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ORIGINAL ARTICLE

Examination of Conceptual Understandings Among Prospective Science Teachers On Electrolytic Conductivity Using Predict-Observe-Explain Implications

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Ethical Statement
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Conflict of Interest
"No conflict of interest is present in the conduction or the reporting of this study."

ABSTRACT

The aim of this study is to determine the effect of the Predict-Observe-Explain technique conducted within the scope of argumentation-supported learning on the conceptual understanding of prospective science teachers on "Electrolytic conductivity". Based on this main purpose action research in practice-based was applied in the study. It was observed that prospective science teachers often constructed non-scientific arguments and had difficulty in justifying many of their arguments before the implications. After the implications, it was observed that the prospective science teachers had the targeted arguments and were able to write grounds and rebuttal in the categories of completely/partially correct to their arguments.

Keywords: Argumentation-supported learning, chemistry-II course, electrolytic conductivity, predict-observe-explain technique, prospective science teachers.

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INTRODUCTION

It is important for science education that students take the necessary decisions accurately and quickly in the face of the negativities that they define as a problem for themselves, use the current technology required by the age, and do more research and more critical thinking (Temel, 2014). For this reason, science educators need to enrich and make competent such learning-teaching environments that focus on students who have acquired 21st century skills including all these skills and more. In learning-teaching environments where argumentation-supported learning method was used, students had the opportunity to use this skills frequently, such as to come up with a solution proposal with the use of various strategies in the process of eliminating the negativities defined as a problem, to enter the scientific discussion process by evaluating the claims with data and reasons, to think critically, to make judgments, to use scientific thinking skills and to make scientific decisions (Erduran & Msimanga, 2014; Osborne, Erduran & Simon, 2004; Vieira, Tenreiro-Vieira & Martins, 2011).

For the body text, use 8-point size with justified alignment. Use 1.5 spacing, except for the tables. For tables and figures, use single spacing. Do not indent the first paragraphs under the headings. Indent the following paragraphs at 0.5 centimeters (0.2 inches).

Argument and Argumentation

The concept of argument was first introduced to the literature by Toulmin in 1958. Toulmin has defined the argument as "a claim and its justification" (Toulmin, 1958). Argumentation, which is an important part of science education, is supported and evaluated with experimental or theoretical evidence (Jiménez-Aleixandre & Erduran, 2007), and included thinking and writing activities as a group or individually (Driver, Newton & Osborne, 2000; Osborne et al., 2004). In science classes, it is necessary to use the most appropriate teaching strategies in order to prevent the negativities experienced by the students during the argument construction stages and to develop these skills.

For this purpose, it is stated that the use of various strategies and techniques in science classes where the argumentation-supported learning method is applied can help prevent these negativities. Various strategies and techniques recommended to be applied in science classrooms where argumentation-supported learning method is used are stated as follows in the relevant literature (Osborne et al., 2004); statements table (Gilbert & Watts, 1983), concept maps (Sizmur & Osborne, 1997), preparing an experiment report (Goldsworthy, Watson & Wood Robinson, 2000), competing theories-cartoons (Keogh & Naylor, 1999; Naylor & Keogh, 2000), competing theories-story, competing theories-opinions and evidence (Solomon, 1991; Solomon, Duveen & Scott, 1992), argument structuring (Garratt, Overton & Threlfall, 1999), predict-observe-explain (POE) (White & Gunstone, 1992), and design experiments.

Predict-Observe-Explain (POE) Technique

The Predict-Observe-Explain (POE) technique was developed by White and Gunstone (1992). This technique was used by Osborne et al., (2004) to develop argumentation skills in the following years. This technique involves students encountering a scientific event and predicting what will happen with their group mates before the scientific event starts, discussing, asking necessary questions and confirming their reasons. In the phase after the predict phase, the scientific phenomenon is shown to the students and opportunities are given to them to review and re-evaluate the arguments they constructed in the first stage. At the last stage, students are asked to review and re-evaluate all their data from the first two stages together with their group mates, and then make a scientific explanation. In this technique, students focus on the theory that they themselves support and develop through discussion, predict, and evidence. Thus, existing misconceptions in students are also detected. This technique can be used at the beginning, middle or end of the lesson respectively.

The Importance of the Research

The existence of educational environments in which students are active and teachers are guides in schools and all kinds of educational environments is important for all societies. This will also enable more widespread use of learning methods based on the constructivist learning approach. Therefore, in order to provide effective learning-teaching environments, students should be provided to construct various science concepts in their own minds and a wide variety of teaching activities should be designed to realize meaningful learning (Köseoğlu, Tümay & Kavak, 2002). Some individuals may come to formal learning environments with a wide variety of ideas and explanations due to the events, experiences and impressions they have witnessed in their previous lives. At the same time, it reveals that these ideas and explanations of individuals are sometimes different from scientific knowledge accepted by scientists (Nakhleh, 1992).

The POE technique argues that individuals can make sense of newly encountered situations by making use of their previous experiences and prior knowledge (White & Gunstone, 1992). The POE technique is an effective technique in concept teaching in that it provides the opportunity to compare individuals with their observations by using their predictive skill (White & Gunstone, 1992). This technique activates the students' prior knowledge and leaves the conflict situation and the solution of this situation to the student. Therefore, it can be said that it is an effective strategy that provides concept teaching by structuring it in the minds of students (Kearney, Treagust, Yeo & Zadnik, 2001). The ability to use evidence, evaluate and criticize are important dimensions of science teaching. This ability also includes understanding the relationship between data, claims, and questions and how to organize these relationships to create evidence. Based on all these, it can be said that this dimension of science can be associated with argumentation. Involving students in the argumentation process should be one of the main objectives of the science curriculum (Driver et al., 2000). Especially written arguments play an important role in producing scientific knowledge in science education (Sampson & Clark, 2008). This technique, especially in predict and explain phases, mobilize students to produce arguments and written opinions facilitate the process.

In this context, the Predict-Observe-Explain (POE) technique which is one of the techniques recommended to be used in argumentation-supported learning method was used for the subject “electrolytic conductivity”. With the active use of the activities within this technique from the beginning to the end of the lesson; it is aimed in order to determine the existing misconceptions of prospective science teachers, to teach all the concepts, phenomenon and events in the relevant subject, and to determine whether the misconceptions determined at the beginning of the process have been eliminated. In this study also examined the views of prospective science teachers about the POE technique**.**

RESEARCH METHODOLOGY

In this study, action research in practice-based, which is one of the qualitative research methods, which aims to determine possible problems that arise in practice, the possible factors that cause these problems and possible ways of intervention, was used (Sagor, 2000).

Study Group

The study group of the research consists of 24 prospective science teachers (3rd grade university students) who took the Chemistry-II practice course. Prospective science teachers take Chemistry-I and II (theoretical and practical) courses in 5th and 6th semesters. The study group of the study was determined according to the purposeful sampling type, one of the non-random sampling techniques (Creswell, 2012). These prospective science teachers participating in the study performed the implications in Chemistry-I course according to the close-ended laboratory approach. The prospective science teachers worked as a group with at least three students during all the implications of the POE technique. It is recommended to work with small groups in technique where the argumentation-supported learning method can be integrated most effectively in the learning process, because students are responsible for the learning of both individually and their group mates (Johnson & Johnson, 2014).

Data Collection Tools

The data collection tools of the research are composed of worksheets filled by prospective science teachers with their group mates before and after the implications. These worksheets start with a problem statement for the specified chemistry subject in the "Predict" stage. In the next stage of the worksheets, there are activities prepared for the "Observe" stage of implications. This stage consists of instructions for experimental implications in order to provide "evidence, data and fact" to the claims and grounds put forward by prospective science teachers for the problem statement given in the first stage. In the last stage of the worksheets, activities related to the "Explain" stage, which is the last stage of the POE technique, are included.

Another data collection tool of the study is the fully-structured opinion form in which prospective science teachers participating in the activities evaluate the whole process. Content validity of the data collection tools was provided by the control of the activities and instructions determined by the researchers for the stages of the POE technique in the worksheets of two educators (science and chemistry educators). The worksheets were finalized in line with the suggestions of the two educators. For the reliability of the worksheets, 87% harmony between the same educators coding and categorizing the data was achieved.

Data Analysis

Content analysis was used in the analysis of the data. Before the implications, certain codes were created to determine the current misconceptions of prospective science teachers and the results were revealed in frequency. As Strauss and Corbin (1990) stated, either pre-determined concepts can be taken into consideration while coding, coding can be done according to the concepts extracted from the data or within a general framework. The data obtained from prospective science teachers were analyzed by coding, category structuring and frequency-percentage calculations. Toulmin argument analysis was used in coding and category structuring of the data. According to Toulmin's Argumentation Model, a simple argument contains claim and grounds (evidence, data and fact) components. In more complex and higher level arguments, there are warrant, backing, qualifier and rebuttal besides these components (Erduran, Simon & Osborne, 2004).

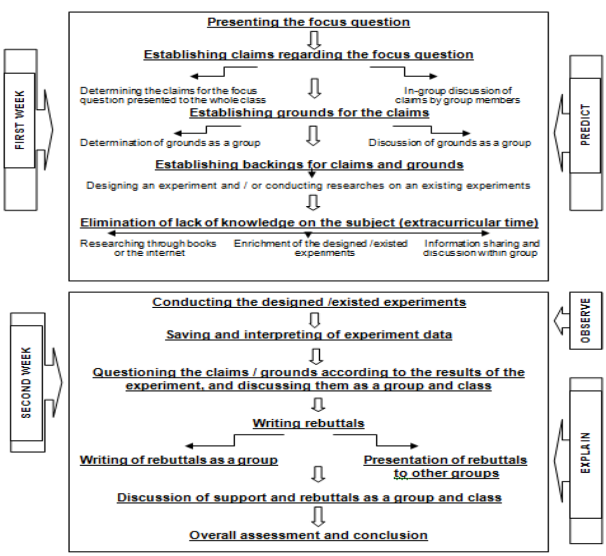
The worksheets were distributed at the beginning of the POE technique to determine the conceptual understanding of the prospective teachers on "electrolytic conductivity" was filled in by the prospective teachers during the implications. There is a main problem statement (focus question) at the beginning of the worksheets. For the POE implications recommended to be carried out in-class within the scope of argumentation-supported learning, studies on the conceptual understanding of students related to many basic science concepts in the literature were examined (Abraham, Grzybowski, Renner & Marek, 1992; Driver, Squires, Rushworth & Wood-Robinson, 1994; Johnson, 2000). The categories and codes determined in the literature were examined and the coding used by Okur and Seyhan (2021) in their studies was used for this study. The claims and grounds submitted by the prospective science teachers, the data obtained from the observations during the experimental activities, backings, explanations and/or rebuttals presented afterwards were coded and examined by the researchers.

Implication Process

The pilot implications of this study was carried out with prospective science teachers who were studying in the semester before the main implications. Pilot implications have been carried out in order to detect negative situations and take precautions before the main implications. It was observed that some problems were experienced during the pilot implications that prospective science teachers had difficulties in structuring the arguments (claim, grounds and rebuttal), this situation decreased with increasing number of activities. As a result of consultations with science and chemistry educators, the worksheets and the content of the activities were arranged. After that, the main implications were started.

In this study, argumentation-supported learning method (pilot and main implications) lasted for 3 weeks in total. The two-week flow chart of the implications is shown in Figure 1.

Figure 1. Predict-Observe-Explain (POE) technique carried out within the scope of argumentation-supported learning method flow chart.



A main problem statement was asked to the prospective science teachers for the "Predict" stage of this implications on the specified chemistry topic in the first week. The content of the main problem statement is about "what they know about the electrolytic conductivity of four solutions (salt solution, sugar solution, acidic and basic solutions) at concentrations of 1M, 3M and 5M and pure water. Whether the electrolytic conductivity of the solutions will change with the change in the concentration of each solution is also among the questions asked. Prospective science teachers were also expected to rank the electrolytic conductivity of different solutions at the same concentration as "very conductive/less conductive/no conductivity". They stated their claims and grounds for all these questions both verbally and in writing.

In the second week, the prospective science teachers performed the planned experiments for their answers to the questions in the first week. They carried out their experiments, made observations and provided backings for their claims and grounds through the data they obtained from their observations. At the last stage, prospective science teachers presented their scientific explanations to the researchers based on all their observations.

Results

The answers given by the prospective science teachers in the "Predict" phase of these implications were categorized and analyzed by the researchers as in Table 1.

Table 1. Categories and Codes Used for Scientific Arguments in the Analysis of Worksheets.

Variables (Table bodies use 6.5-point size)	Codes used in the analysis of prospective science teachers' responds			
	Correct Claim			
Making claim	Completely Correct	Partially Correct	Wrong Claim	No Claim
	Correct Grounds			
Being able to write grounds (Fact/evidence)	Completely Correct	Partially Correct	Wrong Grounds	No Grounds
	Correct Data			
Collecting data	Completely Correct	Partially Correct	Wrong Data	No Data
	Correct Explanation			
Being able to make explanation (warrant, backing, qualifier)	Completely Correct	Partially Correct	Wrong Explanation	No Explanation
	Correct Rebuttal			
Being able to rebuttal	Completely Correct	Partially Correct	Wrong Rebuttal	No Rebuttal

Note. Any table notes go here. (Notes use 6-point size)
JKL, just keep laughing; MN, merry noise. Do not forget to mention each special abbreviation in the footnotes (do not mention statistical abbreviations).

50% of the prospective teachers gave answers to these questions in the category of "***Wrong Claim-Wrong Grounds***";

"Sugar reduces the electrolyte of the water, so the lamp will not turn on; bases does not conduct electricity well, as the concentration increases, the conductivity will decrease; 1M solution of NaCl solution does not conduct electricity".

"However, 3M and 5M solutions will conduct electricity because they are stronger";

*"Pure water conducts electricity; *NaOH solution does not conduct electricity; NaCl does not conduct electricity because NaCl is a base. Therefore, we can say that bases do not conduct electricity. Because it gives to the environment OH- ion. This is not an adequate condition for electricity transmission";*

"Acids neither transmit electricity nor not transmit it, it is a semiconductor substance, their molarities do not affect their conductivity either";

"The sugar solution does not conduct electricity, but the higher its concentration, the higher the electrolytic conductivity; as the concentration increases, the electrolytic conductivity of acids increases, because as the concentration increases, the acid becomes a strong acid".

To some of these questions, 24% of the prospective teachers answered in the category of "***Partially Correct Claim-Wrong Grounds***";

"Since salt solution increases the conductivity of water, it transmits electricity";

"Pure water does not conduct electricity because it is neutral";

12.5% answered in the category of "Partially Correct Claim-No Grounds"; "

"In these solutions, only acids have conductivity";

37.5% answered in the category "No Claim-No Grounds";

"We have no idea about salt solution";

"We can make claims for salt and base solutions. But we could not develop a claim for the electrolytic conductivity of other solutions";

"We can make a claim about whether the sugar and salt solution conducts electricity, but we cannot say exactly why".

We can list the misconceptions encountered in line with the answers given by the prospective teachers to the questions about the specified subject of chemistry in the "Predict" stage as follows: 75% of the prospective teachers have the misconception that, "NaOH is a base and bases do not conduct electricity"; 50% of the prospective teachers have the misconception that "NaCl is a base and does not conduct electricity" and 50% of the prospective teachers have the misconception that "pure water transmits electricity"; 63% of the prospective teachers have the misconception that "the sugar solution does not conduct electricity, but the higher its concentration, the higher the electrolytic conductivity".

For the "Observation" stage of the POE technique carried out within the scope of the study, all the prospective science teachers and their group mates set up the mechanisms given to them and carried out their experiments in line with the instructions given by the researchers. It was observed that the observation data that all prospective science teachers noted during the experimental implications were in the "correct observation" category. Examples of some group members' observation reports are as follows:

" When NaCl dissolved in water, it transmitted electricity. The brightness of the lamp increased as the concentration increased. The lamp burned in NaOH solution. The brightness increased as the concentration increased. The aqueous solution we prepared for acids transmitted electricity. As the concentration increased, the lamp brightness increased. Pure water did not conduct electricity. The lamp did not turn on in the sugar solution".

In the "Explanation" stage, which is the last stage of the POE technique, the prospective science teachers made comparisons of the claims and grounds they put forward before the experimental implications and the data they obtained in the "Observation" stage. A discussion environment was created with the group mates and they were asked to answer the following questions presented to them according to this comparison result. In this way, clues were obtained about the final scientific arguments of the prospective science teachers about "Electrolytic conductivity":

"It is constantly said that when there is a change in the body's electrolyte balance during exercise, when the body loses electrolyte through perspiration after exercise, it manifests itself as muscle cramps, fatigue, nausea and dizziness. If electrolyte supplementation is insufficient, the muscles may not be able to work' at their full strength during the next workout"

- ✓ We hear an explanation like the above everywhere, for example in a sports program or we see it in writing in gyms. Well, have you ever thought what is meant by the term “electrolyte” in the explanation and what effects it has on our body? For which of the solutions of certain concentrations you have been asked to prepare above, would you use the definition of “electrolyte”? Can you make a prediction? Or is more than a prediction necessary?
- ✓ In which solution you prepared in the experimental applications you carried out did the lightbulb turn on and in which solution was the light brighter?
- ✓ What would you say about the effect of three different concentrations of the solutions you dealt with on the light / brightness level of the lightbulb? If you need to make a ranking for the relationship between the increase in concentration and the brightness of the bulb, how would you write a result sentence based on the data you obtained?
- ✓ Did pure water conduct electricity? Well, if you did the same experiment with the water from the tap, what kind of result would you expect to observe, why?
- ✓ Two of the solutions you used in experimental practice were acid and base solutions. If stronger and / or weaker acid and base solutions were used for this experimental application, what kind of a result would you expect for electrolytic conductivity or bulb brightness, why? Explain

The prospective science teachers and their group mates answered all the questions in the worksheets filled in during implications in writing. The answers written by the prospective science teachers on the electrolytic conductivity of acidic solutions were examined first. All the prospective science teachers stated that acidic solutions conduct electricity well before the implications and during the experimental implications. The prospective science teachers also stated that the brightness of the bulb of acidic solutions with increased concentration increased. It was observed that almost all of the participants gave advanced argument level responses, including “rebuttal and supportive” arguments, in their responses on the electrolytic conductivity of acidic solutions. Before the implications, the prospective science teachers had misconceptions that "bases, unlike acids, are solutions that do not transmit electricity". In the "observation" stage, they stated that the basic solution of NaOH conducts electricity at all three concentrations, and the brightness of the bulbs of the basic solutions with increased concentration, as in the acidic solutions, also increased. It was observed that 62.5% of the participants gave answers by using the "rebuttal" argument in their answers on the electrolytic conductivity of basic solutions. In the analysis of the answers written by the prospective science teachers on the electrolytic conductivity of salt solution, it was observed that they had a similar misconception as “NaCl is a base and does not conduct electricity” before the implications. After the implications, the prospective teachers stated that, with the help of the data they obtained from their observations, the salt solutions conducted electricity well, and as the concentration increased, the bulb brightness of the solutions increased. It was observed that almost all of the participants used the “rebuttal/ supporting/qualifying” arguments in their answers on the electrolytic conductivity of salt solutions. In the analysis of the answers written by the prospective science teachers on the electrolytic conductivity of sugar solution, it was observed that they had a misconception as “the sugar solution does not conduct electricity, but the higher its concentration, the higher the electrolytic conductivity” before the implications. After the implications, the prospective science teachers stated that, with the help of the data they obtained from their observations, the sugar solutions do not conduct electricity well. 37.5% of the participants stated that the sugar solution did not conduct electricity, but they did not use a sufficient rebuttal and/or supportive. In the analysis of the answers written by the prospective science teachers on the electrolytic conductivity of pure water, it was observed that they had misconceptions as "Pure water does not conduct electricity because it is neutral", "Since pure water is ionized, it will transmit electricity", "The lamp will turn on as pure water transmits electricity. Because we know that when our hand is wet, we always get electricity", "Pure water transmits electricity. Because it dissolves into ions" before the implications. After the implications, the prospective teachers concluded that, with the help of the data they obtained from their observations, "pure water" does not conduct electricity, and that the water that enables the transmission of electricity is actually tap water, not "pure water".

It was observed that prospective science teachers had misconceptions about the electrolytic conductivity of solutions (acid, base, salt and sugar) and pure water before the implications carried out within the scope of the study. It was determined that the claims and grounds presented by the prospective science teachers before the implications were at the level of simple argument. After the implications, the prospective teachers benefited from their observations they obtained during the experimental applications. They found a comparison opportunity through the diversity and concentration difference of the solutions included in the application. They gave more advanced argument level answers with the guiding questions asked by the researchers at the "Explain" stage after the implications.

After the implications, prospective science teachers were asked to evaluate the POE technique carried out within the scope of the argumentation-supported learning. It was mentioned above by the researchers that the prospective science teachers who were included in the implications carried out the Chemistry-I course using a close-ended experimental learning in the previous semester. While the prospective science teachers were evaluating the activities in this study, they were expected to consider the process that took place in the previous semester. The results obtained as a result of the fully structured interview forms given to prospective science teachers were analyzed by the researchers through content analysis. As a result of the analysis, the views of the prospective teachers were classified under three categories. The answers of the prospective teachers given to each Category are given below.

C1: Students enjoyed the application of the method (f: 19, % 80);

S5: In the 1st semester we were commenting on the experiments, we talked about and processes ready experiments. In the 2nd semester we prepared the mixtures and solutions. I enjoyed it better. I have no recommendations for the application of the course; I think it is quite good right now.

C2: They needed knowledge of chemistry more (f: 24, %100);

S19: I needed basic chemistry knowledge in the 1st semester. We carried out our experiments in the laboratory after we teach the subject in general chemistry. I still need it in the 2nd semester. What changed in the 2nd semester is that I see my mistakes and the things I didn't learn in general chemistry better.

S9: In the 1st semester, before we carry out experiments, there could be a very little error in the results because errors can always occur in experiments. It is the same in the 2nd semester but this time we know where these mistakes could be.

C3: Students prefer close-ended laboratory approach more (f:3, %12.5);

S15: I passed the course in the 1st semester but I couldn't in the 2nd semester. I have difficulty in numerical problems, I suffered too much this semester, and I hope I will pass. We can focus more on experimental calculations and work on examples in the class.

S23: 1st semester was easier compared to the 2nd semester because we knew what we were going to do before starting the experiment. But in 2nd semester we constructed and performed our own experiments. It is more permanent.

One of the questions in the fully structured interview form is about what prospective science teachers think about conducting the experimental implications of the relevant chemistry courses according to two different experimental method. The answer of 87% of the prospective science teachers was that there was a difference; the biggest difference was that in the first semester the experiments were given to them as ready and a written leaflet was distributed instructing how the experiment setting would be prepared and what is expected as a result of the experiment. On the other hand, 12.5% of the prospective teachers stated that there was no difference and they were more comfortable in the first semester and therefore they preferred the first semester more. Another question in the form was about how often they needed basic chemistry knowledge in their close-ended laboratory approach. All prospective science teachers said that no theoretical knowledge about the experiment expected in the first semester experimental implications was asked, the questions were mostly related to the results of the experiment and the findings they would obtain from their observations. Therefore, they stated that they did not need much knowledge of chemistry since they were given instructions for even how the experiments should be carried out in writing. The most important finding expressed by all prospective science teachers for this semester was that they much needed basic knowledge of chemistry. They stated that they did not have any problems about time in the laboratory week that concerns correct and sufficient chemistry knowledge, and that they had difficulties in answering the questions asked by the researchers in an accurate and acceptable level. Another question of the fully structured form was about the POE technique they performed this period. The prospective science teachers were asked at which stage of this implications they had more difficulty and how compatible were their results after their experiments with their predictions. 78% of prospective science teachers realized that they had difficulties individually in the predictions expected from them before the experiment, but when they thought by discussing with their group mates, they reached the answer and/or the expected goal more quickly and accurately. 84% of prospective science teachers said that they realized that what they knew as correct before was actually wrong. For example, a group of prospective science teachers stated that they learned that the basic solutions (NaOH), which they thought never transmitted electricity, actually transmitted electricity and they were very happy about this. In the fully structured interview form, prospective science teachers were finally asked to evaluate both semesters according to their own opinions. 87.5% of the prospective science teachers stated that the experiments in the first term were already ready, that the responsible researchers had already given the instructions to them in writing and that it was sufficient for them to come to the school.

DISCUSSION

In order to be good at chemistry, it is important for the student to make connections between everyday life and chemistry concepts. Because every substance that individuals encounter in daily life has its own characteristics, and chemistry simply explains these properties. However, in reality most students have difficulty in learning and understanding chemistry (Demircioğlu, Ozmen & Ayaş, 2004; Rogers, Huddle & White, 2000; Orgill & Sutherland, 2008). Since chemistry science includes many topics related to daily life, students have a lower level of success due to experiencing more learning difficulties in learning chemistry (King, Bellocchi & Ritchie, 2008; Özden, 2009).

Teachers can provide an educational environment that will create scientific conflict in their students in order to reveal what they think about a subject, phenomenon or concept. It is reported in the literature that many strategies, methods and techniques are used for this educational environment. When students are offered the opportunity for cognitive conflict, students will have to do something with the new information they encounter. The misconceptions encountered in students can provide a start for an effective education environment. Knowing what misconceptions are and using them will also be useful for teachers. Because most teachers sometimes have the same misconceptions as their students (Schoon, 1995; Shymansky et al., 1997).

Since students' misconceptions are defined as an important source of students' learning difficulties, it is also important to determine the reason for these misconceptions that occur in students' minds. An important reason for students' misconceptions is that students cannot explain chemical concepts at macroscopic, microscopic and symbolic levels (Raviolo, 2001). Some other reasons for misconceptions are that students are unable to visualize chemical phenomena as dynamic interactions spontaneously or attribute a different meaning to everyday words that have a different scientific meaning in their minds (Nakhleh, 1992) or students are involved in complex activities that require conceptual understanding (Yılmazoğlu, 2004). As a result, teachers should avoid memorization while teaching chemistry, apply more real-life situations to make the abstract as concrete as possible, and try to develop conceptual understanding by including constructivist teaching methods for students' learning difficulties and by correcting the situations caused by misconceptions. In order to improve the quality of teaching and contribute to the development of chemistry education, it is widely accepted that existing prior knowledge and advanced misconceptions about the concepts should be identified and then changed (Taber, 2002). As a result, studies to determine students' level of understanding of basic concepts are increasing. Methods such as concept mapping, interviews, drawings, tests are used in studies related to the detection of misconceptions and levels of understanding (White & Gunstone, 1992). Many different techniques are used in revealing the prior knowledge of students and in diagnosing their misconceptions and tools such as concept maps (Hazel & Prosser, 1994), predict-observe-explain (POE) (Liew & Treagust, 1998), interview about events and situations (Osborne & Gilbert, 1980; Osborne & Cosgrove, 1983), full / semi-structured student views on concepts and student drawings (Smith & Metz, 1996), word association (Maskill & Cachapuz, 1989), or different combinations of related techniques are the most commonly used techniques.

When the importance of misconceptions in students' understanding and learning was noticed, researchers turned to studies to identify misconceptions in students. Studies on the concepts of “acids and bases” have been investigated, and many different misconceptions about the concept of acid and base have been identified upon the inclusion of “acidic and basic solutions” in the subject of “Electrolytic Conductivity” discussed within the scope of the study. In the reviewed literature, it has been determined that the misconceptions determined on the conductivity of acids and bases and their properties in their solutions are as follows: “Acids are stronger and more dangerous than bases (Ross & Munby, 1991; Sheppard, 2006); Strong acids and bases cannot be fully ionized in their solutions due to the strong bond between them (Demircioğlu, Vural & Demircioğlu, 2012); Strong bases do not conduct electricity (Metin, 2011)”.

In studies examining students with misconceptions about electrolytic conductivity (Özkaya, 2002; Niaz, 2002; Coll & Taylor, 2001; Sanger & Greenbowe, 1997), the existence of many misconceptions about chemical bonds and electrolytic conductivity has been revealed in high school and university students (Coll & Taylor, 2001). In a study aiming to reveal misconceptions in students using semi-structured interviews (Garnett & Treagust, 1992), three different misconceptions about electric current involving the drift of electrons were identified. Sanger and Greenbowe (1997) examined students' misconceptions and proposed the mechanism of current flow in electrolytes. Current is the flow of electrons, but this flow is the flow of current and electrons in the opposite direction. Current flows from positive to negative, and electron flows from negative to positive. Rogers, Huddle and White (2000), while working on electrochemistry, designed a concrete teaching model to eliminate students' misconceptions about current flow.

In this study, it was observed that similar misconceptions encountered in the literature were reached for acid and base solutions, which are two of the solutions of which the prospective science teachers examined their electrolytic conductivity: “NaOH solution does not conduct electricity”; “NaOH is a base and bases do not conduct electricity”; “In these solutions, only acids have conductivity”. When the prospective science teachers, who regarded the basic solution differently from the acidic solution in terms of conductivity, were asked why they thought so, they stated that the acidic solution harmed the skin and other substances, they thought these were stronger and more active solutions than the basic solution, and therefore they thought it would conduct electricity better. They said that they thought that basic solutions could not conduct electricity as in the theoretical lectures on the general properties of acids and bases more innocent examples of basic solutions from everyday life such as “soap” were given. Students starts thinking of acids as “dangerous” when they are younger (Kind, 2004). In order to prevent students from considering “acidic” substances as stronger as and more active than “basic” substances, students should be allowed to develop their alkali knowledge, rather than allowing them to focus solely on acidic substances. In order to provide this educational environment, it may be suggested to classify substances with acid and base properties based on the pH levels of the products that are frequently consumed in daily life. Household cleaners such as ammonia, toothpaste, washing soda have basic pH values, while fruit juice, vinegar, tomato sauce, and shampoos tend to have acidic pH values.

Then, the properties of acidic and basic substances in the laboratory can be tested to show students that acidic substances are not more “dangerous” than base substances. Within the scope of the study, experimental implications were made for the electrolytic conductivity of acidic and basic solutions at different concentrations, and based on the “observations” during the implications, it was concluded that base solutions also have electrolytic conductivity like acidic solutions. In reaching this result, the students were instructed to remember the expressions they gave while making the definitions of the substances with “acidic and basic” properties. As stated by Cros et al., (1986; 1988) in their studies, students often have more difficulty in defining “basic” substances compared to the definition of “acidic” substances. Within the scope of the study, another issue that was understood to be a misconception among prospective teachers is that the conductivity will still not occur with the increase in the concentration of the solutions that they think do not have electrolytic conductivity. Another misconception observed in prospective science teachers is that especially acidic solutions increase their tendency to be strong acids with increasing concentrations. Since the subject of strength in acidic and basic substances is a subject that needs to be discussed separately, the misconceptions encountered in this subject among prospective science teachers were not discussed in detail in the scope of the study. When the literature on the results obtained from our study was examined, it was observed that there were similar misconceptions (Pabuçcu & Geban, 2015). The results of the study on the subject of “electrolytes and electrolytic conductivity” (Çalık & Ayas, 2005) and the results of the study by Akgün, Gönen & Yılmaz (2005) on the “structure and conductivity of mixtures” also support the results of this study. According to Akgün and Gönen (2004), observing the misconceptions encountered in students at primary and secondary education levels in university students also shows the permanence of misconceptions.

Another misconception encountered by prospective science teachers was about whether “pure water” conducts electricity or not. Most of the prospective science teachers agreed that “pure water conducts electricity” before the implications. When asked by the researchers why they thought so, they stated that especially in movies they almost always watched a scene defined by a human figure caught in an electric current after a hair dryer falls into a bathtub full of water. Or they talked about very dangerous situations to do, such as mixing water and electricity in the electrolytic socket in the house. Based on the observations during the implications, they realized that the "pure water" given to them by the researchers did not actually conduct electricity, and even it was a very good dielectric. They realized that the water considered "pure" was distilled water (condensed water from steam) and deionized water (used in laboratories). After the observations, they realized that the "pure water" they examined was also pure enough to contain ions, but it was not sufficient for electric current. When water begins to dissolve the substances around it, it stops being a perfect dielectric. It is best known for dissolving salts such as table salt (sodium chloride, NaCl). Chemically, salts are ionic compounds composed of cations (positively charged ions) and anions (negatively charged ions). In solutions, these ions cancel each other out, so the solutions are electrically neutral. In order to give the prospective teachers the knowledge that the presence of a small amount of ions in a water solution can conduct electricity (therefore, never add salt to your bath water), the prospective science teachers were asked about the conductivity of "NaCl solution" and the concept of "electrolyte" in an article that they can often see on the walls of sports centres. And they were also asked to justify why the human body needs electrolyte solutions when exercising. Electrolyte solutions normally form when salt is put in a solvent such as water. For example, when table salt NaCl is put in water, the salt (a solid) dissolves into component ions according to the decomposition reaction, only compounds that dissociate into component ions in solution are qualified as "electrolytes". After the implications, prospective science teachers emphasized that compounds that easily form ions in solution are known as strong electrolytes, so all strong acids and bases can be strong electrolytes. Researchers were asked to read the descriptive content information of the labels of the various brands of sports drinks brought to the laboratory. They have reached the knowledge that sports drinks are defined as electrolytes because they contain sodium, potassium, magnesium and other ions, that people will lose ions necessary for vital bodily functions when they sweat, that electrolyte solutions should be consumed while doing sports and more ions should be consumed in order to replace them.

The prospective science teachers were also asked their predictions about the conductivity information of non-electrolyte solutions. Most prospective science teachers agreed that non-electrolyte solutions such as glucose or C6H12O6 would not conduct electricity. Their misconception was in their justification of the lack of conductivity. Typically, non-electrolytes are held together by covalent bonds rather than ionic bonds. After the implications, prospective science teachers, who have sufficiently understood the causes of electricity conduction of electrolyte solutions, stated that non-electrolyte solutions are non-ionizing compounds in solution, they stated that glucose (sugar) dissolves easily in water, but is considered a non-electrolyte substance because it does not dissociate into ions in solution, they also explained that solutions containing glucose do not conduct electricity because of this.

CONCLUSIONS AND SUGGESTIONS

Teaching knowledge in a significant part of the current teaching programs in Turkey are designed as content knowledge and pedagogical knowledge, and subjects related to the teaching of the content are not adequately included in the programs. Pedagogical content knowledge covers the type of information on how to teach the subject area and is the ability to present and formulate a topic more clearly for others. In the program updating process, it is aimed to train qualified prospective teachers with high level of pedagogical content knowledge as well as ethical, model prospective teachers who adopted professional values and ideals.

As a result of Council of Higher Educations' revision in 2018 regarding teacher training undergraduate programs, the

Science Education Undergraduate Program are also included in these updates in Turkey (Council of Higher Education, 2018). The teaching of implication stages of Chemistry-I and II courses are planned in a period of approximately 7-8 weeks. While the use of laboratories in science education was seen as unnecessary until 1850's, these started to be discussed by science circles after 1850 and curricula related to this were prepared (Aydın, 2005). However, the curricula prepared were limited to the implications being in the form of demonstration experiment and proof method (Brown & Atkins, 1988). For this reason, environments that would enable students to think independently, give importance to scientific studies and research, and ensure that information is structured with active participation could not be created. When considered in this context, programs using modern laboratory approaches are needed (Aydın, 2005; Yıldız, 2012). According to the results of studies carried out by many science educators, learning environments such as open-ended laboratories emphasize the research and inquiry skills of students (Rocard, Csermely, Jorde, Lenzen, Walberg-Henrikson, & Hemmo, 2007), support the science literacy (OECD, 2012), and motivates students by increasing their interest and achievement levels (Rocard et al., 2007).

It is clearly stated with the results obtained from this project and from various studies that learning environments where more permanent experiences will be realized will not be possible by giving the information to the students in a cookbook format before the implications. Instead of using close-ended experimental method alone, it can be ensured to use different learning environments together, to enrich the teaching and to use them together to support each other and overcome each other's deficiencies. POE technique is student-centred and enriches the course in terms of implications. In this technique, prospective science teachers make predictions about the problem situations presented in the activities, justify their predictions, make observations and try to eliminate if there is a contradiction between the claims they presented and their observations. POE technique contributes to students' conceptual understanding (Kearney et al., 2001; Çimer & Çakır 2008), studies have shown that it is more effective than close-ended experimental method in eliminating misconceptions (McGregor & Hargrave, 2008; Rakkapao, Pengpan & Prasitpong, 2013; White & Gunstone, 1992). In these implications, students experience a mental conflict with the successive estimation and observation phases, their prior knowledge is tested, and it is said to have an effect on correcting misconceptions.

In summary, it comes to the fore that it is necessary to include experimental implications with more interaction with students on the relevant topics covered in the study. In addition to the theoretical knowledge such as the definition and properties of electrolyte solutions, it is also among the suggestions in the study that more educational activities should be included for prospective science teachers in terms of where electrolyte solutions are frequently used in daily life and which properties of non-electrolyte solutions may be advantages and / or disadvantages for living things. For example, it is necessary to focus on the working principle rather than the definition of the "battery" concept, which is a device that stores energy in chemical form and which we use frequently in daily life. It can be said that Predict-Observe-Explain technique carried out within the scope of argumentation-supported learning that reveal the misconceptions of prospective science teachers, make meaningful learning by enabling them to structure various chemistry concepts in their own minds, lead to the development of more positive attitudes towards chemistry, increase motivation and are easy to apply and effective.

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