar misconceptions.

The existence of misconceptions at a higher ratio in secondary education revealed that the students associated energy conservation wrongly with movement and dynamism. Such expressions as "the existing energy decreases or disappears at the end of a movement", "energy is stored at the end of a movement and the existing energy does not disappear" occurred with these misconceptions. It is thought that the formation of these misconceptions were due to the unplanned transition from daily learner centred teaching strategy to the learning process which was scientifically based and included energy conservation.

RESULTS

The following results were obtained with reference to the findings obtained and the comments made in the study which aimed at determining the understanding levels and misconceptions of the students in the final year of primary education , secondary education and university about energy conservation.

1. Generally, the concept examined was not understood at each education level. As expected, the higher the education level got, the higher the ratio of average total understanding level of the concepts increased.
2. The use of energy conservation concept in daily life and its scientific meaning shows difference at changing ratios. The use of energy conservation concept in daily life and its scientific meaning reveals dominance in changing ratios when energy conservation concept is understood by the students at different levels. While at primary education level, the meaning of the concepts related to their use in daily life stands out, scientific definition and school knowledge come into prominence at an increasing rate.
3. The students at primary education level possess partial understanding and misunderstanding about basic concepts of energy such as energy conservation. This condition will make it difficult for the students to understand the new concepts which they are going to come across in their future education life and lead to new misconceptions. Therefore, the higher the education level gets, the more diverse the misconceptions become. Thus, misconceptions at university level appeared more than the misconceptions at lower levels.

SUGGESTIONS

The following suggestions were made with reference to the results obtained in the study which aimed at determining the understanding levels and misconceptions of the students in the final year of primary education, secondary education and university about energy conservation.

1. While the students are being explained the concepts about energy conservation, different examples should be given instead of teaching concepts with similar examples so that the students should be prevented from constructing their knowledge on one example and taking one example as basis with their other applications.
2. Beginning at the 4^{th} grade at primary education, the primary concepts about energy conservation must be planned by taking into consideration the education levels and in such a way to offer sustainability and also the milestones between the daily life knowledge and scientific knowledge must be determined.

3. It is suggested that the teachers and the primary school students at the 5th grade should be considered to be included in the sampling group in the future studies to be conducted about energy conservation and these concepts should be studied separately.

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