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Determination of Pre-service Science Teachers' Conceptual Understandings about the "Solutions: Dissolving-Melting" with Predict-Observe-Explain Technique

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Abstract

In the study, the effect of Predict-Observe-Explain (POE) activities carried out within the scope of argumentation-supported learning method on the detection of the conceptual understandings of the pre-service science teachers about "Solutions: Dissolving-Melting" was examined. Based on this main purpose, a case study was applied in the study, one of the qualitative research methods. The study group of the research consists of 22 pre-service science teachers. According to the data obtained at the end of the study, it was observed that pre-service teachers structured non-scientific claims and justifications, and could not use their refutation skills adequately before applications. It was observed that pre-service teachers were more willing and competent in developing scientific arguments in POE activities.

Keywords: Argumentation-Supported Learning, Predict-Observe-Explain, Pre-Service Science Teacher, Solutions, Dissolving, Melting.

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INTRODUCTION

In order to develop an effective science teaching program, updating science programs in Turkey has begun recent years. The emphasis of the Ministry of National Education (MoNE) on the necessity of educating students as science literate individuals in the vision of the science course curriculum reveals the need for these updates (MoNE, 2017). Skills that increase the development of science literacy in an individual such as problem solving, creativity, and analytical thinking skills (MoNE, 2017) are also frequently used in the argumentation-based teaching approach (Burke, Greenbowe & Hand, 2005; Gott & Duggan, 2007). The Ministry of National Education has included learning-teaching environments where the student will be active and the teacher will be the guide and director at the center of lesson planning and applications in the science course curriculum. Such learning-teaching environments include all methods and techniques that fall into the research/inquiry-based learning strategy. In this learning strategy, learners engage in activities that are in an effort to recognize and understand the universe, are curious to explore their surroundings constantly, and can provide their reasons and/or necessary explanations in this discovery process (MoNE, 2013).

Argumentation is an integral part of science and therefore the necessity of its inclusion in science education has been revealed as a result of the findings of many studies (Jimenez-Aleixandre, 2007; Tippett, 2009; Zohar & Nemet, 2002; Berland & Reisier, 2011; Sampson & Clark, 2011¸ Erduran & Jimenez-Aleixandre, 2007). Scientific argumentation is a social practice in which members of a community make sense of facts such as studying, sharing, evaluating, criticizing, thinking and reviewing claims through discourse (Berland & Reisier, 2011).

In science classes, it is necessary to prevent the difficulties students experience at these stages and to benefit from appropriate teaching strategies to improve these skills. In this context, it is stated that using a wide variety of strategies in learning-teaching environments where argumentation-based learning method is handled can help to overcome these problems. These are; table of expressions, concept maps made up of student ideas, experiment report, competing theories - theories competing with cartoons, theories competing with a story, theories competing with opinions and proofs, structure an claim, predict - observe - explain (POE) and experiment design (Osborne, Erduran & Simon, 2004a).

The Predict-Observe-Explain technique was developed by White and Gunstone (1992), and was later used by Osborne, Erduran, and Simon (2004b) to improve argumentation skills. This technique involves introducing students to a scientific event (without showing the event) and asking students to discuss what they think will happen when the scientific event is initiated in small groups, and verifying the reasons. After this stage, the scientific case is shown and students are given opportunities to review and reconsider their initial arguments. They focus on the theory they support and develop with discussion, predict and evidence. Thus, the student's misconceptions are also detected. This technique can be used at the beginning of the subject in order to find out whether students have any misconceptions about this subject; in order to enable students to learn the subject and discuss it in the classroom during teaching of the subject; and at the end of the subject to in order to make an assessmentto reveal how much students have learned the subject and their existing misconceptions.

Importance of the Research

It is very important for science education to create curricula and course contents (theoretical and applications) for effective university level science courses (Physics, Chemistry and Biology learning areas), to increase the academic success of pre-service teachers, to make science concepts meaningful and to be able to be interpreted with daily life. The applied aspect of science education, which is important for both epistemological and educational reasons, helps to reflect the nature of science and to understand scientific concepts better. It also has a motivating effect on students (Zuzovsky & Tamir, 1999). In the 19^{th} century, laboratory applications, which were used to expose students to concrete experience with objects and concepts, came to the fore with the concept of "learning by doing" within the framework of research-based approach by Dewey. This phenomenon, which has been defended, has preserved its place in the literature as applications performed to verify or revive the information learned from written sources such as teachers or course books. Laboratories were seen as the core of science learning processes in the science curriculum described as "new" in the 1960s, which emphasized scientific processes or the development of high-level cognitive skills (Shulman & Tamir, 1973). In this new laboratory approach, students establish hypotheses, collect and record data, interpret their findings, state their solutions, and generalize (Tamir, Doran & Chye, 1992). There are many laboratory approaches used in laboratory environments today. However, when the relevant literature is examined, it is seen that the closed-ended laboratory approach is used more than other approaches, especially in university level laboratory applications of basic sciences such as physics, chemistry and biology (Güngör Seyhan & Okur, 2020). Constructivist learning theory and other modern learning theories suggest the use of student-centered laboratory environments where the teacher is a guide (Yılmaz & Şahin, 2011). In this context, it is very important to design the physical structure of science laboratories and the activities to be carried out in accordance with the structuring of knowledge (Arı & Bayram, 2011).

Thanks to the importance given to laboratory studies in recent years, laboratories, which were seen as places where educational activities in the form of proof and demonstration experiments were carried out; have been replaced by students as places that they find the science concepts more believable and understandable, and where they find learning effective and dynamic (Renner, Abraham & Birnie, 1985). Instead of transferring information to students with traditional methods, learning-teaching environments in which students are active, learn by doing, experiencing and discovering information themselves should be created (Güngör Seyhan & Okur, 2020).

In the study, Predict-Observe-Explain (POE) activities carried out within the scope of argumentation-supported learning were used as an alternative to the validation laboratory approach, which is a closed-ended experiment technique. In the study, it was aimed to determine the contribution of argumentation-supported learning to the conceptual understandings of pre-service science teachers on the subject of "Solutions: Dissolving-Melting" and to examine the effectiveness of the method in determining the current misconceptions of pre-service teachers.

METHOD

The research, in which qualitative data collection methods such as observation, interview and document analysis are used and a qualitative process is followed to reveal perceptions and events in a realistic and holistic manner in the natural environment, is defined as qualitative research (Yıldırım & Şimşek, 2008, p.39). In this study, the misconceptions of pre-service science teachers about the "Solutions: Dissolving-Melting" were revealed by following a qualitative process. The study was conducted based on case study, one of the qualitative research methods (Bromley, 1986, p.1).

Study Group

The study group of the research consists of 22 pre-service science teachers (19-20 years old). The study group of the study was determined according to the purposeful sampling type, one of the non-random sampling techniques (Creswell, 2012).

Data Collection Tools

The data collection tools of the research consist of worksheets filled by pre-service science teachers during the POE activities. These worksheets include activity papers that contain a problem situation or basic problem statement for each science subject and instructions that allow the argumentation process to be followed. The content validity of the data collection tool was provided by the control of two educators (science educators and chemistry educators) who are experts in field education. The reliability was provided with a 95% consistency between the same researchers' coding and categorizing the data.

Data Analysis

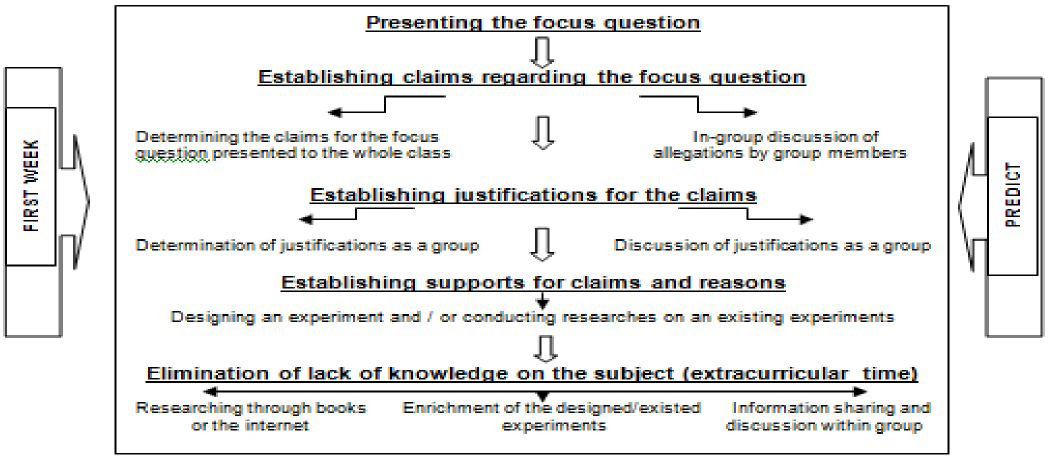
In the analysis of the worksheets distributed to pre-service teachers for argumentation-supported learning, many studies aimed at determining students' understanding and misunderstanding about many basic science concepts in the literature were examined (Abraham, Grzybowski, Renner, & Marek, 1992; Balaydın & Altınok, 2018; Birinci-Konur & Ayas, 2010; Ayvacı & Durmuş, 2016). The pre-service teachers' predictions and their claims; the reasons for supporting their claims; observations and data obtained during the experimental application process; in order to evaluate the scientific explanations and the level of their refutation, if any, the categories determined in the literature were used. The categories given in Table 1 were used in the analysis of the worksheets completed by the pre-service teachers in cooperation with their group mates. While creating the categories, the answers in all categories for the misconceptions of pre-service teachers regarding the levels of "making claims", "writing reasons", "collecting data", "making explanations" and "being able to refute" were examined and analyzed.

Table 1. Categories Used for Scientific Claims in the Analysis of Worksheets

Levels of Claim	Categories used in the analysis of pre-service teachers' responds		
Making Claim	Correct Claim (Completely and Partially Correct)	Wrong Claim	No Claim
Being able to write justification	Correct Justification (Completely and Partially Correct)	Wrong Justification	No Justification
Collecting Data	Correct Data	Wrong Data	No Data
Being able to make explanation	Correct Explanation (Completely and Partially Correct)	Wrong Explanation	No Explanation
Being able to refute	Correct Refutation (Completely and Partially Correct)	Wrong Refutation	No Refutation

Application Process

In the study, argumentation-supported learning practices were carried out for pre-service science teachers' conceptual learning about "Solutions: Dissolving-Melting". The applications, including the argument structuring preparation activities of the pre-serviceteachers, lasted for 3 weeks in total. The two-week flow chart of the applications is shown in Figure 1.



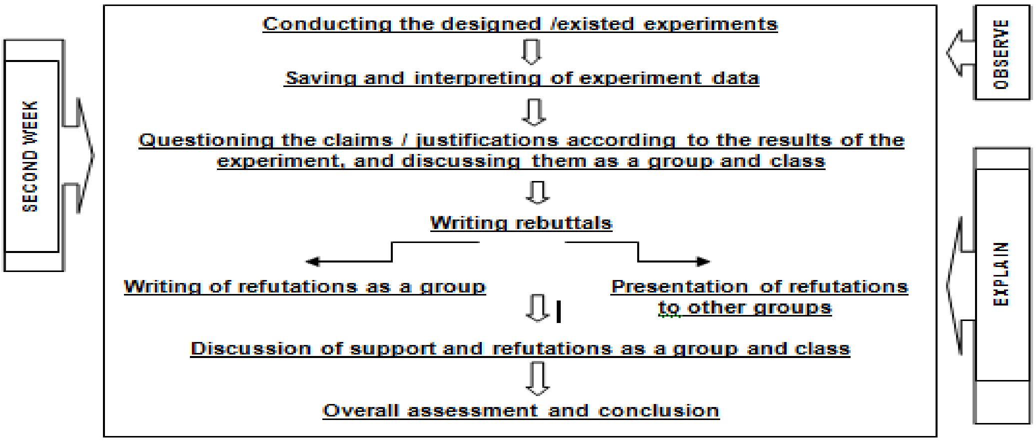


Figure 1. Flow Chart of Laboratory Applications (POE) Based on Argumentation-Supported Learning

Before starting the main applications for argumentation-supported learning, preliminary studies were carried out with the pre-service teachers to activate their argument skills in order to prepare for the applications. Preliminary studies conducted with pre-service teachers consist of the POE activities, which includes studies of "being able to write an argument-justification and then design an experiment" are examined. These pre-study activities started with a problem situation in which pre-service teachers would use their prior knowledge and predictions. Afterwards, they were allowed to design and carry out an experimental activity that they would observe, and consequently, their ability to record their observations was activated in this process. In the last stages of the pre-study activities, an environment was provided in which they compared their predictions and the results they obtained based on the data they obtained during their observations. During all these pre-activity stages, pre-service teachers worked as a group. During the pre-study, the conceptual learning of the relevant subject targeted within the scope of the study was started with the pre-service teachers who had information about the stages of an argument structuring process. The argumentation-supported learning applications for the relevant chemistry subject given to pre-service teachers were carried out for 2 weeks. For the "focus question" given in the first week, pre-service teachers were asked to form their arguments (making claims and providing justifications). They then designed an experiment and/or conducted a pre-study on an existing directed experiment so that they could support their claim and justification. In the second week, the planned experiments were carried out in the laboratory environment and they had the opportunity to test the arguments they created in the previous lesson, and after the experiments, they compared them and made their explanations (presenting scientific arguments and refuting).

FINDINGS AND INTERPRETATION

The findings and results obtained for the main purpose examined within the scope of the research are given below. During the "predict-observe-explain" activities about "Solutions: Dissolving-Melting", the pre-service teachers were asked to fill in the worksheets distributed to them with their group friends. The worksheets start with a "focus question" that requires an experimental process. The claims given by the pre-service teachers in the worksheets were analyzed by content analysis and the findings obtained are presented in Table 2. The claims of the pre-service teachers were criticized based on the following scientific claims (https://www.fossweb.com-Solutions):

- When two matters are mixed, several types of interactions are possible. The simplest type of mixing can be seen when mixing two solids, such as salt and baking soda: The parts of the two mattersmix together randomly, but there is no other interaction beyond random contact. Two types of particles coexist and are completely unaffected by close relationship with each other. Peanuts and raisins or a mixture of oil and vinegar also exhibits such independent coexistence, just like the salt/baking powder mixture.

- Solutions are also mixtures. A solution consists of two (or more) matters that are equally distributed to each other at the particle level. In the case of sugar and water, the sugar particles are evenly distributed among the water particles. Dissolved matter is called "solute". In this case, sugar is the solute matter. The matter in which the soluble matter dissolves is called "solvent". Water is the most common solvent on this planet, as many different matters will dissolve in water to form a solution. Since the most common gas in the air, nitrogen gas is solvent; gases such as oxygen and carbon dioxide are soluble matters, "air" is an example of gas-gas solutions. In the brass sample, which is an example of solid-solid solutions, the solvent is copper and the solute substance is zinc.

- Although two mattes (or more) are required for the dissolving process, students tend to focus only on the solid and compare this process to "melting". In fact, when a solid material is placed in a liquid and the solid disappears into the liquid, we call the solid dissolved, and the resulting mixture is called a solution. Students may not be able to make a clear conceptual distinction between melting and dissolving. Usually they say that a piece of sugar dipped in water "melts". Similarly, sugar thrown into tea "melts" according to them.

- When we heat a solid matter, the particles will move faster as energy is transferred to the particles. When enough energy is transferred, the intergranular spaces change according to their location before the energy is transferred. After this process, the solid is now a liquid. In other words, an "energy transfer" is needed for melting.

- Dissolving is a transformation involving a new structural relationship between particles of different matters. This transformation is the result of kinetic activities and gravitational forces between particles. Let's go back to the sugar-water example. Kinetic activities involve the solvent (water) particles impinging on the dissolved (sugar) crystals and physically binding the separate particles from the crystalline structure.If the gravitational force between the solute and solvent particles are sufficient, the dissolved particles will separate themselves from the crystal and move towards the sea of solvent.

In order to determine the claim levels of the pre-service teachers about the “Solutions: Dissolving-Melting”, the focus question given in the following (Figure 2) was presented by the researchers and then they were asked to write their claims and justifications for the basic problem sentence.

Sometimes we witness solids turning into liquids; just like taking a small ice cube from the freezer and leaving it on the table for 5-10 minutes, then there is no ice left on the table.Because ice is now liquid. How do you think this happened?

For this situation, some people say that solids like ice dissolve and become liquid; others say that solids melt and become liquid. This is so confusing !!!!!

Figure 2. Focus Question Regarding “Solutions: Dissolving-Melting”

Following the claims and justifications put forward by the pre-service teachers with their group mates, the following questions were directed to all group members by the researchers. Pre-service teachers were provided with very quick answers to these questions and brainstormed with them:

- What is dissolving and what makes it happen?
- What is melting and what makes it happen?

The pre-service teachers were asked to write their answers to all these questions in the relevant places in the worksheets distributed to them. After brainstorming with the above two questions, the following questions were posed by the researchers to get the claims and justifications of the pre-service teachers:

- How are melting and dissolving alike? How are they different?
- How would you melt a substance?
- How would you dissolve a substance?

After all these questions posed by the researchers and the feedback from pre-service teachers, all group students were asked to carry out the experiment given in Figure 3 and write their observations in the relevant places on the worksheets.

Hot water **Cold water**

Pour approximately 150 mL of hot water into one of the two 200 mL plastic glasses and approximately 100 mL of cold water in the other. Put another small 40 mL plastic cup into the large glasses. Make sure there is no water in the small glasses before proceeding with the next step. Get four candy-coated chocolates (like bonibon candies), all of which are one color. Put a candy in small glasses (40 mL) and large glasses (200 mL). Do not stir candies or shake the glasses. Record your observations of what happened.

Material	**Hot water**	**Cold water**	**Hot air**	**Cold air**
Candy coating				
Chocolate				

Which one melted?:

Under what conditions?:

What happens at the particle level while melting occurs?:

Which is dissolved?

Under what conditions?:

As dissolving occurs, what happens at the particle level ?:

Figure 3. Experimental Applications Regarding "Solutions: Dissolving-Melting"

Following the claims and justifications put forward by the pre-service teachers with their group mates, the following questions were directed to all group members by the researchers:

In order for pre-service eachers to define "Dissolving", the researchers guided them with the following questions:

1. Do you think the colored coating has dissolved or melted?

2. Where did the color coating go?

3. Has anything dissolved?

4. Did the colored coating disappear at the same rate in both glasses of water?

5. What is left after the color coating has disappeared?

6. Do you think the chocolate has dissolved or has melted?

The researchers guided the pre-service teachers to define "Melting" with the following questions:

1. In which glasses do you think the candies / chocolates melted?

2. What happened to the chocolates in water after the colored coating disappeared?

With all these questions posed after the experimental process, it was aimed to determine the definitions of "melting" and "dissolving" in pre-service teachers. Following the guidance on definitions, the following questions were asked in order to "determine the difference between dissolving and melting":

1. Have the candies dissolved or melted?

2. What was needed to dissolve/melt the colored coating on the candies?

3. What was needed for the chocolate in the center to dissolve/melt?

4. Where did the colored coatings on the candies go?

With the answers given by the group members to all the questions above, the researchers obtained clues about pre-service teachers' preliminary knowledge about the "Solutions: Dissolving-Melting". Afterwards, pre-service teachers were asked to perform their experiments according to the experimental setup given in Figure 3. They were asked to write all their observations during the experiment process in the relevant places in the worksheets distributed to them. This stage is the process in which the students are questioned whether their pre-experimental predictions (their claims to researchers and other classmates) are compatible with their observations during the process and the data they have obtained. The group members were asked to write their final explanations and refutes about the compatibility of the data they obtained from their observations with their claims before the experimental process. At this stage, the feedbacks of the pre-service teachers gave clues about the changes in their argument levels (being able to explain at the scientific argument level and write refutation). After all these applications, pre-service teachers were given research homework:

- Write at least five examples of dissolving or dissolving substances outside the laboratory (kitchen could be a good place for this question!!).

- Candy coating is made from a mixture of candy, corn syrup and artificial coloring. Remember what happened to the coating when you put these candy coatings in water. Well, could all the items create a situation similar to a candy coating in water, write your predictions.

The frequencies and percentages of all findings obtained from the pre-service teachers' POE activities are summarized in Table 2.

Table2. Scientific Argument Levels of Pre-service Science Teachers about "Solutions: Dissolving-Melting"

Argument Levels								
Making claim	Correct Claim				Wrong Claim (Misconception)		No Claim	
	Completely Correct		Partially Correct					
	f	%	f	%	f	%	f	%
	-	-	7	32	15	68	-	-
Being able to write justification	Correct Justification				Wrong Justification (Misconception)		No Justification	
	Completely Correct		Partially Correct					
	f	%	f	%	f	%	f	%
	4	18	-	-	11	54	6	28
Collecting data	Correct Data				Wrong Data		No Data	
	f		%		f	%	f	%
	22		100		-	-	-	-
Being able to make explanation	Correct Explanation				Wrong Explanation (Misconception)		No Explanation	
	Completely Correct		Partially Correct					
	f	%	f	%	f	%	f	%
	15	68	7	32	-	-	-	-
Being able to refute	Correct Refutatiton				Wrong Refutatiton (Misconception)		No Refutation	
	Completely Correct		Partially Correct					
	f	%	f	%	f	%	f	%
	4	18	3	14	-	-	15	68

The pre-service teachers were asked to write their claims and justifications for the focus question, "*Some people say that ice-cold solids dissolve and become liquid, while others say that solids become liquid by melting. Which of these statements do you think is true?"*. The answers given to all questions asked to pre-service teachers before the experimental procedures for the basic gain of "determining the basic difference between dissolving and melting" were analyzed according to Table 1. The pre-service teachers were first asked to give examples of what "melting" and "dissolving" and what melted or dissolved, and answered quickly. 68% of the pre-service teachers made wrong claims and 54% of these pre-service teachers gave the wrong reason, 14% could not present a justification. 32% of the pre-service teachers made partially correct claims and while 18% of these pre-service teachers could present the correct justification, 14% could not present a justification. The misconceptions of the pre-service teachers regarding their current understanding of "dissolving" and "melting" are as follows: "*Dissolving is the observed changes in the states of matter*"; *"Dissolving is the chemical ionization of matter"*; *"Melting is not always required heat, for example, when we put an ice cube from the freezer on the table without heating it on the stove, it will melt"; "Melting is a chemical event according to the type of matter. Ice melts at room temperature and becomes water, but a piece of iron does not melt at room temperature, we melt it in very, very hot furnaces and iron is no longer iron"; "Heat is not always necessary in dissolving, it can only increase the dissolution rate"*. Sample answers frompre-service teachers those make a partially correct claim and can provide correct justification: *"Actually, dissolving and melting seem to be alike. For example, when we put solid oil in a hot pan, it liquefies and the solid sugar disappears when it is put into a hot tea. They are the same as they both turn into liquid; but not quite, because we can see the melted butter but we can't see the sugar"; "We put a butter in a hot pan to melt it or put it on a toasted bread and it will no longer be solid. We can use water this time to destroy another solid, for example, we can see the transition of a tablespoon of salt from solid to liquid by throwing it into water.In the case of oil, heat was required, but in the case of salt or detergent, water is needed, not heat ".*

In applications, pre-service teachers expressed their current understanding of melting and dissolving processes before the POE activities. Afterwards, pre-service teachers were asked to perform their experimental processes according to the procedures. In this process, they observed what happened to the four sugar-coated pieces of chocolate in four different environments: hot and dry, cold and dry, hot water and cold water. They explained different results for the sugar coating and the chocolate in the center. Therefore, students produced definitions for melting and dissolving, based on their observations. The pre-service teachers carried out the experimental procedures as determined by the researchers and in sufficient times and recorded their expected observations.Thepre-service teachers were asked to present scientific arguments based on their observations together with the questions posed during and after the experimental procedure. While 32% of the pre-service teachers provided partially correct explanations, none of these pre-service teachers wrote refutation. 68% of the pre-service teachers provided correct explanations and 18% of these pre-service teachers were able to refute correctly, 14% were able to refute partially correct category and 36% did not refute at all. As an example of partially correct explanations of the pre-service teachers regarding the definitions of "melting" and "dissolving" and "fundamental difference between melting and dissolving" after experimental applications; *“Liquid is not required as a secondary matter for melting, but a liquid appeared later”; “A liquid may be required for dissolving and usually this is water”; "Generally, when we look around, we can say that solids always dissolve in water: for example, sugar or salt dissolves when we throw it into water."*As an example of the sentences that the pre-service teachers produced correct definitions for "melting" and "dissolving" based on the data they obtained in their observations during the experimental process; *“When a solid substance melts, its solid state goes into liquid. This change is caused by heating”; "When a solid is placed in water or other liquid, the gravitational force between the particles of the solid matter can be broken and the broken particles can move between the particles of the liquid"; "A solution of a matter consists of particles of the substance that are homogeneously mixed with the particles of the liquid in which it dissolves"; “In fact, melting is the transition from solid to liquid caused by heating.For example, in this experimental application, only the chocolate melted, the sugar coating dissolved”; "The kinetic energy of the particles in a melting matter increases because heat is given and the particles move away from each other as the matter passes from solid to liquid"; During dissolving, the particles of a solid are separated from each other and spread equally in the liquid.. For example, only the sugar coating dissolved in this experiment”*.

The pre-service teachers carried out their experimental applications to support their claims and justifications for the focus question. They tried to write their scientific arguments with the observations they obtained during the experimental application process. At this stage, it was observed that pre-service teachers were able to refute. Also, at this stage, pre-service teachers reflected how their thoughts might have changed from their first ideas. They added their idea of what happens when the particles dissolve or melt. All people frequently encounter instances of both melting and dissolving during everyday events; a pool of liquid wax forms around the wick of a lighted candle; in winter, we see that the snow on the street sometimes turns into water; we observe that a piece of chocolate in the sun becomes sticky. These are all examples of matters that transfer from solid to liquid when energy is transferred to these solid matters. In some other changes, energy, namely heat, transfer is not required. It's like the solid detergent you pour into a bowl of water to wash the laundry disappears after a while. These solids disappear in the water, and sometimes the color and sometimes the odor remain as evidence that the solid is there. These two processes, melting and dissolving are fundamentally different. Melting requires heat; dissolving requires a second matter to interact.

The most striking finding after POE activities within the scope of the argumentation supported learning applications is that pre-service teachers usually construct non-scientific arguments before the activity, and after the activity, they change their wrong and or incomplete/inadequate arguments, form scientific arguments and realize their misconceptions and correct them. Furthermore, it was observed that while the pre-service teachers could not justify many of their arguments before the experiments they carried out during the activities, they were able to write completely or partially correct explanations and refutes for their arguments in the light of the data they obtained based on their observations during the experimental procedures they were expected to do in practice.

RESULTS AND DISCUSSION

The reasons why chemistry is seen as a difficult field for students; it can be thought by both teachers and researchers that the way many chemical events occur is unfamiliar to learners and that the language used by chemistry is difficult to express these events. All these cause students to develop misconceptions about some chemical concepts (Ayaş & Demirbaş, 1997; Pardo & Partoles, 1995; Nakhleh, 1992; Zoller, 1990). Studies conducted to determine students' pre-knowledge and misconceptions show that misconceptions are not specific to a particular age group and are carried by students from all groups and levels (Fensham, Gunstone & White, 1995; Gonzalez, 1997; Bar & Travis, 1991; Özmen, 2005). If there are misconceptions in the students' pre-knowledge, these may not only interpret new information, but also sometimes prevent the comprehension of new information and lead to new misconceptions, which can increase the formation of undesired learning products (Andersson, 1986; Griffiths & Preston, 1992).

This study showed that students have some misconceptions about "Solutions: Dissolving-Melting" issues. Within the scope of the study, it was determined that the pre-service teachers' information about the concepts of "melting and dissolving" is in accordance with scientific facts, as well as incompatible with scientific facts, and summarized in Table 3.

Table3. The Misconceptions of Pre-service Teachers on " Solutions: Dissolving-Melting"

Identifed misconceptions
Dissolving is the changes observed in the state of matters such as melting.
Dissolving is the chemical ionization of matter.
Melting is not always necessary, for example, when we put an ice cube from the freezer on the table without heating it on the stove, it melts.
Heat is not essential for both melting and dissolving.
Melting is a chemical process that changes according to the type of matter, ice melts at room temperature and becomes water, but a piece of iron does not melt at room temperature, we can melt it in very high temperature furnaces and iron is no longer iron.
Heat is not always required for dissolving; heat can only increase the dissolution rate.

"Melting and dissolving" are two of the basic processes discussed in chemistry education, but these two concepts are often confused (Prieto, Blanco & Rodriguez, 1989; Ebenezer & Gaskell, 1995; Ebenezer & Erickson, 1996; Goodwin, 2002; Pierri et al., 2008; Çalık et al., 2010; Smith & Nakleh, 2011). This confusion may be a result of how students view melting and dissolving processes on a microscopic level. It is very important to transfer the subjects taught under the name of daily life chemistry to daily life in chemistry education. These two commonly used concepts are misused interchangeably: for example, dissolving of sugar in tea or dissolving of salt in water. As Goodwin (2002) states, melting and dissolving are concepts that can't be fully distinguished. There are many misunderstandings about melting and dissolving, such as: "Dissolved sugar starts melting, if sugar starts to dissolve in water, then it will take the characteristics of water, melting and dissolving are the same, lime cannot dissolve because it is very hard" (Slavy, 1991).

In this study, students' misconceptions about dissolving and dissolving were determined and POE activities were carried out within the scope of argumentation-supported learning as an alternative method to various current methods used for the same purpose to overcome these misconceptions. The POE technique puts the student at the center and makes the lesson practice-oriented. In this technique, pre-service teachers are asked to make a prediction about the phenomenon, event or concept presented in the activities, to explain their predictions with their reasons, to observe the events and to eliminate the contradiction between their predictions and observations (Atasoy, 2004; Köse, Coştu & Keser, (2003); Keeratichamroen, Panijpan, & Dahsah, 2007; Şahin & Çepni 2009). There are many studies that reveal POE technique contributes greatly to students' conceptual understanding success (Kearney & Treagust, 2000; Çimer & Çakır 2008; Aydın, Ekmekçi & Özkara, 2010). It can be said that with POE technique, students' motivation increased, they tested their current prior knowledge and had the opportunity to correct their wrong knowledge. They determined that the educational environments performed using the POE technique positively contributed to both the scientific process skills and the views on the nature of science (Bilen & Aydoğdu, 2012). It is emphasized that there is a mental conflict in students as a result of the succession of the prediction and observation stages in POE activities, and POE is an effective method in correcting misconceptions (McGregor & Hargrave, 2008). It is stated that revealing students' prior knowledge and teaching afterwards is an important factor in meaningful learning (Liew & Treagust, 1998). Meaningful learning takes place by establishing correct connections between newly learned concepts and previously learned concepts (Gil-Perez & Carrascosa-Alis, 1994). Studies have shown that the activities carried out with the POE technique contribute to meaningful learning and have a greater effect on eliminating misconceptions than traditional methods (McGregor & Hargrave, 2008; Rakkapao et al., 2013; White & Gunstone, 1992; Dumuş, 2014; Tetik, 2019; Yaman, 2012; Yıldırım, 2016; Altınok, 2017).

Concept teaching in learning-teaching environments has an important place in revealing students' misconceptions. Misunderstanding about a phenomenon/event or concept negatively affects the learning of other subjects. Therefore, it is important to diagnose and eliminate misconceptions in advance. In this context, educators should plan their learning-teaching environments by taking the prior knowledge of students into consideration and make arrangements to eliminate existing misconceptions beforehand. Considering from this point of view, one of the learning-teaching environments that can be used in the diagnosis and elimination of misconceptions in science education is the argumentation supported learning practices (POE activities) that we have discussed in the scope of the study.

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