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AN ACTIVITY BASED ON PREDICTION-OBSERVATION-EXPLANATION STRATEGY USED FOR TEACHING THE PARTICULATE NATURE OF MATTER

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ABSTRACT

This study aims to determine the effects of activities based on the Prediction-Observation-Explanation [POE] strategy on sixth grade students' understanding of the particulate nature of matter. The study was carried out with a sixth grade group consisting of 41 students from a middle school in an eastern city. Three activities were carried out based on the POE strategy for teaching the particulate nature of matter: Movement of the Syringe, What Happened to Iodine? What Happened to Sugar Cube? While the students initially gave answers that were not related to the particulate nature of matter and were far from being scientific, after participating in the activities using the POE strategy, the answers of the students were at a scientifically acceptable level. The results of the study indicate that different activities based on the POE strategy may be useful in teaching abstract subjects such as the particulate nature of matter.

Keywords: particulate nature of matter, poe strategy, middle school students, science education.

MADDENİN TANECİKLİ YAPISININ ÖĞRETİMİ İÇİN KULLANILAN TAHMİN-GÖZLEM-AÇIKLAMA STRATEJİSİNE DAYALI BİR ETKİNLİK

ÖZ

Bu çalışmanın amacı Tahmin-Gözlem-Açıklama [TGA] stratejisine dayalı etkinliklerin altıncı sınıf öğrencilerinin maddenin tanecikli yapısını anlamaları üzerine etkisini ortaya koymaktır. Çalışma bir doğu ili şehir merkezi ortaokulunda yer alan 41 öğrenciden oluşan bir altıncı sınıf ile yapılmıştır. Çalışma kapsamında maddenin tanecikli yapısının anlaşılması için TGA stratejisine dayalı olarak üç etkinlik yapılmıştır. Bu etkinlikler; Şırınganın Hareketi, İyoda Ne Oldu?, Küp Şekere Ne Oldu? etkinlikleridir. Bu etkinliklerde TGA stratejisinin başında, öğrenciler tanecikli yapıyla ilişkili olmayan ve bilimsellikten uzak cevaplar verirken, TGA stratejisiyle işlenen dersin tamamlanması sonrasında öğrenci cevaplarının bilimsel olarak kabul edilebilecek düzeye yükseldiği tespit edilmiştir. Çalışma sonucunda maddenin tanecikli yapısı gibi soyut bir konunun öğretiminde TGA stratejisine dayalı olarak farklı etkinliklerin yapılmasının faydalı olabileceği ifade edilmiştir.

Anahtar kelimeler: maddenin tanecikli yapısı, tga stratejisi, ortaokul öğrencileri, fen bilgisi eğitimi.

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INTRODUCTION

Students' embracement of science culture which is essential at every stage of life is directly proportional to the effectiveness of the teaching of the concepts in science lessons (Yağbasan & Gülçiçek, 2003). Learning the concepts correctly and establishing hierarchical relationships among the concepts that have been learned in a proper way also lead to a reliable knowledge structure (Canpolat & Pınarbaşı, 2012). It is very important that the basic science concepts are fully and correctly taught in the primary and secondary education processes for an adequate science education (Bayram, Sökmen, & Savcı, 1997).

Science education in Turkey begins from the third grade of the elementary schools. According to the science curriculum which was updated by the Ministry of National Education [MoNE] in 2018, one of the units in the curriculum of the third grade science class in primary school is "Let's Learn Matters'' unit. Within the scope of this unit, students are expected to explain the features which characterize matters with their sensory organs and to classify the matters which they see in their surroundings according to the states of the matters. Therefore, this unit aims to provide students with basic information about the nature of the matter. On the other hand, in the fourth grade of primary schools and in the fifth grade of middle schools, the students are prepared for learning the concept of "particulate nature of matter'' without using its title in accordance with the unit and learning outcomes related to the structure of matter. Therefore, students indirectly encounter with the concept of particulate nature of matter from the third year onwards in primary schools.

It is known that the concept of particulate nature of matter (Özmen, Ayas, & Coştu, 2002), which is one of the most basic concepts of science and chemistry, forms the basis for teaching many other concepts (Ayas, 2002). This shows the significance of the concept of "particulate nature of matter." According to the curriculum of the science course which is being implemented in this academic year, one of the learning outcomes regarding the particulate nature of matter in the sixth grade is "Students comprehend that the matters have particulate, hollow, and moving structure." Therefore, students first meet the concept of particulate structure of matter in the sixth grade of middle school when this learning outcome is taken into consideration. For this reason, it is very important for the students to understand this concept correctly and precisely in a scientific sense.

When the relevant literature is reviewed, it could be stated that the concept of particulate nature of matter is the most important and fundamental theme of science both in international science curricula and national secondary school chemistry curricula (Adadan, 2014). It is simply because the concept of particulate nature of matter is a microscopic and abstract concept which is used to explain many events in everyday life (Kenan & Özmen, 2012). This concept is included in the sixth, seventh, and eighth grade science curriculum, chemistry curriculum of the secondary schools, and higher education science curriculum. Therefore, it is of utmost importance that this concept is taught accurately and precisely in the sixth grade where students encounter with this concept for the first time. However, students may have difficulty in understanding the concept of particulate structure since it is a microscopic and abstract concept (Özmen et al., 2002). In the related literature, it is stated that students of all ages have learning difficulties or misconceptions in understanding and using the scientific model which is expressed as *all matter is made of moving particles between which there are spaces* (Özmen et al., 2002). Therefore, while the subject is taught or discussed, especially starting from the middle school level, the subject should be explained by emphasizing the microscopic dimension rather than the macroscopic dimension (Saydam, 2013).

Many learning theories have been put forward to explain the nature of the learning-teaching process, but constructivist learning theory is the most popular one in recent years (Özmen, 2004). For this reason, strategies that are compatible with the constructivist approach should be preferred in teaching science concepts. According to constructivist theory, the information that the individual receives from his/her environment is structured by associating it with the information that already exists (Hand, Treagust, & Vance, 1997). As students are responsible for their own learning according to this approach, it is appropriate to use student-centered strategies in this approach. A strategy that is used in accordance with the constructivist approach is the Prediction-Observation-Explanation [POE] strategy. This strategy is suitable for science courses because it allows students to structure their knowledge by making a connection with the new knowledge based on their previous knowledge and express it in a meaningful way (Bilen, 2009; Bulunuz & Bulunuz, 2016). The POE strategy is seen as a constructivist-focused learning strategy in order to encourage the conceptual learning of the students (White & Gunstone, 1992). The POE strategy helps students be active in the class and understand the abstract chemistry concepts (Karamustafaoglu & Mamlok-Naaman, 2015). The POE strategy involves a three-step procedure in which students are expected to make a prediction related to a demonstration, an experiment, or a topic that will be presented together with the reasons of this prediction, then observe the phenomenon, and lastly explain the previously made prediction along with the observation together (White & Gunstone, 1992).

This study aimed to enable the sixth grade students, who have encountered with the concept of particulate nature of matter for the first time directly, understand this concept correctly and precisely through using POE strategy. Since the concept of particulate nature of matter is an abstract concept, it is not possible for the students to make an observation directly (Ayas & Özmen, 2002). In order for students to learn the information permanently and in a meaningful way, learning environments in classroom/school and out of school need to be designed in accordance with the research-investigation-based learning strategy (MoNE, 2018). In this study, students are expected to reach the idea of particulate nature of matter on their own with the prediction-observation-explanation phases included in the experiments carried out by students. In this respect, it is believed that this study will be much more effective compared to a lesson taught in a traditional way as this lesson is based on the "learning strategy in which students are responsible for their own learning in general, actively involved in the learning process based on research-investigation and transfer of knowledge" (MoNE, 2018, p. 10). The reason is that when students are asked questions such as "Why?", "How?", "How do we explain this event?" in laboratory studies, they are generally not interested in the questions and try not to take the responsibility for finding answers to these questions (Tekin, 2008). However, since it is necessary for students to make a written prediction and explain the reason of this prediction in an activity based on POE, this strategy requires students to participate in the lesson mentally and actively (Güngör & Özkan, 2017). The effectiveness of the POE strategy which has been applied in this study will also be observed. This study and the results obtained from it will also contribute to the teachers and prospective teachers who work in this field.

ACTIVITY IMPLEMENTATION

“Movement of the Syringe” which is one of the activities to create the idea that the materials have a particulate nature rather than a holistic form, is included in the course book which is taught in this academic year (Gökçe & Işık, 2017), while the other two activities are recommended in the course book which was taught in the previous years (MoNE, 2009). The three activities used in this study are:

1- Movement of the Syringe,
2- What Happened to Iodine?
3- What Happened to Sugar Cube?

These activities were carried out by implementing the Prediction-Observation-Explanation strategy which is used in science education studies as mentioned above.

The study was carried out with 41 sixth grade students attending to a state middle school in an eastern city in Turkey. The necessary permissions for the study were obtained. At the beginning of the lesson, the students were divided into eight separate groups, which would be homogeneous in terms of academic achievement. Experiment equipment and worksheets prepared by the researcher (the teacher and the author) were distributed to each group member.

The steps to be followed in the activities can be described as follows: At the beginning of the lesson, students sit with their group members. Then the lesson materials and the worksheets are distributed by the teacher (Appendix 1). Students are given instructions regarding what to do at "Prediction-Observation and Explanation" phases for "Movement of the Syringe" which is the first activity. After that students begin to work. As part of the activity, students are first asked to make a prediction before the experiment as stated in the worksheet and write the reasons for this prediction. They are then asked to make observations by making the experiment and finally make an explanation by comparing the results obtained from this experiment with their predictions. Students take notes regarding all of these steps on the worksheets. Afterwards, a classroom discussion is carried out with all students. Finally, some conclusions are reached about the experiment with the whole class. After the first experiment, the same stages are followed for the second and third experiments.

Each experiment took 1 lesson hour. When the experiments were conducted, the teacher distributed the necessary materials and worksheets and checked whether the students had written the specified steps. No intervention was made to the students regarding what to observe and conclude at any stage of the POE strategy. Only class discussions were made about the results of the experiments with the students after the explanation stage of the experiment. During these class discussions, the teacher asked open-ended questions to guide the students in explaining their thoughts and making connections about the concept.

The experiments were completed within a total of 3 class hours. Then a worksheet (Appendix 2) was distributed to the students to write the results obtained from these three experiments separately which took another class hour. Therefore, the study was completed in total of 4 lesson hours. Experiments which have been conducted within the scope of this study and the answers given by the students at the POE stages related to these experiments are as follows.

“Movement of the Syringe” Experiment and Obtained Findings

Students were asked the question in Figure 1 related to the movement of syringe experiment during the "prediction" phase. The answers given by the students to this question at this stage and the number of students giving these answers are shown in Table 1 below.

What can you say about the movement of the piston when there is air in the syringes shown above and you push the piston of the syringe putting your finger to the tip of the syringe and then release the piston?

Figure 1. Prediction Question of the “Movement of the Syringe” Experiment

Table 1. Students’ Predictions in the First Experiment

Predictions	**Number of Students**
The piston moves backwards.	22
The piston does not move.	6
Air goes out if we push the piston.	1
The piston moves forward.	1
The piston closes itself.	1
No answer.	10

At the “observation” stage in the first experiment, the students were asked to write their observations that they obtained by making the experiment. The answers given by the students are shown in Table 2.

Table 2. Students’ Observations in the First Experiment

Observations	**Number of Students**
The piston has returned to its original state.	35
No answer related to the movement of the piston.	6

At the “explanation” stage in the first experiment, the students were asked to compare their observations with their predictions and explain the reasons of this observation. The answers given by the students to the first question at the explanation stage are shown in Table 3.

Table 3. Students' Ideas Related to the Explanation Stage in the First Experiment

Prediction-Observation Comparisons	Number of Students
My prediction is correct.	31
My prediction is wrong.	10

In the second question of the explanation stage, students were asked to explain the reason for this observation. Answers given by the students to this question and the number of students giving these answers are shown in Table 4 below.

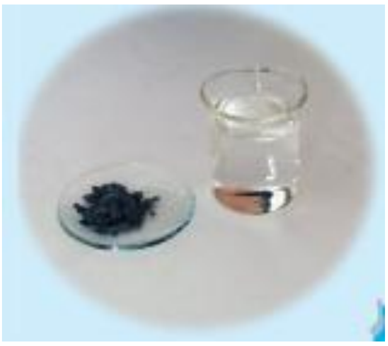
Table 4. Students' Explanations Related to the First Experiment

Reason of the Observations	Number of Students
Compression and expansion of air.	7
Compression and expansion of air.	2
It was compressed because of pressure and went back.	2
Air entered into the syringe.	2
Air and piston pushed each other.	2
Air is trapped and cannot find a place to discharge and piston goes back.	1
A force had an impact on the air and another force prevented it.	25

When the student explanations given above are analyzed, it can be seen that there is no direct explanation of the particulate nature of the matter. Following this stage, the teacher started a class discussion based on the answers given by the students and student answers were examined in a scientific sense. For example, some students stated that the air pushed the piston back. By asking about how the air is structured, the teacher helped students to reach the idea that there are particles that are too small to be seen in the air that pushed the piston. After the classroom discussion, the first lesson was completed and the second lesson began.

"What Happened to Iodine?" Experiment and Obtained Findings

In this part of the study, the second experiment, "What happened to Iodine?" was conducted. In this activity, the students were given alcohol and a sum of iodine in the beaker and the question in Figure 2 was asked. Students were asked to write their predictions for this question and these predictions are given in Table 5.



There is some ethyl alcohol in the glass container and iodine particles in the small container. What kind of changes do you expect in iodine and ethyl alcohol when the iodine particles are put into the glass container?

Figure 2. Prediction Question of the "What Happened to Iodine?" Experiment

Table 5. Students' Predictions in the Second Experiment

Predictions	Number of Students
The color of ethyl alcohol changes.	19
Iodine begins to melt.	4
Iodine evaporates.	2
Iodine melts and color of alcohol changes.	2
Particles dissolve and changes color of the alcohol.	2
Iodine evaporates and changes the color of ethyl alcohol.	1
Iodine dissolves and disperses.	1
Ethyl alcohol freezes.	1
The iodine particles disappear and the color of the alcohol changes.	1
Iodine foams ethyl alcohol and changes its color.	1
Because alcohol is inflammable, iodine burns and disappears.	1
Iodine pales and burns.	1
Iodine burns until alcohol runs out.	1
Acid comes out, particles melt and the color turns into yellow.	1
Bubbles come up and the color turns into yellow.	1
No answer.	2

At the "observation" stage in the second experiment, the students were asked to write their observations that they obtained by making the experiment and the answers given by the students are shown in Table 6 below.

Table 6. Students' Observations in the Second Experiment

Observations	Number of Students
The iodine particles were dissolved, the color of ethyl alcohol changed.	15
Iodine particles got smaller, yellowish orange color came up.	4
The color of the ethyl alcohol changed, it turned red.	4
Iodine did not completely dissolve, yellow color occurred.	3
The particles dissolved and began to give color.	3
The iodine particles dissolved, the ethyl alcohol became dark orange.	2
The iodine particles dissolved, a color darker than yellow occurred.	1
Iodine dissolved, the color of the ethyl alcohol darkened.	1
The color of the iodine came out, ethyl alcohol first became yellow then red and finally black.	1
Iodine was green, its color darkened when it was poured into ethyl alcohol.	1
Some of the iodine gave color did not dissolve completely and the ethyl alcohol had a red-orange color.	1
The iodine particles were chemically altered and an orange color occurred.	1
Ethyl alcohol became red, iodine disappeared.	1
The iodine was evaporated and the ethyl alcohol became red.	1
No observations.	2

At the "explanation" stage in the second experiment, the students were asked to compare their observations with their predictions and explain the reasons of this observation. The answers given by the students to the first question at the explanation stage are shown in Table 7.

Table 7. Students' Ideas Related to the Explanation Stage in the Second Experiment

Prediction-Observation Comparisons	Number of Students
My prediction is correct.	24
My prediction is wrong.	17

In the second question of the explanation stage, students were asked to explain the reason for this observation. Answers given by the students to this question and the number of students giving these answers are shown in Table 8 below.

Table 8. Students' Explanations Related to the Second Experiment

Reason of the Observations	Number of Students
The acid in alcohol melted the iodine and color changed.	6
Since ethyl alcohol is a chemical substance, iodine dissolved.	6
Since ethyl alcohol is flammable, iodine gave color to ethyl alcohol.	4
Iodine particles melted and gave color.	3
Ethyl alcohol burned iodine.	2
Iodine gave color with ethyl alcohol.	2
Iodine particles and ethyl alcohol reacted physically.	1
The color changes because alcohol is additive free.	1
Ethyl alcohol absorbs iodine particles and slowly disappears.	1
The colored particles in the iodine colored ethyl alcohol.	1
The red dye in the iodine colored.	1
No answer.	13

At the end of this experiment, the teacher engaged the students in a class discussion and posed open-ended questions. For example, students were asked why the iodine particles were large at the beginning of the experiment and then decreased. Based on the shared reponses, the students were able to conclude that the particles which are too small to be seen by the eyes were separated and therefore the iodine was reduced and the alcohol changed color.

"What Happened to Sugar Cube?" Experiment and Obtained Findings

In this part of the study, the third experiment, "What Happened to Sugar Cube?" was conducted. In this experiment, students were asked the question in Figure 3. Students were asked to write their predictions for this question and these predictions are given in Table 9 below.

What do you expect when you put the sugar cube on your desk into the water in the glass container?

Figure 3. Prediction Question of the "What Happened to Sugar Cube?" Experiment

Table 9. Students' Predictions in the Third Experiment

Predictions	**Number of Students**
Sugar melts.	10
The sugar melts in water and divides into its particles.	5
In the water, it divides into its particles and gives its own taste.	4
Sugar melts and the taste of water changes.	3
Sugar cube melts and splits into particles.	2
It melts in time, the foam comes out and the color does not change.	2
Sugar has a particulate nature, dissolves and melts.	2
Small particles which are too small to be seen in the sugar mix with the water and taste of the water changes.	2
Water becomes sweet.	1
Bubbles occur in water, the color of the water comes out the same.	1
The particles are dispersed and mixed with water.	1
Sugar absorbs water.	1
Sugar dissolves in water and splits into particles.	1
Sugar dissolves in water.	1
Sugar cube becomes granular.	1
Sugar melts and mixes with water.	1
Sugar particles are scattered and spread everywhere.	1
Sugar begins to shrink and disappear, the water becomes sweet.	1
No answer.	1

At the "observation" stage in the third experiment, the students were asked to write their observations that they obtained by making the experiment and the answers given by the students are shown in Table 10.

Table 10. Students' Observations in the Third Experiment

Observations	**Number of Students**
Sugar melted, mixed with water and water became sugary.	6
Sugar cube melted, particles disappeared.	4
Sugar melted in water and dissolved.	3
The particles in the sugar cube were dispersed and mixed with water.	3
The sugar completely disappeared.	3
Sugar cube separated into pieces.	3
Sugar melted in water.	3
Sugar dissolved and melted.	2
Sugar cube is a melting material and does not give color.	2
Sugar dissolved and taste of the water changed.	1
Sugar divided into particles in water.	1
Sugar particles rise to the surface.	1
The sugar particles are dispersed into the air, the sugar disappears and the water became sugary.	1
Sugar cube particles started to fly in water.	1
Sugar divided into particles that could not be seen in water.	1
Sugar disappeared, dissolved.	1
Sugar melted and divided into too small particles to be seen.	1
Small pieces of sugar are scattered around, sugar cube melted.	1
The particles of sugar and water mixed together and the sugar melted.	1
The bubbles came out of sugar, the water was sweet.	1
Small particles in the sugar began to melt thanks to the invisible particles in the water.	1

At the "explanation" stage in the third experiment, the students were asked to compare their observations with their predictions and explain the reasons of this observation. The answers given by the students to the first question at the explanation stage are shown in Table 11 below.

Table 11. Students' Ideas Related to the Explanation Stage in the Third Experiment

Prediction-Observation Comparisons	**Number of Students**
My prediction is correct.	40
My prediction is wrong.	1

In the second question of the explanation stage, students were asked to explain the reason for this observation. Answers given by the students to this question and the number of students giving these answers are shown in Table 12 below.

Table 12. Students' Explanations Related to the Third Experiment

Reason of the Observations	Number of Students
Melting of sugar in water and giving its taste to water.	9
Dissolution of sugar in water and giving its taste to water.	6
Melting of sugar.	5
Melting of sugar and mixing of the particles of sugar which make it sweet with water.	3
Mixing of sugar with water and disappearing.	2
Since sugar cube is sweet, the taste of the water is sweetened.	2
The sugar particles are dispersed in water, the sugar is dissolved and the water is mixed with the sugar particles.	2
Mixing of sugar particles with water and changing the taste of water.	2
Mixing of sugar particles with water and taste of sugar is mixed with water.	1
Sugar dissolves in water and sugar and water combine.	1
Sugar melts, sugar particles stay in the water and we get the taste of it.	1
Sugar cube particles mixed with water and the taste changed.	1
Water mixed with substance in sugar.	1
Sugar divided into particles, the water was sweet because sugar particles were sweet.	1
Some materials give taste and color to water.	1
Sugar dissolved in water, water became sweet.	1
No answer.	2

At the end of the third experiment, a class discussion was made and the students were asked about what happened to the sugar. It was also asked if sugar did actually disappear and how it would be explained if it did not disappear. This discussion supported students to conclude that the sugar divided into too small particles to be seen by the naked eye.

Up until this point, findings obtained from experimental stages which were carried out based on the POE strategy have been presented. In the following part, results which the students obtained from these experiments conducted within the scope of the study after the classroom discussions are presented. The purpose of presenting these data is to enable students evaluate their explanations through classroom discussions after the explanation stage and reveal to the extent to which students reached the expected conceptual meanings. For these reasons, the results expressed by the students belonging to each experiment are again presented in tables.

The results obtained by the students from the first experiment of this study, "Movement of the Syringe", are presented in Table 13 below.

Table 13. Results of the "Movements of the Syringe" Experiment

Results of the Experiment	Number of Students
Air particles pushed the piston.	10
The air was compressed and spread.	6
Air and all gases can be compressed.	5
Air has particles and these particles can be compressed.	4
The air has an invisible granular structure.	4
There are matters in the air that we cannot see.	1
Particles were compressed and pushed the piston when released.	1
The gases can be compressed and particles occur that are too small to be seen.	1
No answer.	9

When Table 13 is analyzed, the answers given by the students in this section indicate that particulate nature of matter is understood better by the students compared to the answers given in the explanation stage of POE (Table 4). The fact that students mentioned "particulate nature of the matter" while explaining the results of the experiment in Table 13 shows that the classroom discussions were useful during the implementation of the POE strategy. In addition, the finding that the students mentioned to a large extent particles in the answers that they gave shows that they reached the desired outcomes.

The results obtained by the students from the second experiment of this study, "What

Happened to Iodine", are presented in Table 14.

Table 14. Results of the "What Happened to Iodine" Experiment

Results of the Experiment	Number of Students
Iodine underwent chemical change.	4
The particles in the iodine dispersed and gave its color to the alcohol.	4
There are particles in iodine.	4
There are particles too small to be seen in the iodine.	4
Iodine did not disappear, the color of ethyl alcohol changed.	4
Iodine particles dissolved.	3
Iodine particles are coloring agents.	3
Iodine particles mixed with ethyl alcohol.	2
The iodine particles gave color to ethyl alcohol and dissolved.	2
Iodine in ethyl alcohol was separated.	1
Iodine has a granular structure.	1
Iodine and ethyl alcohol had a physical reaction.	1
Solid iodine has small particles.	1
Iodine divided into particles and changed color through melting.	1
Iodine particles were mixed with ethyl alcohol.	1
Color changed with material change.	1
Ethyl alcohol was colored by chemical change.	1
No answer.	2

When Table 14 is analyzed, it is seen that number of the answers given by the students increased and they gave answers more correctly compared to the answers given at the explanation stage of POE (Table 8). During the classroom discussions conducted with the students, questions were asked to them about the answers that they gave and students were given an opportunity to find missing parts and errors in their answer on their own. From this moment on, students have thought about how consistent the answers are in scientific terms, and by the end of the class discussion they have arrived at the appropriate answers themselves. The fact that the idea of particulate nature of matter is expressed at the end of this experiment can be considered as an achievement of this work.

The results obtained by the students from the third experiment, "What Happened to Sugar Cube?" are presented in Table 15.

Table 15. Results of the "What Happened to Sugar Cube" Experiment

Results of the Experiment	Number of Students
Sugar cube melted.	5
Sugar melted and particles were mixed in water.	4
Sugar cube melted and the taste of the water changed.	4
Sugar cube has a particulate nature.	3
Sugar cube separated into invisible particles.	3
Sugar underwent physical change and dissolved, particles separated.	2
Sugar particles mixed with water and we could not see them.	2
Sugar cube particles mixed into the water and changed its taste.	2
Sugar cube separated into particles and mixed with water.	2
Solid materials and liquids have particles which are too small to be seen.	1
Sugar cube was separated into particles like iodine.	1
Sugar dissolved and separated into particles.	1
Small particles which we cannot see constitute the matter.	1
Solid materials have particles which are too small to be seen.	1
There are particles in sugar cube which are too small to be seen.	1
The substance gives color or taste when chemically altered.	1
There are particles forming solids, liquids and gases.	1
Sugar matter dissolved as particulate granular.	1
Color of the water did not change.	1
Melting of sugars in water with air particles.	1
No answer.	3

When Table 15 is analyzed, it is seen that the number of the answers given by the students which involve particulate nature of matter increased compared to the answers given at the explanation stage of POE (Table 12). When the answers given by the students are examined, it is seen that not all students were able to answer the questions at the desired level; however, the idea that the matter has a particulate nature is expressed in the given answers which can be considered as a sign of the conceptual understanding. This suggests that the conducted study enabled students to form the idea of particulate nature of matter.

CONCLUSIONS and SUGGESTIONS

The purpose of this study is to help the sixth grade students understand that matters have a particulate, hollow, and moving structure through POE strategy. When the related literature is examined, it has been determined that there is a misconception that the material is composed of continuous structure rather than particulate structure among the students from different age groups (Ayas, Özmen, & Çalık, 2010). At the end of this study, in general the students got the idea of particulate structure of matter. It is really important for the students to acquire scientific thinking about the particulate nature of the matter after the relevant units have been taught and this suggests that the goal has been achieved (Ayas & Özmen, 2002). From this point of view, the fact that the idea of particulate nature of matter is expressed by the students can be considered as an advantage for the teaching of the following subjects. In the following sections of this topic, the particulate nature of matter can be emphasized constantly and the other students can reach the idea of particulate structure. Therefore, with these activities, an awareness related to this issue has been established and the idea of particulate nature of matter can be conceptually simplified by using these activities in later topics and classes.

As mentioned above, this activity was completed in four class hours. It is of vital importance for the students who will be learning a significant subject for the first time to carry out these or similar activities themselves with respect to understanding the subject. The teacher himself observed that almost all the students in the class were interested in the conducted activity looking for answers to the questions in the worksheets. When the experiments are made according to the POE strategy, the level of conceptual understanding of the students is increased. These kinds of activities encourage the students who are inclined to prefer only to observe the conducted experiment to be more careful and interested (Güngör & Özkan, 2017). These kinds of activities contribute to the students' reaching the idea of particles more easily.

In this study, rubrics (Appendix 4) developed by the researcher based on the related literature were used for each experiment in order to understand the extent to which the students reached the particulate structure idea. While none of the students mentioned the idea of particle at the explanation stage of the first experiment, 20 students formed sentences expressing the idea of particles at the end of the classroom discussion. At the explanation stage of the second experiment, only six students expressed the idea of particle but after the class discussion, this number increased to 26. In the last experiment, nine students formed a sentence expressing the idea of particles while at the end of the class discussion, this number increased to 25. In this case, it can be said that at the end of the class discussion, the particle idea was more frequently expressed among the students. During the class discussions, the course teacher did not express the idea of particles directly but the teacher asked open-ended questions to students about the experiments that they were doing. Students have reached their own conceptual explanations using their observations in the experiments and their existing knowledge. Therefore, it can be said that this kind of practice is compatible with constructivist approach. Increasing the number of these types of activities, both in secondary school and high school, might contribute greatly to the understanding of the subject.

The number of students in the classroom in this study was 41 and a total of eight groups were formed for the experiments. The crowded classroom may have prevented the teacher from fully providing the necessary guidance. It is recommended that such an activity should be carried out with fewer students. Another suggestion is that POE strategy can also be used for teaching the subject of the "change of state" based on the data obtained from this study.

While this study was carried out, some materials were placed on student worksheets. Especially during the "What Happened to Iodine?" activity, the fact that solid iodine particles were placed on students' worksheets and the change of color seen on the paper at the same time may have influenced the opinions that the students actually wanted to express. For this reason, it would be more appropriate to put such materials in glass containers.

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Appendix 1

Activity Worksheets

ACTIVITY NAME: MOVEMENT OF THE SYRINGE

PREDICTION PHASE:

If there is air in the syringes shown on the side, when we close the tip of the syringe with a finger and push the piston of the syringe and then release the piston, what can we say about the movement of the piston? Please write down your prediction and the reason why you predicted that way.

MY PREDICTION AND WHY:………………....……………..…………………………….

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OBSERVATION PHASE: Now do the experiment and write down what you have observed along with an explanation.

MY OBSERVATIONS AND WHY:

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EXPLANATION PHASE:

- ✓ Now compare your prediction with your observation Write a reason for why it is right or wrong.

  ……………………………………………………………………………………………

  ……………………………………………………………………………………………

  ……………………………………………………………………………………………

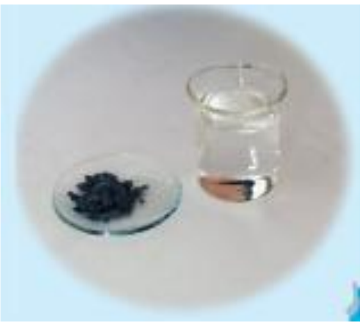
  ……………………………………………………………………………………………

- ✓ Explain the reason for your observation.

  ……………………………………………………………………………………………

  ……………………………………………………………………………………………

ACTIVITY NAME: WHAT HAPPENED TO IODINE?



PREDICTION PHASE:

There is some ethyl alcohol in the glass container and iodine particles in the small container. What change would you expect in iodine and ethyl alcohol when the iodine particles are thrown into the glass container? Please write down your prediction and the reason why you predicted that way.

MY PREDICTION: …………….……………………………………………………………..

……………………………………………………………………………………………

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

WHY:……………………………………………………………………………………….

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OBSERVATION PHASE: At this stage, take a few particles of iodine and put them on ethyl alcohol in the glass container. Then, write down your observations together with the reasons why there is a change in both ethyl alcohol and iodine.

MY OBSERVATION:………………………………………………………… …….....

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………………………………………………………………………………………...

MY REASONS:…………………………………………………………………………...

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EXPLANATION PHASE:

- ✓ Now compare your prediction with your observation. Is your guess the same as your observation or is it different? Write a reason for why it is same or different.

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- ✓ How do you explain the color change you see during the observation phase and the shrinking of iodine particles? Write down an explanation.

……………………………………………………………………………………………

……………………………………………………………………………………………

ACTIVITY NAME: WHAT HAPPENED TO THE SUGAR CUBE?

PREDICTION PHASE: What do you expect when you throw a sugar cube into water in the glass container on your desk? Please write down your prediction and the reason why you predicted that way.

MY PREDICTION:……………………………………………………….……….......................

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

MY REASON:…………………………………………………………………………..…….

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

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OBSERVATION PHASE: Now throw some sugar cubes into the water in the glass container and observe. How would you explain the cause of this situation?

MY OBSERVATIONS:…………………………………………………………………..

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

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

MY REASONS:………………………………………………………………………...

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

EXPLANATION PHASE:

- ✓ Now compare your prediction with your observation. Is your guess the same as your observation or is it different? Write a reason for why it is same or different.

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…………………………………………………………………………………………

- ✓ How do you explain the disappearance of the sugar that you see during the observation phase and the change of water taste? Explain in writing.

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…………………………………………………………………………………………

Appendix 2

Activity Result Analysis

ACTIVITY NO: 1

ACTIVITY NAME: MOVEMENT OF THE SYRINGE

THE PROCEDURES OF THE ACTIVITY:……………………………………………....

…………………………………………………………………………………………

…………………………………………………………………………………………

RESULT OBTAINED IN THE ACTIVITY:…………………………………………….....

…………………………………………………………………………………………...

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ACTIVITY NO: 2

ACTIVITY NAME: WHAT HAPPENED TO IODINE?

THE PROCEDURES OF THE ACTIVITY:……………………......................................

…………………………………………………………………………………………

…………………………………………………………………………………………

RESULT OBTAINED IN THE ACTIVITY:...……………………………………………..

………………………………………………………………………………………….

....

ACTIVITY NO: 3

ACTIVITY NAME:WHAT HAPPENED TO THE SUGAR CUBE?

THE PROCEDURES OF THE ACTIVITY:………… ……………………………………

…………………………………………………………………………………………

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RESULT OBTAINED IN THE ACTIVITY:…………………………..........................

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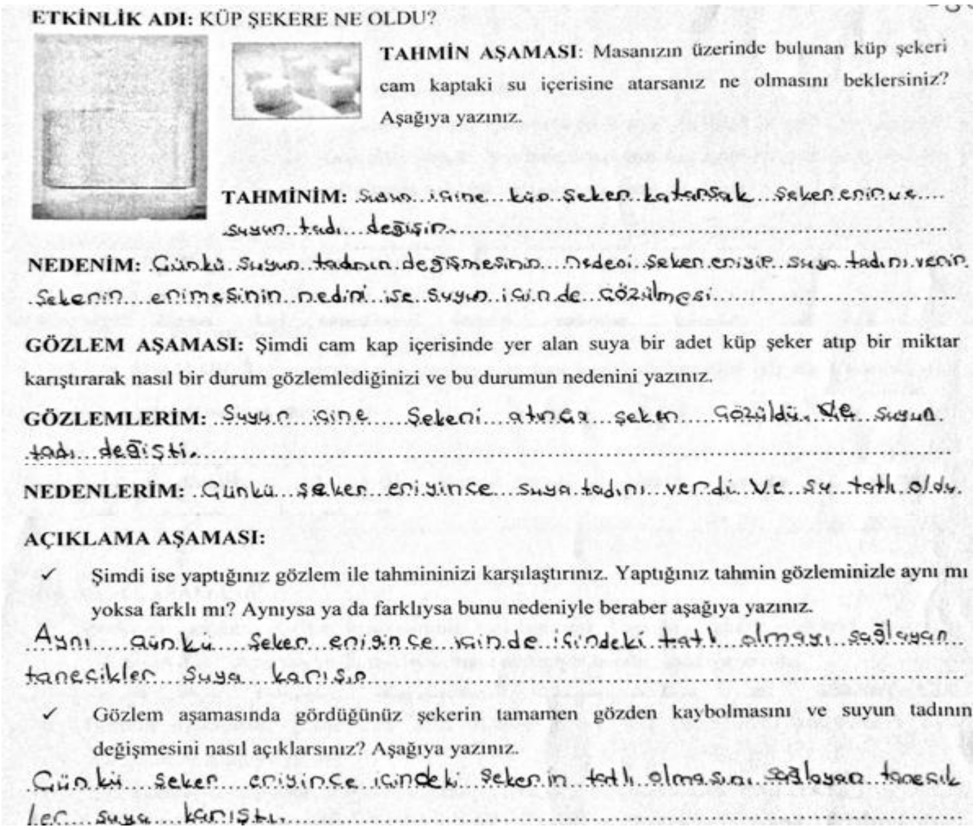
Appendix 3
Examples from Student Worksheets



ETKİNLİK ADI: KÜP ŞEKERE NE OLDU?

TAHMİN AŞAMASI: Masanızın üzerinde bulunan küp şekeri cam kaptaki su içerisine atarsanız ne olmasını beklersiniz? Aşağıya yazınız.

TAHMİNİM: Suyun içine küp şeker katarsak şeker erir ve suyun tadı değişir.

NEDENİM: Çünkü suyun tadının değişmesinin nedeni şeker erir suya tadını verir. Şekerin erimesinin nedeni ise suyun için de çözülmesi

GÖZLEM AŞAMASI: Şimdi cam kap içerisinde yer alan suya bir adet küp şeker atıp bir miktar karıştırarak nasıl bir durum gözlemlediğinizi ve bu durumun nedenini yazınız.

GÖZLEMLERİM: Suyun içine şekeri atınca şeker çözüldü. ve suyun tadı değişti.

NEDENLERİM: Çünkü şeker eriyince suya tadını verdi ve su tatlı oldu.

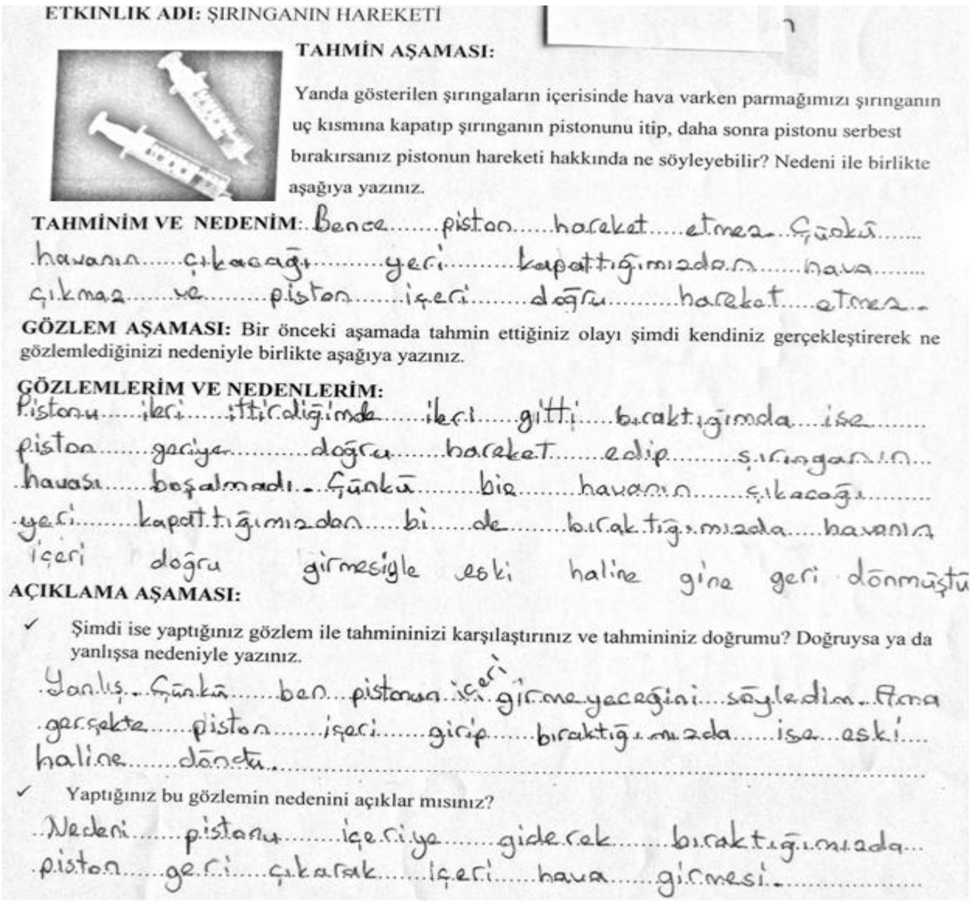
AÇIKLAMA AŞAMASI:

✓ Şimdi ise yaptığınız gözlem ile tahmininizi karşılaştırınız. Yaptığınız tahmin gözleminizle aynı mı yoksa farklı mı? Aynıysa ya da farklıysa bunu nedeniyle beraber aşağıya yazınız.

Aynı çünkü şeker eriyince içinde içindeki tatlı olmasını sağlayan tanecikler suya karışır

✓ Gözlem aşamasında gördüğünüz şekerin tamamen gözden kaybolmasını ve suyun tadının değişmesini nasıl açıklarsınız? Aşağıya yazınız.

Çünkü şeker eriyince içindeki şekerin tatlı olmasını sağlayan tanecikler suya karıştı.



ETKINLIK ADI: ŞIRINGANIN HAREKETİ

TAHMİN AŞAMASI:

Yanda gösterilen şırıngaların içerisinde hava varken parmağımızı şırınganın uç kısmına kapatıp şırınganın pistonunu itip, daha sonra pistonu serbest bırakırsanız pistonun hareketi hakkında ne söyleyebilir? Nedeni ile birlikte aşağıya yazınız.

TAHMİNİM VE NEDENİM: Bence piston hareket etmez. Çünkü havanın çıkacağı yeri kapattığımızdan hava çıkmaz ve piston içeri doğru hareket etmez.

GÖZLEM AŞAMASI: Bir önceki aşamada tahmin ettiğiniz olayı şimdi kendiniz gerçekleştirerek ne gözlemlediğinizi nedeniyle birlikte aşağıya yazınız.

GÖZLEMLERİM VE NEDENLERİM: Pistonu içeri ittirdiğimde içeri gitti bıraktığımda ise piston geriye doğru hareket edip şırınganın havası boşalmadı. Çünkü bir havanın çıkacağı yeri kapattığımızdan bi de bıraktığımızda havanın içeri doğru girmesiyle eski haline gine geri dönmüştü

AÇIKLAMA AŞAMASI:

✓ Şimdi ise yaptığınız gözlem ile tahmininizi karşılaştırınız ve tahmininiz doğrumu? Doğruysa ya da yanlışsa nedeniyle yazınız.

Yanlış. Çünkü ben pistonun içeri girmeyeceğini söyledim. Ama gerçekte piston içeri girip bıraktığımızda ise eski haline döndü.

✓ Yaptığınız bu gözlemin nedenini açıklar mısınız?

Nedeni pistonu içeriye giderek bıraktığımızda piston geri çıkarak içeri hava girmesi.

ETKİNLİK NO: 1

ETKİNLİK ADI: ŞIRINGANIN HAREKETİ

ETKİNLİKTE YAPILANLAR: Şırınganın ucunu parmağımızla kapattıktan ve şırıngayı bastığımızda pistonun nasıl bir yol izlediğini gördük. Yani piston hareket ettirdikçe ileri gidip tekrar geri geldi.

ETKİNLİKTE ELDE EDİLEN SONUÇ:

Pistonu ileriye doğru ittirdikçe şırınganın içindeki hava sıkıştı ve en sonunda havanın içindeki bir takım tanecikler dağılarak piston geri itti. Yani bu bize şunu gösteriyor: Havanın da içinde birtakım tanecikler olduğunu ve bu taneciklerinde sıkıştırılabilir olduğunu gördük.

ETKİNLİK NO: 2

ETKİNLİK ADI: İYODA NE OLDU?

ETKİNLİKTE YAPILANLAR: İyodu beherin içindeki etil alkole attık ve iyodu attıkça ise etil alkolün rengi değişti.

ETKİNLİKTE ELDE EDİLEN SONUÇ:

Demekki iyodun içindeki tanecikler bazı maddelere karşı savunmasız diyebiliriz. Yani iyot bazı maddelerle temas ettikçe iyodun içindeki tanecikler dağıldı ve rengini etil alkole verdi.

ETKİNLİK NO: 3

ETKİNLİK ADI: KÜP ŞEKERE NE OLDU?

ETKİNLİKTE YAPILANLAR: Küp şekeri beherin içindeki suya attık ve karıştırdık. Küp şekerin dağıldığını gördük.

ETKİNLİKTE ELDE EDİLEN SONUÇ:

Küp şekerde iyot gibi girdiği bazı maddelere taneciklerini salıyor. Ama bu tanecikler suya rengini vermiyor. Sadece gittikçe kayboluyorlar ve suyun görünümünde bir değişiklik olmadı. Sadece suyun tadında bir değişiklik oldu.

Appendix 4

Rubrics

Rubric for Experiment 1

Scientific Understanding: The air in the syringe is compressed by pushing the piston. After the air is compressed, when the piston is released, the backward movement of the piston reveals that particles that are too small to be seen by the naked eye in the air come in, hit the piston and push it. Therefore, the air that is in the form of gas is made up of small particles that are too small to be seen.

Not Understanding: Explaining the experiment without expressing the particulate nature of matter can be evaluated as not understanding category.

Rubric for Experiment 2

Scientific Understanding: Particles which constitutes alcohol surround the particles forming iodine and cause iodine to disperse in alcohol. During the dissolution of iodine in alcohol, iodine is separated into its particles and spread in the alcohol, thus alcohol is colored.

Partly Scientific Understanding: The alcohol is colored because very small particles forming iodine are dispersed in alcohol.

Not Understanding: Explaining the experiment without expressing the particulate nature of matter can be evaluated as not understanding category.

Rubric for Experiment 3

Scientific Understanding: The particles forming water surround the sugar and separate the particles forming sugar. Thus, the particles forming the sugar enter between the particles forming the water.

Partly Scientific Understanding: Expressing that only sugar or water consists of particles and trying to explain the experiment based on idea that only one matter has particulate nature.

Not Understanding: Explaining the experiment without expressing the particulate nature of matter can be evaluated as not understanding category.