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CONCEPT CARTOON SAMPLES INTEGRATED INTO PROBLEM BASED LEARNING IN A SCIENCE COURSE[1]

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ABSTRACT

This study aimed to present a module related to the use of concept cartoons integrated into problem-based learning (PBL) method in science lessons. As part of the study, concept cartoons were developed based on scenarios dealing with daily life situations. A module was designed using these concept cartoons. The module focused on the topic "heat insulation" under the unit "matter and heat" in the 6th grade science curriculum and was implemented in 9 different classrooms at 9 different schools. Semi-structured interview technique was used to learn the students' (n=27) views about the module. The students explained that they learned the subject of heat insulation in a meaningful way, remembered their previous knowledge through the activities, could associate the science topics with daily life more easily, and that their interest in the lesson increased.
Keywords: science courses, problem-based learning, concept cartoons, heat insulation.

FEN DERSİNDE PROBLEME DAYALI ÖĞRENME YÖNTEMİ İÇERİSİNDE KAVRAM KARİKATÜRÜ KULLANIM ÖRNEKLERİ

ÖZ

Bu çalışmada, fen derslerinde probleme dayalı öğrenme (PDÖ) yöntemi içerisinde kavram karikatürü etkinliklerinin kullanımına ilişkin bir modül ile etkinlik örneklerinin sunulması ve modülün nasıl uygulandığının paylaşılması amaçlamıştır. Bu amaçla, ortaokul 6. sınıf "Madde ve Isı" ünitesi "Isı Yalıtımı" konusuna ilişkin PDÖ yöntemi senaryolarına ve senaryolardaki olaylara ilişkin kavram karikatürü kullanım örneklerine yer verilmiştir. Hazırlanan modül 9 farklı ortaokulda 9 farklı sınıfta öğrenim gören öğrencilere uygulanmıştır. Uygulamaya katılan 27 öğrenciyle kavram karikatürü destekli PDÖ'ye ilişkin yarı yapılandırılmış görüşmeler yapılmıştır. Görüşme verilerinin analizi sonucunda öğrencilerin, ısı yalıtımı konusunu anlamlı şekilde öğrendiklerini, çalışmadaki etkinlikler sayesinde önceki bilgilerini hatırladıklarını, bilgiyi günlük yaşamla daha kolay ilişkilendirebildiklerini ve derse yönelik ilgilerinin olumlu yönde geliştiğini düşündükleri tespit edilmiştir.
Anahtar kelimeler: fen dersi, probleme dayalı öğrenme, kavram karikatürü, ısı yalıtımı.

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INTRODUCTION

Rapid developments in information, communication, and technology have caused a change in the vision of science education. This new vision aims to educate students as science literate individuals with social and higher order thinking skills such as creativity, inquiry, and collaboration. Aligned with this goal and vision, pedagogical approaches that allow students to take ownership during the learning process have been used in science education. Several research studies have examined the effectiveness of student-centered pedagogical approaches such as cooperative learning, problem-based learning, inquiry-based learning, argumentation-based learning, and techniques such as concept cartoons, concept maps, and mental maps (Arts et al., 2002; Kaçar, 2019; Ormancı, 2018; Özdemir & Eryılmaz, 2019; Saputra et al., 2019; Varlı & Uluçınar-Sağır, 2019; Yaman, 2019). One of these methods, problem-based learning, is the focus of this paper. Problem-based learning (PBL) is a strategy that allows students to participate in the learning process actively and to take their own responsibilities.

Problem-Based Learning

PBL engages students in investigating a meaningful problem, identifying the known information and the constraints of the problem, searching for solution methods, and reflecting on the solution strategies (Arts et al., 2002; Berkel & Schmidt, 2000). Students usually work in small groups to solve real life related problems collaboratively. During the learning process, students are firstly presented half-established problems from real life. They examine the problem by considering its context and identify the knowledge necessary to solve the problem. Next, they conduct research to expand their knowledge and try to find solution methods. In the last stage, students share their solutions with the other students and receive their feedback (Chung & Chow, 2004). Students present their solution methods drawing on their present knowledge, experiences, and research on the problem. During the PBL lessons, the teacher acts as a facilitator, makes students' thinking visible, and poses questions to solicit reflections (Barron & Darling-Hammond, 2008).

The PBL process promotes critical thinking, reflection, and experimentation. In the 21st century, students need higher order thinking skills, self-regulated learning habits, and problem-solving abilities (Barron & Darling-Hammond, 2008; Malmia et al., 2019; Savery, 2006). The PBL method can offer students opportunities to develop these 21st century skills as well as help them enhance their conceptual learning and social skills such as working collaboratively with other students (Hmelo, 1998; Herron & Major, 2004; Fidan & Tuncel, 2019).

PBL lessons can be enriched by integrating different instructional techniques into the lesson design to make the content more meaningful and interesting for secondary school students (Atan et al., 2005; Kaçar, 2012). It is believed that supporting PBL through the use of other teaching techniques will be useful for increasing students' interest as well as identifying and overcoming their misconceptions. Accordingly, this study integrated concept cartoons into PBL method in a series of science lessons.

Concept Cartoons

Concept cartoons are visual materials composed of cartoon characters discussing real life issues by offering different perspectives and are frequently used in science education (Coll et al., 2005; Keogh & Naylor, 2000; Yilmaz, 2020). Özyılmaz-Akamca et al. (2009) considered concept cartoons as drawings where misconceptions or thinking ways of students are discussed by human or animal figures. In concept cartoons, the questions or opinions of three or more characters related to a daily event are presented. Since cartoon characters are in equal status related to their points of view, students are encouraged to reveal their current conceptions of the related science topics (Allen, 2006; Özdemir & Eryılmaz, 2019; Woolman, 2019). When concept cartoons are used in a class environment, the cartoon characters put forward their alternative points of view related to a scientific situation and then the students are invited to get involved in the discussion with the cartoon characters (Akbaş & Kılıç, 2019; Keogh & Naylor, 2000). Concept cartoons encourage students to defend their arguments with evidence as they participate in the class discussion. They can

also reveal and deal with misconceptions about the science concepts (Özyılmaz-Akamca et al., 2009). For these reasons, using concept cartoons in science lessons is a promising instructional strategy to increase students' conceptual understanding.

A related literature review has revealed that there are quite a few studies in which PBL and concept cartoons are used together as supportive of each other (Balım et al., 2016; Jamal et al., 2019). Considering that secondary school students have difficulty in determining the problem in a real life scenario, presenting problems in the context of a concept cartoon might help students better make sense of the problem situations. Accordingly, this study aimed to present a module and effective examples of concept cartoons integrated into the PBL method in science lessons and to examine how they were implemented in the classroom. Within this scope, students' views towards concept cartoon integrated problem-based learning were examined. The module shared in this paper was designed as part of a larger project. Before presenting the module in detail, some background information about the project will be shared.

Contextual Background of the Module

The module that is introduced in this article was developed as part of a project titled "Studying the Effects of Using Concept Cartoons Integrated into PBL Methods in Science and Technology Teaching." The project was supported by The Scientific and Technological Research Council of Turkey (TUBITAK) under the program "Scientific and Technological Research Projects" and was completed between April 2010 and April 2013. The project examined the effects of using concept cartoons integrated into PBL in science lessons on conceptual learning, problem solving, and critical thinking skills of the sixth grade students.

For this purpose, the project team (included the authors of this paper) designed four PBL science modules for the sixth grade students. The modules focused on the "matter and heat" unit and included 16 lesson plans. Two separate booklets containing PBL activities with concept cartoons were developed, one being teacher's guidebook and the other one being students' activity booklet. These booklets were shared with the project teachers who were selected on the bases of being volunteer and teaching three equivalent sixth grade classes. Nine science teachers from nine different schools participated in the project (each teacher had three classes, making 27 classes in total). The teachers participated in project workshops to learn about concept cartoons and PBL and how to use both approaches in the science lessons.

The project employed a quasi-experimental research design with pre-test/post-test control group. The science lessons of the "matter and heat" unit were taught in 27 classes including 553 sixth grade students in Izmir province of Turkey and its districts. Each project teacher taught science lessons in two experimental and one control group for 4 weeks (4 hours in each week). In one of the experimental groups (experimental group 1), concept cartoons integrated into PBL modules were used. In the other experimental group (experimental group 2), the lessons were taught with PBL modules without concept cartoons. In the control group, the teachers used their regular science lessons that included neither PBL nor concept cartoons.

Results of the project showed that there is a significant positive relationship between students' inquiry-based learning skills and problem solving skills (Özcan et al., 2017) and that students' inquiry-based learning skill perception scores are in favor of the experimental groups (Balım et al., 2016). It was also found that there was a significant difference in favor of experimental groups in terms of problem solving skills (Balım et al., 2015). The project team examined the views of the participating teachers and students through semi-structured interviews at the end of the project. Results showed that according to the project teachers, concept cartoons integrated into PBL enhanced students' critical thinking skills, inquiry-based learning skills, and ability to connect science concepts with real life (Balim et al., 2014). Students in the experimental groups expressed the views that they were more willing to participate in the lessons; they had productive discussions; and they had a better grasp of the science concepts taught in the project lessons. The positive findings of the project suggest that sharing its

teaching materials with the science educators may help spread the use of concept cartoons integrated into PBL method in more classrooms and more students can benefit from these lessons.

PLANNING THE MODULE

"Let's prevent heat loss" is one of the modules developed as part of the larger project explained above and will be described in detail in this paper. The module focuses on the topic "heat insulation" within the "matter and heat" unit and consists of three parts to be implemented in 4 lesson hours. The first part takes 2 lesson hours and the other parts take 1 hour each. At the time of planning this module, 2005 science and technology curriculum was in effect in Turkey. Therefore, the module was designed based on the content standards included in the 2005 curriculum. Table 1 presents a comparison of the content standards that the module was based on to the content standards of the current 2018 science curriculum (Ministry of National Education [MoNE], 2005, 2018).

Each part of the module was planned targeting certain content standards. The first part of the module was planned towards the standards 3.1 and 3.2; the second part was planned towards the standards 3.1, 3.2, and 3.3; and finally the third part was planned towards the standards 3.3, 3.4, and 3.5 (see Table 1).

As part of planning the module, real life scenarios were developed by the project team to create the concept cartoons. The scenarios were selected considering the science units of the module and also the students' age group, interests, and experiences. In order to help students comprehend the heat insulation concepts, scenarios dealing with daily life problems were selected and the concept cartoons were developed based on these scenarios. In these concept cartoons, three characters (Ceyda, Nilay, and Buse) discuss a daily life problem. During this discussion, the characters do not ask questions to each other. Instead, they make suggestions about what the solution to the problem in the scenario could be. In other words, the possible solutions to the problem discussed in the scenario are hidden in the speech balloons of the characters in the concept cartoons.

Table 1. Comparison of the Content Standards of the 2005 and 2018 Science Curricula

2005	**2018**
3.1. Predicts when insulation is required and gives examples for when conduction is preferred to insulation.	F.6.4.3.1. Categorizes matter by means of heat conduction.
3.3. Gives examples for common heat conduction materials; suggests materials by considering insulation materials' thermal properties and lifespan.	F.6.4.3.2. Defines the selection criteria for heat insulation materials used in buildings. F.6.4.3.3. Develops alternative heat insulation materials.
3.4. Examines what else should be taken into account besides the insulating properties in the selection of heat insulation materials used for different purposes.	F.6.4.3.4. Discusses the importance of heat insulation in buildings in terms of family and nation economy and effective use of resources.
3.2 Give examples of conditions where conductivity is preferred rather than insulation.	
3.5. Explains the relationship between insulation and energy consumption in buildings.	

The module was developed to be implemented by using a PBL method with concept cartoons. During the lessons, students work in small groups of 3-5 members. They first read the scenario presented in the concept cartoon. After understanding the situation presented in the concept cartoon, they identify the problem hidden in the scenario. As students explore the problem, they recall their prior knowledge related to the problem and identify their future learning needs to solve the problem. This process leads them to conduct research about the science content. Then, the students begin to generate possible solutions to the problem presented in the concept cartoon. Afterwards, they explain their views in relation to the solution together with rationales. Through all these processes, students build new knowledge about the science topics included in the "heat insulation" section and develop their discussion skills by generating well-reasoned arguments.

The module titled “Let’s prevent heat loss” was taught by the project teachers. The teaching approach used by the teachers was similar to each other since they all participated in the project workshops and worked with the project team closely during the implementation process. In the following section, a typical implementation session will be described. The authors observed the module lessons in different classrooms and took field notes. The implementation process will be explained in detail to give the reader a clear picture about the learning environment created by the module. The worksheets of the module are given in Appendix 1.

In this study, semi-structured interview technique was used in order to learn the students’ views about the module. Interviews were conducted at the end of the project with 27 students. Randomly selected three students from each of the experimental group 1 were interviewed to understand their opinions about the module. Specifically, the students were asked to compare the project lessons with their prior lessons and to explain how the module lessons influenced their learning. All necessary legal permissions were obtained prior to data collection.

IMPLEMENTING THE MODULE

The First Session

The students are introduced to the first scenario given in Figure 1. Students read the scenario and discuss what it is about.

> *One evening, Ceyda, Nilay, and Buse meet for their friend Sıla’s birthday. They prepare delicious meals, desserts, and ice-cream, and they begin to wait for Sıla to come. Suddenly, the lights turn off and they panic. Sıla is supposed to come an hour later. Ceyda says to Nilay and Buse, “Oh my God! This is an electric oven, and the meals will get cold until the power is back on”. The three friends begin to argue about what to do for keeping the meals warm/hot.*

Figure 1. The First Scenario

The teacher asks “What is/are the problem(s) in this scenario?” Students share their ideas. With the guidance of the teacher, the class agrees to answer the following two problems “What can be done to keep the meals hot? (Problem 1)” “What might be the reason for the meals to get colder? (Problem 2)” Next, the students are encouraged to identify what knowledge they need to solve the problem. The students are asked "What knowledge do we need to solve the problem of Ceyda and her friends?" The students may respond with the following ideas: "Where and how the materials of insulation can be used", “What the materials of insulation are”, and “What insulation is.” At this stage of the lesson, the students are expected to think about and discuss which heat insulation materials can be used in order to solve the problem in the scenario and how heat can be preserved as a group.

In PBL, it is important for students to build new knowledge on their prior knowledge through internal connections. To help students make this connection, the teacher asks "What do we know about the heat insulation?" Some expected answers for this question could be "Heat is a type of energy.", “The heated particles move faster.”, “There is a heat exchange between hot and cold substances.”, “There are temperature changes during heating and cooling processes.” and “Matter is composed of particles.” At this stage, the teacher reminds that they need to find a solution to the initial problem of preserving heat. And, they need more knowledge on heat insulation. The students are guided to do some research on the topic. They read related text and exchange ideas with each other. As students conduct research on the topic, they propose solution methods for the initial problems. Each group proposes solutions with supporting details. Then, they present their solutions to the whole class. Figure 2 and 3 show example solutions that might be expected from the students.

> *What can Ceyda and her friends do to keep the meals hot?*
> *In order to prevent the meals get colder, materials which have heat insulation features can be used. Due to these materials, the heat transfer decreases. Therefore, the meals still lose heat but heat loss occurs in a longer period.*

Figure 2. A Solution to the Problem 1

What might be the reason for the meals to get colder?

The materials whose temperatures are different exchange heat until their temperatures are equal to each other. Heat exchange between the substances is always from the hotter one to the colder one. Hot meals give off heat to the atmosphere because they are hotter than the atmosphere. This process continues until the temperature of the meal is equal to that of the atmosphere they are in. For this reason, hot meals become colder by losing heat.

Figure 3. A Solution to the Problem 2

As a follow up activity, the concept cartoon in Figure 4 is shown to the students. A larger version of the concept cartoons is given in Appendix 1. Student groups are asked to decide which character's argument is scientifically more valid and provide a justification for their choice.

Figure 4. Concept Cartoon 1

Each group shares their answers with the whole class. Then, the students complete the Activity 1 in order to reach a conclusion for the concept cartoon 1.

Activity 1: Let's Keep the Heat!

The following materials are needed for this activity: metal container, glass container, porcelain pot, thermometer, and heater. The instructor gives the groups a metal bowl, a glass bowl, a porcelain bowl, and boiled hot water (students are warned about the temperature of the water). The students are asked to clean the pots with hot water by rinsing them, to add equal amounts of hot water to the pots, to measure the temperature of the hot water in the pots with a thermometer, and to record the temperatures in their notebooks. Students are asked to make predictions about how the water temperatures in the containers will change after 10 minutes and compare their predictions with the measurement results.

With the experience and knowledge gained from completing the activity 1, the students discuss about the concept cartoon 1 again. A possible explanation about which character's argument is valid is as follows:

> We think that Nilay's answer makes more sense because the containers made of earthenware such as porcelain can be good heat insulators. The distance between the particles of materials which are heat insulators is longer than the distance between the particles of materials which are heat conductors. For this reason, these materials slow down the heat flow. As a result, hot dishes such as soup which is put in earthware pots gets colder in a longer period of time.

The Second Session

The second part of the module starts in the third lesson. In this part, the scenario in Figure 5 is given to students.

Ceyda, Nilay, and Buse take the necessary precautions to keep the meals warm. Sıla, on the other hand, calls her friends and says that she will be late for an hour because of the traffic. There is still power outage. Buse checks the ice cream boxes in the fridge and sees that they begin to melt. Buse says to Nilay and Ceyda "Oh my God! Ice cream will melt until the power is back!" Three friends begin to argue about what to do to prevent the ice cream from melting.

Figure 5. The Second Scenario

Similar to the first session, the class discusses about the problem in this scenario. Students are expected to define the problem in the scenario as "What can be done to prevent the ice cream from melting? (Problem 3)" After this stage, the lesson continues same as in session 1. Students discuss the questions given in part 2 of the module with their group mates (See

Appendix 1). For the question "What knowledge do we need to solve this problem?", the students may give the following answer: "We can solve the problem by researching what kinds of materials are used for heat insulation." Regarding the question "What do we know?" expected answers may include "We know that heat is a type of energy.", "There is a heat exchange between substances whose temperatures are different.", "Heat insulation materials slow down the heat flow between the substances whose temperatures are different." A solution for the initial problem in this session is given in Figure 6.

What can be done to prevent the ice cream from melting?

Insulation materials decrease heat loss by slowing down the heat flow from inside to outside or from outside to inside of the surface it covers. Therefore, the temperature of ice cream is preserved much better.

Figure 6. A Solution to the Problem 3

As a follow up task, the concept cartoon in Figure 7 is given to students. The groups are asked to decide which character's argument is scientifically more valid and provide a justification for their choice.

Figure 7. Concept Cartoon 2

Students are expected to discuss about the concept cartoon and provide a well-thought-out explanation for whose idea they agree with. They complete the Activity 2 in order to reach a conclusion for the concept cartoon 2.

Activity 2: Racing Ice Cubes

The following materials are needed for this activity: ice cubes, wool fabric, cotton fabric, nylon, and beaker. The teacher distributes three 50 ml beakers to each group, puts ice cube in each beaker, and asks students to wrap one beaker with wool fabric, one beaker with cotton fabric, and one beaker with nylon. The groups should wait and observe the melting ice cubes. In the mean time, the teacher asks students to make predictions about what will happen to ice cubes, which ice cubes will melt faster and which ice cubes will melt slowly. Then, the students unwrap the wool fabric, cotton fabric, and nylon, inspect the ice cubes, compare their observations with the predictions, and write down their thoughts in the notebooks.

At the end of activity 2, students turn back to the concept cartoon 2 and finalize their conclusion. A possible explanation can be as follows:

> We think that Buse's suggestion is more meaningful. The reason is that the temperature of the ice cream box covered by a woolen jacket is different from the temperature of the weather outside. The temperature of the weather is a little higher than the ice cream box covered by the jacket. So, there will be a heat exchange between the substances which have different temperatures. Heat exchange occurs from the hot substance to the cold one. As a result, the ice cream can remain for long without melting because heat flow into the ice cream which is well insulated from outside will be lower.

The Third Session

So far, the students have learned that heat insulation helps preserving the current heat. They will apply this knowledge to a new situation in the third session. It takes 1 lesson hour to complete this part of the module. The lesson starts with discussing the scenario in Figure 8.

The students might suggest the following questions as the problems that arise from this scenario: "What types of thermal insulation materials are used in houses?", "What are the benefits of heat insulation? (Problem 4)" For the question "What knowledge do we need to solve this problem?" the students may give the following answers: "Common thermal insulation materials", "How heat insulation is done in buildings", "Where the insulation

materials are used in buildings", and "We can investigate the benefits of heat insulation."

Ceyda and her friends preserved the food and ice cream until the power is back on. 15 minutes after the electricity is back on, Sıla arrived at the house. Meals, ice creams, and birthday cakes were eaten with pleasure. The four friends were engaged in a long conversation. Ceyda told her friends that she should prepare her house for winter by insulating. They started a conversation about the benefits of insulating the house.

Figure 8. The Third Scenario

Regarding the question "What do we know?" the students shared their knowledge about double glazing on the windows of the houses, wood window frames, sponge used under the doors and windowsills, glass wool on roofs, and styrofoam inside the walls. A solution for the initial problem in this session is given in Figure 9.

What are the benefits of heat insulation?

It prevents heat loss in winter and heat flow from outside to inside in summer. Heat insulation reduces energy consumption.

Figure 9. A Solution to the Problem 4

Similar to the first two sessions, a concept cartoon is shown to the students and they are asked to decide which character they agree with. The concept cartoon is given in Figure 10.

Figure 10. Concept Cartoon 3

Students discuss in their groups, decide with whom they agree, and suggest a justification for their decision. In this process, students conduct research about the topic. A sample justification could be as follows:

> We agree with Sıla because heat insulation in buildings prevents heat flow between the air inside the house and the air outside. Since the heat loss is not much in the winter months, heaters will be used less to heat the house, so energy consumption will reduce. Similarly, in the summer months, since the heat flow from outside to inside decreases, the air conditioners will work less and energy consumption will again reduce. Heat insulation also has a relationship with global warming. Since less energy will be spent with heat insulation, energy consumption will decrease. Power plants emit significant carbon dioxide gas into the atmosphere while generating energy. Heat rays reflected from the earth to the atmosphere are held by greenhouse gases such as carbon dioxide and cause the earth's temperature to rise.

With session 3, all parts in the module are completed. At the end of the module, students are asked to assess their own learning as well as their peers' learning throughout the module lessons using the "Self assessment form" and "Peer assessment from" given in Appendix 2.

FINDINGS

In this part, the students' views about the concept cartoons integrated into PBL are presented. During the interview, three open-ended questions were asked to the students. When the answers to the first question "How would you compare the Matter and Heat unit lessons to the lessons of previous science units?" were examined, it was found that the students identified important differences between the two types of lessons. Students expressed this difference with sentences such as "Of course it was different, because we were engaged in activities with the module lessons. In the previous lessons, we were mainly taking notes in our notebooks." and "There were concept cartoons. In previous lessons, there were some experiments in the textbook, we were doing them."

The second question was "What do you think about the tasks in the Matter and Heat unit?" Students' responses included "Very good,

concept cartoons were very interesting. There were interesting characters.", "Studying with concept cartoons was a pleasure, help me to remember what I have learned.", "Sometimes I felt confused, but it was good to find out what the problem was, we discussed what we have learned and it was also fun.", and "The issues were similar to we face in our daily life. It was about the solution of problems. That is why it helped us in our daily life. It was fun to read the scenarios and investigate the problems that we may experience in our daily lives."

The third question was "Do you think that the lessons of the Matter and Heat unit had an effect on your learning?" Typical student answers included comments such as "The lessons helped me remember the topics we had learned before. I could recall my prior knowledge, learned even more, and developed knowledge by doing experiments.", "…informed us about our daily lives, too, because in scenarios there were problems that we might face in our daily lives. We learned how we can solve these problems, and which knowledge we can seek to solve them." Analysis of students' answers to the interview questions indicates that concept cartoons integrated into PBL approach might have promoted students' motivation and meaningful learning. Students thought that they built new knowledge on their prior knowledge, related the science concepts with real life, and learned the concepts meaningfully.

CONCLUSION and SUGGESTIONS

Science curriculum aims to educate science literate individuals who are able to think analytically, solve problems, make effective decisions, and work collaboratively (MoNE, 2018). Accordingly, teaching methods should engage students in problem solving, conducting research, and collaborative work. Concept cartoons integrated into PBL method is an example of such teaching methods as evidenced in the lessons described in this paper. The current implementation of the PBL method used daily life situations to increase students' motivation and to promote conceptual learning of the science concepts. The observations of the lessons by the authors and the participating students' opinions on the unit suggest that the module "Let's prevent heat loss" was implemented successfully. The module lessons encouraged students to participate in the tasks actively, connect science concepts with real life, develop conceptual understanding, propose scientific arguments, and work collaboratively with their groupmates.

The findings of this study corroborate previous research findings. For example, Inel and Balım (2013) found that science lessons involving concept cartoons integrated into PBL encourage students to learn meaningfully while enjoying and help them to participate in the lessons actively. In addition, the related literature suggests that PBL approach develops students' individual and group work skills, helps them to learn conducting research, and promote meaningful learning (Barron & Darling-Hammond, 2008; Herron & Major, 2004; Hsieh & Knight, 2008). Similarly, concept cartoons encourage students to propose and defend arguments, make logical predictions, and improve critical thinking skills (Birişçi et al., 2010; Cengizhan, 2011). Parallel to the previous research, the current study in which both PBL and concept cartoons are used together may increase students' motivation and interest towards science, promote meaningful and long-term learning, and help relating science knowledge with daily life.

In conclusion, we suggest that integrating concept cartoons into PBL method is an effective teaching approach in science lessons. This method could be used in other disciplines or in other science units. Future endeavors in this area might focus on preparing books that include sample concept cartoons or designing websites that illustrate the application of this teaching method in classroom.

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Appendix 1

"Let's Prevent Heat Loss" Module Worksheets

The First Session

Scenario: *One evening, Ceyda, Nilay, and Buse meet for their friend Sıla's birthday. They prepare delicious meals, desserts, and ice-cream, and they begin to wait for Sıla to come. Suddenly, the lights turn off and they panic. Sıla is supposed to come an hour later. Ceyda says to Nilay and Buse, "Oh my God! This is an electric oven, and the meals will get cold until the power is back on". The three friends begin to argue about what to do for keeping the meals warm/hot.*

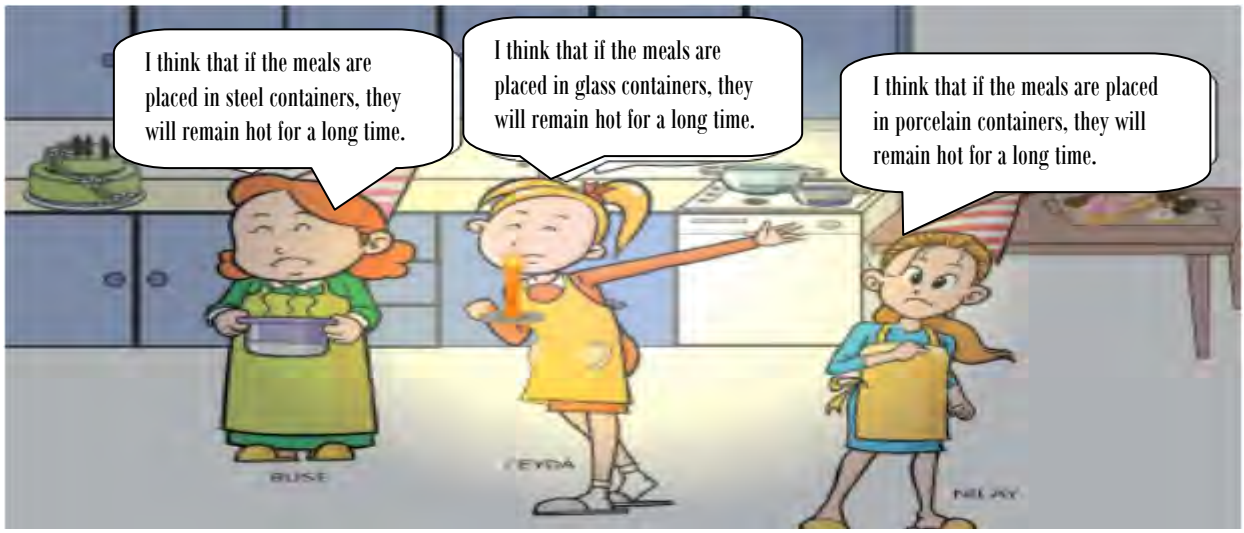
1. What is/are the problem(s) in the scenario?

2. What knowledge do we need to solve the problem of Ceyda and her friends?

3. What do we know?

4. What can be done to keep the meals hot?

5. What is the solution to the initial problem? Explain.



Which character's argument is scientifically more valid? Put an (x) into the box of the person you agree with. Provide a justification for your choice in the space below.

Buse ( ) *Ceyda ( )* *Nilay ( )*

The Second Session

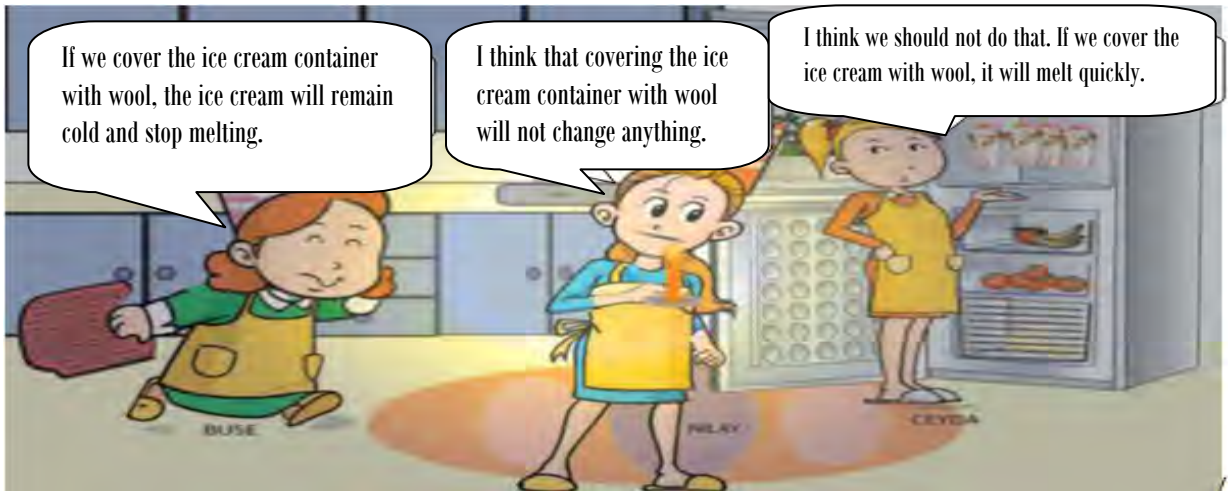
Scenario: *Ceyda, Nilay, and Buse take the necessary precautions to keep the meals warm. Sıla, on the other hand, calls her friends and says that she will be late for an hour because of the traffic. There is still power outage. Buse checks the ice cream boxes in the fridge and sees that they begin to melt. Buse says to Nilay and Ceyda "Oh my God! Ice cream will melt until the power is back!" Three friends begin to argue about what to do to prevent the ice cream from melting.*

1. What is/are the problem(s) in the scenario?

2. What knowledge do we need to solve the problem of Ceyda and her friends?

3. What do we know?

4. What is your answer to the problem in the scenario? Explain.



Which character's argument is scientifically more valid? Put an (x) into the box of the person you agree with. Provide a justification for your choice in the space below.

Buse ( ) *Nilay ( )* *Ceyda ( )*

The Third Session

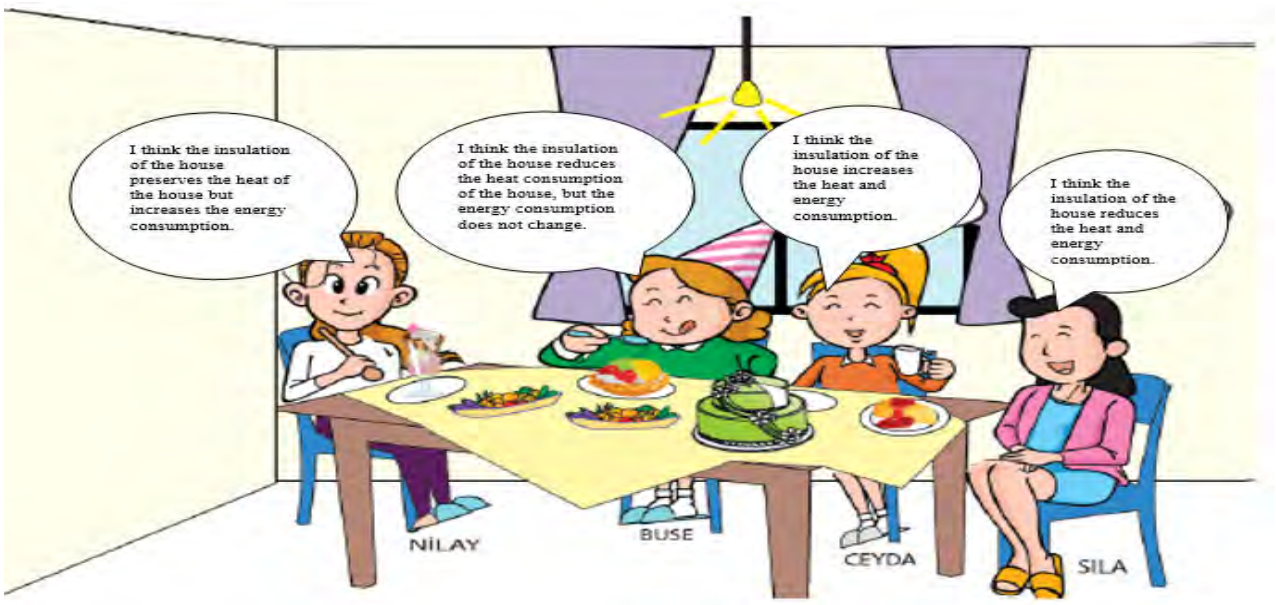
Scenario: *Ceyda and her friends preserved the food and ice cream until the power is back on. 15 minutes after the electricity is back on, Sıla arrived at the house. Meals, ice creams, and birthday cakes were eaten with pleasure. The four friends were engaged in a long conversation. Ceyda told her friends that she should prepare her house for winter by insulating. They started a conversation about the benefits of insulating the house.*

1.What are the problems that need to be addressed in the scenario?

2.What information can we investigate to solve the problem(s)?

3.What Do We Know?

4. What is your answer to the problem in the scenario? Explain.



Which character's argument is scientifically more valid? Put an (x) into the box of the person you agree with. Provide a justification for your choice in the space below.

Nilay ( ) *Buse ( )* *Ceyda ( )* *Sıla ( )*

Appendix 2

Assessment Forms

Self-Assessment Form

Name and surname : ……
Class : ……
No: ……

This form has been prepared for self-assessment. Tick the option that best reflects your work (X).

SKILLS	**DEGREES**		
	Always	**Sometimes**	**Never**
I read the scripts carefully. I have identified the problem or problems that need to be addressed in the scenarios.			
I expressed what I know to solve the problem in the scenarios.			
I followed the instructions on the module. I encouraged my friends without hurting them.			
I supported my groupmates in their work.			
I asked questions when I didn't understand.			
I used my time wisely during my studies.			
I used different sources during my work.			

What did I learn from this module?
……
……
……
……

How did I help my friends in my group during this module?
……
……
……
……

Things I did during this module (what I could do, what I couldn't do, had difficulties, etc.):
……
……
……
……

COMMENTS :
……
……
……
……
……
……

Peer Assessment Form

Group number: ……
Name and surname : ……
Class : ……

	1. Your friend's name and surname:			**2. Your friend's name and surname:**			**3. Your friend's name and surname:**			**4. Your friend's name and surname:**			**5. Your friend's name and surname:**		
	Always	**Sometimes**	**Never**	**Always**	**Sometimes**	**Never**	**Always**	**Sometimes**	**Never**	**Always**	**Sometimes**	**Never**	**Always**	**Sometimes**	**Never**
S/he is voluntary to participate in the activities in the sessions.	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)
Fulfills his/her duty on time.	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)
Identifies the problem or problems that need to be addressed in the scenarios.	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)
Expresses what s/he knows for solving the problem in the scenarios.	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)
Follows the instructions in the module.	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)
Collects information from different sources.	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)
Respects the opinions of her/his groupmates.	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)
Uses positive language while disagreeing with her/his friends.	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)
Shares her/his thoughts with group members.	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)
Participates in the division of labor within the group.	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)
Fulfills her/his responsibilities.	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)	(3)	(2)	(1)