The Review on the Science Process Skills and the Levels to Create a Graphic: The Sample on Preservice Science Teachers*

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Abstract. In science education, drawing tables and graphics is a part of science process skills, and preservice teachers are expected to have these skills. The aim of this study is to examine the science process skills and create a graphic levels of preservice science teachers based on a given problem scenario. In the research, the survey method has been used. The research has been conducted with 87 preservice teachers in total who receive their education at the third grade in The Department of Science Education in a state university in Blacksea region. The worksheet which has been developed by the expert researchers in their field has been used in order to collect the data. 17 items and 3 aspects have been used in order that the data on this activity worksheet has been evaluated. The exact statements which include the scientific accuracy have been encoded as sufficient, the partly scientific accuracy have been encoded as partially sufficient, and the incorrect statements and the empty answers have been encoded as insufficient. According to the frequency distribution table which has been made as a result of the data, it has been determined that the preservice teachers are insufficient on the subjects of being able to show the data of variables in the scenario on the ready figures, to position the variables correctly onto the axes. According to the results obtained from the research, it is thought that other studies can be conducted on the subjects that the preservice teachers are partially sufficient and insufficient.

Keywords: Science process skills, science education, create a graphic, preservice teachers, problem scenario

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1. INTRODUCTION

Many teaching contents such as concept cartoons, concept maps, problem-based learning, project-based learning, brainstorming, puzzle and puzzle creation, open-ended experiments, story writing, role-playing, creative drama, asking questions and scientific discussions can be provided in research and inquiry-based learning philosophy, and these kinds of learning experiences can have significant effects on science process skills (Demir, 2014). Inquiry positively affects students’ academic success, problem-solving skills, ability to organize and reflect learning and increases motivation (Medrano, 2012). According to Werner (2007), a research-based learning approach consists of case study activities, social activities, invention-based, project-based studies and problem-solving studies. Observing and improving science process skills, especially with problem scenarios, is a very effective method.

Considering the development of science process skills with inquiry-based learning, the interaction between them is quite effective in science education (Şahin and Benzer, 2012). As a matter of fact, while Demir (2014) revealed in her study that research and inquiry-based learning have a positive effect on science process skills, Anagün and Yaşar (2009) concluded that the application of the constructivist approach based on the 5E model is effective on the development of science process skills of fifth-grade students. Similarly, Şensoy and Yıldırım (2017) found that the inquiry-based learning approach has a positive effect on students’ science process skill levels.

Ewers (2001) defines science process skills as observing, classifying, making inferences, predicting, measuring and communicating and states that these skills are the basis for developing scientific knowledge, but besides this, many science lessons do not include the process of how knowledge is developed. Appropriate teaching methods should be used to ensure that students have a positive attitude towards science and improve their science process skills (Başdaş, 2007). Ongowo and Indoshi (2013) stated that science teachers should encourage the development of science process skills as these practices lead students to investigate important issues in their environment. Tan and Temiz (2003) in their research emphasized the importance of science process skills in science teaching with the titles of problem-solving, contribution to mental development, persistence in learning, contribution to scientific literacy, child-scientist similarity and laboratory approach.

Science process skill is an approach that enables the organization of skills suitable for different science disciplines (Karamustafaoğlu and Yaman, 2006). Actually, science process skills can be defined as the process of recognizing the science that is in life. Based on this definition, the development of science process skill requires the habit of looking at events from different perspectives.

In her study, Kemiksiz (2016) reached the conclusion that scenario-based learning provides permanence on success and attitude towards science course. In addition, Sezgin Selçuk (2015), as a result of her research conducted with science teachers, stated that the scenario is effective and useful and can be used during in-service teacher
training. As can be seen from all these studies, problem scenarios constitute a very effective environment for inquiry-based learning. With problem scenarios, students try to find a solution to the problem in their mind and try to test the solutions by experimenting or generating ideas. Thus, they can experience the process of obtaining a scientific solution. One of the most important elements in raising individuals who can produce independent ideas, make observations, be creative, problem-solving, researcher and make interpretations is seen as experimenting especially in science lessons (Yıldırım and Türker Altan, 2017). As a matter of fact, Aydoğdu (2009) in his study which aims to examine the effects of research-based and open-ended experiment techniques used in science and technology lessons on students' science process skills, views on the nature of science and learning approaches stated that these variables affect each other.

Drawing tables and graphics in science teaching is a part of science process skills, and preservice teachers are expected to have these skills. In this context, it is thought that the use of two-dimensional tools such as tables, graphs and figures are effective tools in expressing the science process skills based on the scenario. A table or graph can sometimes summarize a very long paragraph nicely and help students learn concretely with the visual aids used. As a matter of fact, during the processing and interpretation of the data, the students draw a graph on the vertical and horizontal axis of the data obtained from the experiment, try to determine how the independent variable affects the dependent variable by interpreting the graph (Küçüközer, 2017). In this respect, according to Talaslıoğlu and Şahin (2018), graphs, which are sufficiently included in the science education programme and have an effect on the development of students' science process skills, appear as important educational tools that help concretize the data. Creating graphs and interpreting the existing graphs can provide a very effective learning process in science process skills, especially in terms of developing the analysis step. At this point, the individual feels the need to evaluate his existing knowledge and enters into structuring the knowledge as a scientific method in his mind.

As can be seen from all these literature reviews, problem scenarios, science process skills and creating graphs seem to be important elements that complement each other. Based on this point, it is thought that the development of science process skills and graph creation skills are important for forming problem-based learning and inquiry-based learning environments.

In this context, the aim of the study is to examine the science process skills and graph creating levels of preservice science teachers based on a given problem scenario.

2. METHOD

Research Model

The research is a survey study, which aim to collect data to determine specific characteristics of a group are called survey studies (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel, 2008). Descriptive research is often used as a method to obtain
summary information about different phenomena and events that we want to study (Büyüköztürk et al., 2008).

Research Group
The research has been conducted with 87 preservice teachers in total who receive their education at the third grade in The Department of Science Education in a state university in Blacksea region. In the research, the convenience sampling method was selected with respect to easy access to sampling and implementation.

Collection Data Tools
The worksheet which has been developed by the expert researchers in their field has been used in order to collect the data. In addition, preservice teachers applied the semi-open-ended experiment activity developed by the researchers as well as the activity sheet. The preservice teachers were taken to the laboratory for implementation in rotation, and the activity lasted approximately 2 lesson hours for each group.

The scenario given to preservice science teachers through the activity sheet in the study is as follows:

“One day, the teacher asks a question to three hardworking friends named Ayşe, Mehmet and Umay and says that he will award whoever answers the question correctly. The question is as follows: “Let’s put a 120 cm long rope through a cylinder with both ends open and tie a 20 g mass to the end of the rope on the side that will make a circular motion. Then, let’s tie a 100 g mass to the other end of the rope in the vertical direction, put a mark on the rope with a felt-tip pen every 10 cm. Then, taking these points as a reference, let’s turn them over our head to form circles with 10 cm, 30 cm and 50 cm radius. In which mechanism do you think the time for the mass to reach the same position will be the shortest?” The teacher gives the students 3 minutes to think and asks them to show their answers on a piece of paper at the same time. The answers are quite different from each other…”

The predictions of the three friends are given in Figure 1.

![Figure 1. Predictions of the three friends](image-url)
Semi-open-ended experiment process:

“As a result of these different answers, the teacher asks the students to carry out this experiment. The students start measuring the times with a stopwatch by obtaining the necessary materials and setting up the mechanism. Realizing that one full turn of the mass that moves in a circular motion is very short and that it will be very difficult to measure with a stopwatch, Mehmet suggests to his friends to measure the time that passes for 10 complete turns of the mass and from there to switch to period measurement. Umay, who thinks that this idea will be good, states that they cannot get accurate results with a single measurement and emphasizes the necessity of repeating the same operations 5 times for each radius distance. Ayşe also agrees with Mehmet and Umay friends, and they start to obtain the data together.”

✓ First; the times elapsed for 10 complete turns of a 10 cm radius circle are 2.40 s; 2.42 s; 2.38 s; 2.43 s; 2.47 s
✓ Later; the times elapsed for 10 complete turns of a 30 cm circle are 2.85 s; 2.82 s; 2.96 s; 2.79 s; 2.93 s and
✓ Then; the times elapsed for 10 complete turns of a 50 cm radius circle are 3.11 s; 3.14 s; 3.17 s; 3.14 s; 3.20 s.

The ready-made shapes are given in Figure 2.

![Ready-made shapes](image)

**Figure 2. Ready-made shapes**

**Analysis of Data**

The 17 evaluation criteria used for the evaluation of the data in the activity sheet were created from the pool prepared by science expert researchers by creating various codes. For the analysis of these evaluation criteria, 3 dimensions were determined as Likert type, which includes sufficient, partially sufficient and insufficient options. Validity was achieved by comparing the evaluation criteria and dimensions of the two researchers. Descriptive analysis was used as a method of analyzing qualitative data in the study. Yıldırım and Şimşek (2006) define descriptive analysis as summarizing and interpreting data according to predetermined themes and data are placed according to the thematic framework created based on the existing dimensions. Here, the findings are defined and interpreted by providing direct quotations where necessary. Indeed, in research, the
exact statements which include the scientific accuracy have been encoded as sufficient, the partly scientific accuracy (if the number of correct numbers are more than the number of errors) have been encoded as partially sufficient, and the incorrect statements and the empty answers have been encoded as insufficient.

In order for a research to be considered as scientifically accurate, it should also be examined by other researchers (Yıldırım and Şimşek, 2006; Yıldırım, 2010). Therefore, the percentage of agreement of two researchers was checked with the formula [Agreement/(Disagreement + Agreement) x 100] (Miles and Huberman, 1994) and this value was calculated as 90%.

3. FINDINGS
The findings regarding the preservice teachers’ skills of analyzing the problem scenario before the graph creation process have been analyzed and presented. The evaluation of the preservice teachers’ ability to make predictions is given in Table 1.

Table 1

| Evaluation Criteria                                      | Sufficient | Partially Sufficient | Insufficient |
|---------------------------------------------------------|------------|----------------------|--------------|
| Being able to make a prediction based on the scenario and explain the reason | 34         | 42                   | 11           |

When Table 1 is examined, it is seen that the preservice teachers’ ability to make a prediction based on the scenario and explain the reason is partially sufficient (f=42). The evaluation of preservice teachers’ ability to record data on the shape is given in Table 2.

Table 2

| Evaluation Criteria                                      | Sufficient | Partially Sufficient | Insufficient |
|---------------------------------------------------------|------------|----------------------|--------------|
| Being able to show the data of the variables in the scenario on the given shapes | 20         | 32                   | 35           |
When Table 2 is examined, it is seen that preservice teachers’ ability to show the data of the variables in the scenario on the given shapes is insufficient (f=35). The evaluation of preservice teachers’ ability to determine hypothesis and variables is given in Table 3.

Table 3

*Evaluation of the ability to identify hypotheses and variables*

| Evaluation Criteria                                                                 | Sufficient | Partially Sufficient | Insufficient |
|------------------------------------------------------------------------------------|------------|----------------------|--------------|
| Being able to determine an appropriate hypothesis for the scenario                 | 58         | 24                   | 5            |
| Being able to express the independent variable                                   | 38         | 20                   | 29           |
| Being able to express the dependent variable                                     | 37         | 16                   | 34           |
| Being able to express the controlled (constant) variables                       | -          | 75                   | 12           |

When Table 3 is examined, it is seen that preservice teachers’ ability to determine an appropriate hypothesis for the scenario is sufficient (f=58), ability to express the independent variable is sufficient (f=38), ability to express the dependent variable is sufficient (f=37) and ability to express the controlled (constant) variables is partially sufficient for (f=75). The evaluation of preservice teachers’ ability to create a table is given in Table 4.

Table 4

*Evaluation of the ability to create a table*

| Evaluation Criteria                                                                 | Sufficient | Partially Sufficient | Insufficient |
|------------------------------------------------------------------------------------|------------|----------------------|--------------|
| Being able to create an appropriate table based on the scenario                     | 69         | 13                   | 5            |
| Being able to organize the data in the                                             | 4          | 46                   | 37           |
scenario and record in the table

Being able to express the units and symbols belonging to the variables correctly for the table

|       | Sufficient | Partially Sufficient | Insufficient |
|-------|------------|----------------------|--------------|
| 36    | 39         | 12                   |              |

When Table 4 is examined, preservice teachers’ ability to create an appropriate table based on the scenario is sufficient \((f=69)\), ability to organize the data in the scenario and record in the table is partially sufficient \((f=46)\) and ability to express the units and symbols belonging to the variables correctly for the table is partially sufficient \((f=39)\). An example table created by preservice teachers is given in Figure 3.

![Figure 3. Example table](image)

When Figure 3 is examined, it is seen that the preservice teachers used the period \((T)\) symbol for the time elapsed for \((PT63w)\) 10 complete turns, but they did not express the second \((s)\) as the unit and did not express the radius variable on the table with a symbol \((r)\) and unit \((\text{cm or m})\). The evaluation of the graph drawing skills of the preservice teachers is given in Table 5.

| Evaluation Criteria | Sufficient | Partially Sufficient | Insufficient |
|---------------------|------------|----------------------|--------------|
| Being able to create an appropriate graph based on the data in the table | 84         | -                     | 3            |
Being able to position variables accurately on axes 40 4 43

Being able to express the units and symbols belonging to the variables correctly for the graph 8 56 23

Being able to place the data proportionally to the axes 71 14 2

Being able to place the data correctly in the table on graph paper 7 73 7

Being able to show the point of the data by drawing a small circle around the specified point 14 66 7

Being able to draw an appropriate line/curve covering the determined points 79 - 8

Being able to explain the similarities and differences between initial prediction and observation results 27 35 25

When Table 5 is examined, it is seen that preservice teachers’ ability to create an appropriate graph based on the data in the table is sufficient (f=84), ability to position variables accurately on axes is insufficient (f=43), ability to express the units and symbols belonging to the variables correctly for the graph is partially sufficient (f=56), ability to place the data proportionally to the axes is sufficient (f=71), ability to place the data correctly in the table on graph paper is partially sufficient (f=73), ability to show the point of the data by drawing a small circle around the specified point is partially sufficient (f=66), ability to draw an appropriate line/curve covering the determined points is sufficient (f=79) and ability to explain the similarities and differences between initial prediction and observation results is partially sufficient (f=35).

An example graphic created by preservice teachers is given in Figure 4.
When Figure 3 is examined, it is seen that the preservice teachers (PT40w) could not place dependent (period-T) and independent (radius-r) variables on the correct axes according to the graph they drew and instead of period T(s), used t(s) for the time value obtained for each measurement in the drawing.

4. CONCLUSION, DISCUSSION AND SUGGESTIONS

It has been determined that there are points where the science process skills of preservice science teachers for a given problem scenario are insufficient, partially sufficient and sufficient regarding recording data, using the data and creating a model which are among the science process skills and creating tables and graphs which covers data interpretation steps. The process of extracting and determining data obtained from a scenario and transforming these data into graphs seems to be significantly related to science process skills. The ability to identify and extract data from an existing situation, create graphs from these data and interpret the graph can be expressed as a very important situation in terms of science literacy. As a matter of fact, according to Yeh and McTigue (2009), it is emphasized that visual literacy such as table and graphic reading should be taught especially at an early age in order to raise individuals who can make decisions in many areas. The most important person who can realize this situation in the individual is seen as the science teachers.

When the results obtained from the study are examined, although the preservice science teachers have at a sufficient level of determining an appropriate hypothesis belonging to the scenario, expressing the dependent and independent variables, it is important to state that they have partially sufficient level of making predictions based on the scenario and explaining the reason, and expressing the controlled (constant) variables and they have an insufficient level of showing the data of the variables in the scenario on the given figures and positioning the variables correctly on the axes. At this point, it is seen that preservice science teachers need a little more experience, especially in determining variables.

While it was determined that preservice science teachers could create a table from the scenario and an appropriate graph based on the data obtained from the table, the fact
that they have an insufficient level of showing the data belonging to the variables included in the scenario on the given figures indicates that this skill has not yet fully developed in preservice teachers regarding the ability to extract and interpret the data from the scenario. In the study conducted by Kozcu Çakır and Sarıkaya (2018), it was determined that the preservice teachers have good skills in such dimensions as constructing and interpreting hypotheses, determining variables, reading and interpreting the graph, designing an experiment and interpreting the results and recording the data of the experiment with respect to their integrated process skills while it was observed that they had difficulties in defining and determining dependent, independent and controlled variables and in identifying and understanding science process skills. As a matter of fact, when another study on science process skills is examined, it is seen that students have deficiencies in interpreting data and graphics (Bowen & Roth, 2005). Accordingly, Talaslıoğlu and Şahin (2018) emphasized that sufficient importance should be given and supported to the graphic reading skill, which is included in international exams, in order to create a difference in the perception of the individual.

In the study conducted by Abdi (2014), it was determined that the inquiry-based learning method had an effect on the academic achievement of the students in the science course. According to Kaptan and Korkmaz (1999), science process skill develops more than organizing observable information and using these skills in daily life and having a more positive attitude towards science. As a result of the research conducted by Ünalı (2012), it was determined that the science education practice based on science process skills has positively changed students’ attitudes towards science and technology lesson and their science process skills. In addition, Meador (2003) emphasized that thinking and discussing like a scientist are necessary for science process skills. Based on all these literature and results, it is thought that it is necessary to focus more effectively on these deficiencies existing in the teaching process in order for our students to reach a point where they can compete at an international level and develop their skills. It is thought that the experimental activities associated with the problem scenarios and including the steps such as creating tables, graphs and figures are essential for the students to develop their science process skills and to construct inquiry-based learning more effectively.

In this context, it is thought that such practices should be adapted to different subjects, contents and acquisitions, and similar situations should be presented more to the preservice teachers.
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