The effect of the case-based learning method on high school physics students' conceptual understanding of the unit on energy

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Abstract

The purpose of this research was to examine the effects of two different methods of teaching physics (Case-based Learning and Traditional Instruction) on the conceptual understanding of 9th-grade students regarding topics related to energy. The research was conducted in two different 9th-grade classes in a high school. The research used a pretest/post test quasi-experimental method with a nonequivalent control group. The research was carried out with two groups--a study group (n=30) and a control group (n=30). The Study group were instructed using the method of Case-Based Learning while the control group were approached with traditional teaching methods. Data for the research were collected using the "Energy Conceptual Test." The data collected were analyzed in the SPSS 15.0 statistics program in terms of frequency, percentages, arithmetic means, and standard deviation. When the results of the study were examined as to the changes in the conceptual understanding attained in the two groups (on a question basis), it was found that the most positive change could be seen in the case story group.

Keywords: Case-Based Learning, Conceptual Understanding, Physics Teaching

Introduction

Starting from the reality that physics is an essential part of nature and technology and almost every other field, exposing students to physics by placing them in contexts that will arouse their interest and curiosity (sports, health, environment, technological tools, etc.) will provide the opportunity to create a need or a reason for learning. By associating physics with daily life, the idea that physics can be carried outside of the classroom as a science that can explain us the phenomena occurring around us is a notion that must be developed (Turkish Ministry of National

Education, Board of Education [TTKB], 2013). In this context, the student-centered active learning method of Case-Based Learning-CBL forms the focus of this study.

In recent years, considerable attention on active learning have been established by researchers around the world (e.g. Hillyard, Gillespie & Littig, 2010; Buckley, Pitt, Norton, & Owens, 2010; Meltzer & Thornton, 2011; Smith & Sodano, 2011; Samsudin et al., 2016). Based on several references (e.g. Prince, 2004), instructional methods that actively engage students in the learning process are generally defined as active learning (Samsudin et al., 2016). In physics education only presenting the available scientific information to the students and making them gain the problem solving skills that are far away from the daily life will not be enough to prepare students for the future. Students should be able to use their physics knowledge in the daily life and should be able to make sense of physical events that directly affect their lives. In this context, active learning techniques that put students into the centre should be used in physics education. One of the active learning technique is Case-Based Learning. Case-Based Learning environments are designed in such a way that the students are actively involved in changing their misconceptions and in enhancing their conceptual understanding. The essence of the method of Case-Based Learning lies in carrying events or problems that students may encounter in their everyday lives into the classroom setting. This technique provides students with the opportunity to explore, question, discuss and share, thus fostering an active learning experience. Herreid (1994) has reported that Case-Based Learning (CBL) has been used in medicine, law and school affairs since the 1800's but was not fully embraced until the 1950's when it started gaining importance.

The CBL approach is undertaken to offer students the chance to learn a subject or a skill and to engage in practicing what they have learned. Case stories are generally in written form but they can apply to visual events as well. The method is mostly used in the approach of teaching through discovery and having students develop conceptual behavior (Demirel, 1999; Açıkgöz Ün, 2003; Özkan & Azar, 2005). This approach encourages students to inquire about events and reach a conclusion as a result of their analysis (Herreid, 1994). A good case story allows students in class to discuss events that they may have encountered in the real world but have not been made clear to them, and gives them the opportunity to arrive at some conclusion (Johnson and Purvis, 1987:118; Ünal Sümen, 2013).

Cases may be taken exactly from real life. These may be called already existing case stories. Each already existing case story may be taken from sources such as newspapers, scientific books and journals, scientific studies, libraries, the Internet, television and radio broadcasts, events taking place in our own daily lives, films, videos and other similar sources taken from real life.

If cases suitable for achieving learning gains cannot be found, an imaginary scenario may be drawn up in line with the teaching activity planned by the teacher in order to give the student a feeling of the real experience. Even if cases already exist or have been rewritten, they may still not be in their entirety suitable in terms of educational criteria (Herreid, 2005; Alacapınar, 2008:10). If the teacher uses a real-life situation and the event that will be shared presents a hazard for the people involved, it is then necessary to change the place, time and persons in the story. There are as many benefits in a teacher's recounting an imaginary situation as there are in the teacher's describing a real-life situation. This is because when the student is confronted with the event in CBL, he/she will act in accordance with the form of behavior that had previously been learned and thus easily cope with the problem (Ergün & Özdaş, 1997; CoHE, 2003; Horzum & Alper, 2006). The student who learns through sample cases is able to use the knowledge gained in daily life and is more capable of easily interpreting them (Thomas, O'Connor, Albert, Boutain & Brandt, 2001; Horzum & Alper, 2006).

According to Horzum & Alper (2006), the Case-Based Learning method, with its application of learned concepts and principles, helps to fill in the gap between theory and practice in learning environments. The Case-Based Learning method further removes itself from traditional Science/Physics education, and targets teaching students how to adopt positive attitudes toward learning, become aware of their own cognitive levels and develop competencies in areas such as scientific literacy (Çakır, Berberoğlu & Alparslan, 2001; Özkan & Azar, 2005). Making use of case-based learning methods in science classes causes students to develop an increased interest in the course and by facilitating the daily-life applications of the knowledge learned in class, allows students to explore different solutions to problems, thereby improving their practical intelligence (Çakır et al., 2001; Özkan & Azar, 2005).

Case-Based Science Education

Conant (1957) was the first to use CBL in science education. Conant made use of stories about science in his own classes. (Çakır, Berberoğlu, Alpsan & Uysal, 2006).

While the application of Case-Based Learning (CBL) provides a powerful pivot point in physics education, there are very few studies on Case-Based Learning (CBL) in physics education. In a previous study by Özkan & Azar (2005), the researchers made a comparison of Case-based Learning and traditional instruction in terms of the achievements of 9th grade students in the physics unit on "Heat and Temperature," their ability to learn concepts, and their attitudes toward the course. When the literature was reviewed, no study related to Case-Based Learning (CBL) in physics education was encountered.

Among the most frequently posed questions of students during their physics education is related to how they can use the knowledge they gain in school in their daily lives. In the light of the related literature (e.g., Sudzina, 1997; Wellington, 2006; Kreber, Klampfleitner, McCune, Bayne & Knottenbelt, 2007), it can be said that the case-based learning method is one of the best ways of answering students' questions in this context. It is through this method that students will be able to satisfy their curiosity by having their questions answered.

Student Misconceptions on the Subject of Energy

Work and energy are topics about which students have alternative concepts in their minds and thus frequently form misconceptions (Bahar, Öztürk & Ateş, 2002; Aydın & Balım, 2005; Aydoğmuş, 2008; Cerit Berber, 2008; Hırça, 2008; Şahin, İpek & Ayas, 2008; Arslan & Kurnaz, 2009; Ayvacı & Devecioğlu, 2009; Emepue & Soyibo, 2009; Uzunkavak, 2009; Treagust et al., 2010; Ergin, 2011; Torosluoğlu Çekiç, 2011; Chabalengula, Sanders & Mumba, 2012; Erduran Avcı, Kara & Karaca, 2012). It is observed that students find work in the context of physics difficult to understand and that they confuse the concept of work in real life with the idea of work in the physical sense of the word (Watts,1983; Solomon, 1982,1983; Diakidoy, Kendeou & Ioannides, 2003; Torosluoğlu Çekiç, 2011; Kurnaz; 2011). It has been found that students are conceptually challenged by the notion of conserving mechanical energy (Gülçiçek & Yağbasan 2004a; Gülçiçek & Yağbasan 2004b). In a study by Yürümezoğlu and Çökelez (2010), it was reported that students had difficulty with understanding forms of energy in the context of energy conversion. Various studies have been undertaken to eliminate the various alternative concepts students have about the topics of work and energy (Akbulut, Şahin & Çepni, 2013; Erduran Avcı et al., 2012; Torosluoğlu Çekiç, 2011; Cerit Berber & Sarı, 2009a, 2009b; Cerit Berber, 2008; Hırça, 2008; Forde, 2003). When these studies are reviewed however, it can be seen that these topics have not been taught with Case-Based Learning applications.

One of the basic concepts taught in the 2013 Secondary School Physics Course Program is energy. The concept of energy is one of the most difficult concepts that students conceptualize (Stylianidou, Ormerod & Ogborn, 2002; Yürümezoğlu, Ayaz & Çökelez, 2009: p.56). Many concepts in physics education are associated with each other and these relationships are usually expressed with formulas. The relationship between work and energy, for example, is expressed with the formula $W=\Delta E$ and when explaining this relationship, it is said that, "work exerted is equal to the change in energy." It is an undeniable fact that students of physics generally find it difficult to make associations between concepts. Moreover, in forming relationships between concepts, students may also form misconceptions. Some alternative concepts and misconceptions were encountered in a review of the literature in the field (e.g., Akbulut et al., 2013; Erduran Avcı et al., 2012; Yağbasan et al., 2005).

Two-tier tests are used in many Turkish and international studies to enable an in-depth review of student concepts (e.g., Karataş, Köse & Coştu, 2003; Çalık, 2006; İpek, 2007; Er Nas, 2008; Treagust & Chandrasegaran, 2007; Şahin & Çepni, 2011). In the relevant literature, however, it is seen that there are only a limited number of studies that use the two-tier test in the context of the subject of "Energy" (e.g., Hırça, 2008). In this context, to determine the conceptual understanding and conceptual achievement of students with respect to the concepts in the unit on "Energy" (related to Mechanical Energy), developing a two-tier test will be a contribution to the literature.

Ayas et al. (2007) have reported that in teaching concepts, both traditional instruction and new approaches are put to use but since many concepts cannot be definitely described verbally, the methods of traditional instruction fall short in teaching concepts, whereas new methods introduce the student to examples of concepts for which descriptive qualities can be found and the student can be led into making a generalization from examples.

In this context, it can be said that since the application of concepts and principles learned in Case-Based Learning method brings students face-to-face with real life, the method fills the gap between theory and application in learning environments and for this reason, stands out as an alternative teaching method that may be used in place of traditional instruction when teaching concepts.

Research Focus

In the light of the relevant literature, our aim in this study of 9th grade students exposed to both Case-Based Learning and traditional instruction was to determine whether there were significant differences between the effects of these two methods on the students' conceptual understanding and conceptual achievement. The study sought answers to the following sub-problem:

- How did the conceptual understanding of students in the Case-Based Learning group and the traditional instruction group change from pre- to post-instruction?

Methodology

Research Design

A quasi-experimental research design with a nonequivalent control group and a pretest-posttest was used in this study. The research was carried out with two groups--a study group and a control group. In the study group (Case-Based Group-CBG), the physics topics that were to be taught were treated using the Case-Based Learning approach. In the control group (Traditional Instruction Group-TIG), the same topics were treated using traditional instruction methods (in line with the 2013 Secondary School 9th Grade Physics Course Teaching Program). The research was conducted with students enrolled (n=60) in two different 9th-grade physics classes in an Anatolian Girls' Vocational High School located in the province of İzmir, Turkey. Because the guidelines to teaching and education at the schools were not conducive to creating new groups (since the conditions needed for a fully experimental research design could not be met), it was decided that an nonequivalent control group, pretest-posttest quasi-experimental research design would be used (Gay & Airasian, 2000). The independent variable in the study was the method of instruction that was used. The dependent variables were the students' scores on the Energy Conceptual Test (pretest and posttest).

Study Groups

Students at the school where the study took place were randomly assigned into two 9th grade classes at equivalent achievement status, which comprised the study (n=30) and the control groups (n=30). The study group was named the "Case-Based Group" and the other group, the "Traditional Instruction Group." All of the students in the study group were girls because the school was Girls' School.

Materials

Energy Conceptual Test (ECT)

The Energy Conceptual Test (ECT) that the researchers drew up in line with the Secondary School 9th Grade Physics Course Teaching Program was used to determine which misconceptions students had about the subject of energy and to measure their conceptual understanding. The number of questions were distributed in accordance with the learning gains expected from the topics of "Work, Energy and Power, Mechanical Energy, Conserving Energy and Energy Conversion, Productivity, Energy Sources" contained in the Energy unit in the 9th grade physics course program.

As Treagust and Chandrasegaran (2007) suggest, the review of the students' conceptual changes was made with the use of multiple choice questions that would enable both qualitative and quantitative analysis and an additional number of open-ended questions concerning the topics mentioned above. The two-tier test developed in this study started out with a multiple-choice test of five choices. In the second tier, an open-ended answer was expected of the students as they were asked to explain the grounds for the choices they made in the first tier.

After the researchers constructed the conceptual test on the basis of 19 items, two physics teachers (with more than 10 years teaching experience) and three faculty members who were specialized in physics education were asked to check the test for content and visual validity. In line with the opinions of the specialists, two items in the test were eliminated because they were thought to be unsuitable for the conceptual test construct. The remaining 17 test items were declared appropriate for the 9th grade level as well as valid in terms of content and appearance. The test was tested for reliability in the province of İzmir at two high school 10th, 11th and 12th grade classes, encompassing a total of 131 students. The analysis of the test used the categories classified by Coştu and Ayas (2005). The scoring of the test in Table 1 was achieved by the evaluation of the data in both the first and second tiers. The categorization of the answers to the two-tier test was based on the following:

✓ Right response-Right reason: Sound Understanding (SU)
✓ Right response-Partially right reason or Wrong response-Right reason: Particular Understanding (PU)
✓ Right response-Wrong reason, Right response-Blank or Wrong response-Partially right reason: Specific Misconception (SM)
✓ Wrong response-Wrong reason, Wrong response-Blank or Completely Blank: No Understanding/No Response (NU/NR)

Table 1. The evaluation criteria used in assessing the two-tier open-ended questions

Levels of Understanding	Explanation	Assessment Criteria	Scores
Right reason	Responses that contain all aspects of valid reasons	right response-right reason wrong response-right reason	3 2
Partially right reason	Responses that do not contain all aspects of valid reasons	right response-partially right reason wrong response-partially right reason	2 1
Wrong reason	Responses that contain incorrect information	right response-wrong reason wrong response-wrong reason	1 0
Blank	Irrelevant, unclear response or leaving blank	right response-leaving blank wrong response-leaving blank leaving completely blank	1 0 0

Explanatory factor analysis was performed to determine the factor construct of the test. Because of a low item-test correlation (item discrimination index) on a revised item on the ECT (r=0.007) and also since the first factor analysis yielded a negative value, it was decided that this item would be removed from the conceptual test. The remaining 16 items after one item was removed showed in the new factor analysis that the eigenvalue of the test items were collected in 4 dimensions greater than 1. These 4 dimensions explained 53.58% of total variance.

After construct validity, as part of the reliability study for the ECT, the instrument's Cronbach Alpha coefficient was calculated to define internal consistency. The reliability coefficient for the whole test is 0.784. According to Büyüköztürk (2011), for a conceptual test to be reliable, it is considered adequate for the Cronbach Alpha coefficient for the entire test to be 0.70 or greater (e.g., Samsudin et al., 2016). In the light of this information, it may be said that the Energy Conceptual Test developed for Energy topics is a valid and reliable measurement tool. A sample question contained in the test is presented in Appendix A.

Learning Materials

In the teaching process in this project, Case Stories were used in the Case-Based Group while in the traditional instruction group, the learning materials recommended in the High school 9th grade physics textbook published by the Turkish Ministry of National Education Head Council of Education and Morality were employed. The teaching materials have been described in detail below.

Case Stories

In this project, 8 case story scenarios were prepared for use in the case story teaching method addressing the 9th grade Physics Energy Unit topics of Work, Energy and Power, Mechanical Energy, Conservation of Energy and Energy Conversion, Efficiency, Energy Sources. These texts, which were developed by the researcher (who had 5 years of experience in physics teaching), were devised to suit the 9th grade level and the curriculum.

To ensure that the case story scenarios were appropriate for the level of the students and the curriculum (in terms of both scope and educational gains), the views of specialists (an experienced physics teacher and a faculty member specialized in physics education) were enlisted and the scenarios were revised in the direction of the feedback from these specialists. Later, a pilot run was performed with a similar student group outside of the study group; no problem was encountered with the scenarios during this pilot experiment.

The scenarios developed presented a real-life situation or a slice of life. The scenarios that were devised were written out on a worksheet and supported with videos (case stories presented online) and illustrations. Each scenario was given a heading that reflected the essence of the story. Also, the stories were supported with questions that sought to develop students' thinking skills and thus ensure integration with the theoretical dimension. The characteristics of the group, their times and gains were reviewed and the single session "Short Story-Based Learning" (Waterman and Stanley, 1998), then the "Direct Story-Based Learning" (Waterman and Stanley, 1998) session where questions began to be asked, and the "Abridged Case Stories" (Sönmez, 2005) generally limited to one paragraph were implemented. Some existing stories were taken from the newspapers and the Internet but names were deleted to avoid harming real persons and organizations. The scenarios were developed to follow a discussion format that was appropriate for a small group.

Meanwhile, because the scenarios are written out on a worksheet, they may be passed out to students as homework. One of the case stories is presented in Appendix B.

Procedure

The research was conducted in the spring semester of the 2013-2014 academic year and involved the unit of "Energy" in the 9th grade physics course. The duration of the study was a total of 6 weeks. Both groups were administered an "Energy Conceptual Test" as a pretest and a posttest before and after the implementation of the experiment. The study experiment was initiated immediately after the pretesting.

Treatment in the Case-Based Group

The first lesson in the Case-Based Group was geared to introduce the method of Case-Based Learning and how this would be handled with a short case story about Newton's Law of Inertia in a worksheet entitled "A Ride on the City Bus." In all the other lessons, the Case-Based Group was arranged in the classroom in 6 groups of 5 students each. Teaching the topics using the case story scenarios started with the distribution of the worksheets containing the case stories. Each student received a worksheet. The students were first asked to read through the text of the case story. Then the students were asked to make use of the resources they brought to class (textbooks and other helpful references) to answer the open-ended questions they found right below the texts of the case stories. The researcher walked around the groups at this time to help the students use their resources and guide them in how they might be more efficient in this. At the same time, the researcher gave the students clues about how they could find the right answers, without actually correcting their mistakes. After the students finished answering the questions, the group spokespersons were asked one by one to come to the board and read out the answers to each question. After this was completed, the students were given the opportunity to hold a short discussion about each question. The teacher also participated in the discussions. Ultimately, after the incorrect answers were found with help from the teacher, a student secretary was asked to write down the best answers on the board. The same process was repeated for the other questions as well. At the next class, the students were presented with a new case story. The sample problems solved in the Traditional Instruction Group were solved together with the students in the Case-Based Group.

Treatment in the Traditional Instruction Group

In this group, the teaching remained loyal to what was offered in the Physics 9 Textbook published by Turkish Ministry of National Education (2013). The lecture method and question and answer technique were used in the TIG. It was the teacher who played a more active role over the course of the session than the students. As the topics were taken up, discussions were held with the students. At the end of each topic, sample problems were solved together with the students.

Data Analysis

All the data obtained from the Energy Conceptual Test were analyzed using the SPSS 15.0 program. The data collected from the research were analyzed using frequencies (f), percentages (%), arithmetic means (M), and standard deviation (SD).

Results

At the pretest and posttest, the students answered the multiple-choice questions in the first tier of the conceptual test and also the section that asked for the reasons for their answers, which constituted the second tier of the test, and the responses were reviewed together and determined for each item separately. After the application of the Energy Conceptual pre- and posttest, the students' responses were scored as described in the Methods section and then separated into categories.

A review of the pretest data showed that the responses of the CBG were deficient by 90% or more in items 12, 13 and 16 of the test and that the students had misconceptions; it was also seen that test items 2, 3, 4 5, 6, 11, 14 and 15 were also deficient and reflected misconceptions on the part of the majority of the group. In the TIG, the deficient conceptualization in the responses given to item 13 was 90% and test items 4, 5, 6, 8, 9, 12, 14, 15 and 16 showed the majority of the group had deficient notions and misconceptions. In addition, in both groups, full understanding percentages were markedly low and the same was also seen in items 1, 2, 4, 5, 7, 9, 10, 11, 12, 13 and 15. In the light of all of these results, it may be said that the students in both groups had deficient knowledge and misconceptions prior to the instruction.

When the posttest data were reviewed, the conclusion was reached that the full understanding percentages of the students in the study group (CBG) were higher than those of the students in the control group (TIG) in all the items except items 2, 7 and 11. When the pretest is compared with the posttest in Table 2, it can be seen that the total scores of the study group in the first and second tiers of the posttest showed no difference in items 13 and 16 but displayed increases in all the rest of the items. In the control group, however, it was found that the first and second steps of the posttest showed a decrease in total scores in item 1, no change in items 5 and 16, and increases in all of the rest of the items.

Table 2 demonstrates the difference in percentages in the pre- and posttest of the two-tier Energy Conceptual Test in the two groups. The difference was derived from subtracting the percentages on the pretest from the percentages on the posttest. Table 2 represents increases as (+), decreases as (-) and no change as (0).

Table 2. Pretest-Posttest Percentage Changes in student responses to the two-tier test items by Understanding Categories

	Cased-Based Group (N=30)				**Traditional Instruction Group (N=30)**			
Number of Items	**SUC (%)**	**PUC (%)**	**SMC (%)**	**C(NU/NR) (%)**	**SUC (%)**	**PUC (%)**	**SMC (%)**	**C(NU/NR) (%)**
1	+13.3	+6.7	-20.0	0	+3.3	0	-16.7	+13.3
2	+16.7	+6.7	+6.7	-30.0	+30.0	+6.7	-26.7	-10.0
3	+36.7	+13.3	+3.3	-53.3	0	0	+36.7	-36.7
4	+6.7	+10.0	+13.3	-30.0	0	+20.0	-10.0	-10.0
5	+6.7	+16.7	-6.7	-16.7	0	0	0	0
6	+10.0	+6.7	-3.3	-13.3	+3.3	+10.0	+13.3	-26.7
7	0	+50	-56.7	+6.7	0	+13.3	+6.7	-20.0
8	+30.0	-16.7	+3.3	-16.7	+26.7	+20.0	0	-46.7
9	+16.7	-6.7	0	-10.0	+3.3	+3.3	+10.0	-16.7
10	+26.7	-6.7	-23.3	+3.3	+3.3	+26.7	-23.3	-6.7
11	+3.3	+13.3	+23.3	-40.0	+6.7	+30.0	-6.7	-30.0
12	+3.3	+3.3	+40.0	-46.7	0	+13.3	+6.7	-20.0
13	+3.3	-3.3	-3.3	+3.3	0	+3.3	-3.3	0
14	+53.3	+13.3	+3.3	-70.0	+33.3	+20.0	+13.3	-66.7
15	+26.7	+10.0	+13.3	-50.0	+20.0	+36.7	+3.3	-60.0
16	0	0	0	0	0	+3.3	-6.7	+3.3

Note: SUC: Sound Understanding Change; PUC: Partial Understanding Change; SMC: Specific Misconception Change; C(NU/NR): Change in No Understanding or No Response. Figures have been rounded off.

When examined, it will be seen that Table 2 demonstrates that increase in the number of items in sound understanding, which was above 10% (f=3), was higher in the study group compared with the control group. The changes that remained below 10% were considered negligible. Some items showed no change at all in sound understanding. The number of items where there was no change in sound understanding was higher than in the control group.

In addition to the data given above, the alternative notions (35) that emerged from the responses of both groups of students in the Energy Conceptual Pretest and the misconceptions (9) that emerged on the Posttest are shown below:

- To have an object perform physical work, force must be applied to it to get it to move.
- Work is performed when force is applied to an object.
- Physical work is performed if the object changes its place.
- Work only occurs when objects are pushed horizontally.
- Work occurs when an object is touched.
- Moving objects perform work in the physical sense.
- More movement means more work.
- When force is exerted, the object must move.
- Force moves horizontally.*
- If the force is exerted perpendicular to the direction of the object, this means that physical work has been performed.*
- A leaf breaking off a branch and falling to the ground applies potential energy relative to the ground.
- A leaf breaking off a branch and falling to the ground expends kinetic energy.
- If the object falls to the ground, kinetic energy is released.
- Kinetic energy diminishes as the leaf falls down from the branch.
- Potential energy increases as the leaf falls down from the branch.
- A hairdryer conducts heat.
- Electrical energy cannot be converted into kinetic energy.
- Because we exert force on a basketball when we're throwing it, potential energy increases.
- Potential energy diminishes as altitude increases.
- An increase in the energy spent doing the same work increases efficiency.
- An increase in the speed of an object increases its efficiency.*
- If a horizontal object changes place, kinetic energy will increase.

- Potential energy diminishes when there is motion, but kinetic energy does not change.
- Kinetic energy will increase as long as movement is on a flat plane.*
- When the same work is done in a shorter time, more energy is spent.*
- When the same work is done in a shorter time, more power is spent.
- When altitude increases, the potential energy spent increases too.
- When a book is lifted, potential energy is less because work is being performed.
- Increasing the altitude of an object that is already high up from the ground does not change its potential energy.
- After the dam gates are opened, gravity takes hold.
- Turbines apply kinetic energy by turning.
- Renewable energy sources are not natural, they are artificial resources.
- If an object moves, it gains potential energy.
- When an object's direction of motion changes, the object gains kinetic energy.
- If the object changes place, it gains potential energy.
- The object gained potential energy because it was moved.*
- The more an object moves, the more the kinetic energy.*
- The force applied to an object is equal to kinetic energy.*
- The movement of an object on a steep incline is more difficult and signifies more work.
- The higher the incline, the harder and the more the work that is performed.
- Energy is spent only during the motion.
- We spend energy because we move.
- Heat energy is found in objects used and cannot be transferred to other materials.
- Friction does not lead to the loss of mechanical energy in the form of heat; just the opposite, it produces heat.*

Most of the alternative concepts in the above list were observed in the responses given in the pretest. Some of the alternative concepts were found in both the pretest and in the posttest. Some of the items on the list (with the asterisk) appeared in the responses in the posttest. One of the reasons these appeared later on may have been that in general, the items that had been left blank on the pretest were answered in the posttest. Also, both groups provided similar alternative concepts and misconceptions but there were more alternative concepts and misconceptions in the control group on both the pretest and the posttest.

Discussion

In the implementation of the study, the effects of two different teaching methods (Case-Based Learning and Traditional Instruction) used for the topic of "Energy" in the 9th grade school curriculum were examined in terms of the change in the students' conceptual understanding after the instruction. The pretests implemented (ECT) showed that conceptual understanding in both groups was very similar. The results of the posttests (ECT) showed that the full comprehension percentages of the study group (CBG) were higher than the control group (TIG) in 13 out of 16 items. The results of the posttests (ECT) demonstrated that there was a decrease in alternative concepts in both groups. It may said that after the implementation, the Case-based Learning method resulted in more positive results in more items than the Traditional Instruction method in terms of the students' conceptual understanding. We may thus reach the conclusion that there was more of an increase in the conceptual understanding of the study group. Also, from the responses given in both the pretest and the posttest, it can be seen that there were more alternative concepts and misconceptions in the control group.

The finding that the change in conceptual understanding is more pronounced in the CBL method compared to the traditional instruction method is supported by many previous studies (e.g., Aydoğan, Güneş & Gülçiçek, 2003; Ayyıldız & Tarhan, 2013; Bilgin & Geban, 2001; Çam, 2009; Özkan & Azar, 2005; Ünal Sümen, 2013). To reduce or eliminate student misconceptions in Science/Physics education and ensure a positive change in terms of their conceptual understanding, alternative teaching approaches must be embraced in place of traditional instruction methods.

Conclusion

When the results of the study were examined as to the conceptual understanding attained in the two groups, it was found that a clearly visible change took place in the Case-Based Group. At the same time, no significant difference was revealed between the two groups' general conceptual achievement scores. The conclusions derived from this study are limited to the topics in the unit on Energy and to a defined period of 6 weeks. In the light of the findings of this study, the following recommendations may be made: The CBL method may be tried in different levels of education, different classes, different schools and different topics in physics to explore its effect on the same variables. The study may be repeated for a longer period of time on different groups. Similar to the present study, a comparison may be made of the CBL method and other alternative teaching methods (conceptual change-based teaching methods, life-based teaching methods). When it is considered that all events can be explained with the laws of physics, it may be said that the Case-Based Learning method occupies an important place in physics education. We may say that all events experienced in daily life are each a case story. It is therefore recommended that educators make use of the Case-Based Learning method to help students make associations between daily real-life situations and physics topics and develop an awareness in this context.

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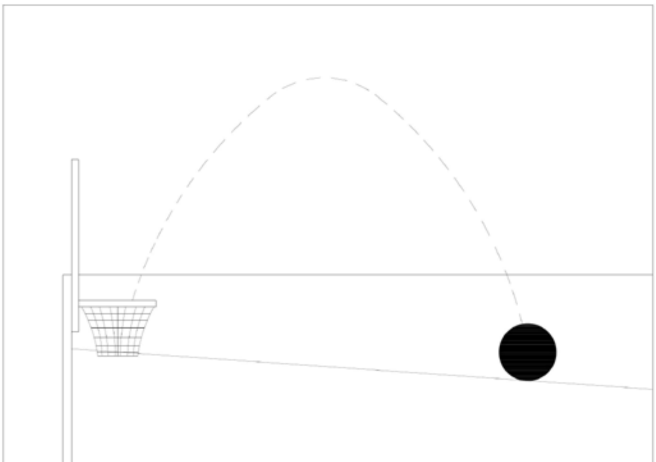
Appendix

Appendix A: An example of the test item on the two-tier test contained in the ECT

A basketball player aims the ball at the basket and gets it through the ring. Based on the figure, which of the following can be said about the potential energy and the total mechanical energy of the ball as it moves from the point it has been thrown toward the basket? (Air friction is not to be considered)



	Potential energy	Mechanical Energy
A)	First diminished, then increased	Didn't change
B)	First increased, then diminished	Didn't change
C)	Didn't change	Didn't change
D)	First diminished, then increased	Diminished
E)	First increased, then diminished	Increased

Please explain the reason for your answer.

………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
……………………………………………………………

Appendix B: "Case Story Worksheet" Sample

BEFORE THE EXAM

The physics teacher who stood on ground floor took the bag which stood on the ground and walked to the elevator. The class which he was going to make an exam was on the third floor. He got on the elevator and arrived at the third floor. The teacher came into the class with his bag. Students were watching the bag because the exam questions were in it. The teacher went next to the table with his bag without moving his arm and put the bag on the table by lifting it. Then he greeted his students and " desks are too close to each other could you please come to the front'' he said, by showing the students front rows. Elif and Fatma pushed their desks to the front, came closer immediately, when the other students on the front were coming closer to the front, the students who sat behind " teacher , we are pushing our desks but we are not able to move on'' they said. The teacher replied '' you don't have to come to the front.'' The teacher started the exam after a part of students left their bags and books on the floor which stood on their desks, and wished good luck.

1. In which of the cases mentioned above is there expenditure of energy?

   ………………………………………………………………………………
   ………………………………………………………………………………

……………………………………………………………

2. In which of the cases mentioned above work has been done in the physical meaning? Please explain.

………………………………………………………………………………
………………………………………………………………………………
……………………………………………………………

3. In which of the cases mentioned above work has not been done in the physical meaning? Please explain.

………………………………………………………………………………
………………………………………………………………………………
……………………………………………………………

4. To do work in the physical meaning;
   1. ……………. must be applied to an object,
   2. This object must …………………

5. Is there a relationship between the work and energy? Please explain.

………………………………………………………………………………
……………………………………………………………………………...
…….…………………………………………………………