Examining preservice science teachers' skills of formulating hypotheses and identifying variables[1]

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Received 6 Jan., 2014
Revised 12 Feb., 2015

Contents

Abstract

The aim of this study is to examine preservice science teachers' skills of formulating hypotheses and identifying variables. The research has a phenomenological research design. The data was gathered qualitatively. In this study, preservice science teachers

[1] Part of this study was presented as an oral presentation at the 10th National Science and Mathematics Education Congress organized by Niğde University, TURKEY

were first given two scenarios (Scenario-1 & Scenario-2) containing two different research problems, which examined in detail preservice science teachers' skills of formulating a hypothesis and identifying variables. Then, pre-service science teachers were divided into three groups (those who formulate a hypothesis and identify variables correctly, partially correctly, and incorrectly). Three pre-service science teachers were selected from each group. They were asked to teach formulating a hypothesis and identifying variables based on two scenarios (Scenario-3 & Scenario-4) and observed for confirmation. The gathered data were analyzed using both descriptive (Scenario-1 & Scenario-2) and content analyses (Scenario-3 & Scenario-4). Two hundred and five (205) senior preservice science teachers, studying at the Department of Science Teacher Education at a state university in Turkey, participated in the study. At the end of the study, the results showed that preservice science teachers' skill at formulating a hypothesis and identifying dependent, independent and control variables accurately was low; their skill at identifying and controlling variables accurately was especially lower. The data from observations also indicated that pre-service science teachers had difficulty even in defining a hypothesis, formulating a hypothesis based on a problem, exemplifying ideal hypotheses, and defining, identifying and controlling variables. One of the most important reasons why preservice science teachers were not able to identify variables accurately was that they mistook one for variable another. Preservice science teachers accepted their mistakes and made various excuses for their poor performance.

Keywords: Formulating hypothesis, identifying variables, preservice science teachers, science process skills

Introduction

In general, students do not perceive science lessons in relevance to daily life and see them merely as content that is learned at school (Ledbetter, 1993). However, it is very important that students recognize how science process skills learned in science classes, such as search and inquiry, can be applied to problems they encounter in their daily lives. Learning science is not remembering content, but also learning to master the science process skills and to apply those skills in scientific investigation (Jeenthong, Ruenwongsa and Sriwattanarothai, 2014). Students who have these kinds of experiences will realize the usefulness of their knowledge, learn how to reach sources of knowledge, and produce new knowledge using their present knowledge. In order to achieve this result, students should learn the scientific research process (Gay, Mills & Airasian, 2009:5). The scientific research process can be taught through using science process skills (American Association for the Advancement of Science, 1989). The scientific research process can be described as identifying a problem, gathering data, analyzing the data and interpreting the gathered results (Fraenkel & Wallen, 2006:7). Therefore, scientific research develops students' higher level thinking skills, such as asking questions, doing research, solving problems (Cuevas, Lee, Hart, & Deaktor, 2005). In fact, we know that science process skills are related to scientific research process (Aydoğdu, Erkol & Erten, 2014). Science process skills help students to become active individuals in the learning process (Çepni, Ayas, Johnson, & Turgut, 1996). Using science process skills is an important indicator of transfer of knowledge which is necessary for problem-solving and functional living (Akinbobola & Afolabi, 2010). Therefore, these skills are necessary for individuals living in a rapidly developing society. Individuals with these skills have the ability to make a major contribution to the improvement of society.

Science Process Skills

Individuals who have science process skills have learned to solve problems (Aktamış & Ergin, 2007) and have developed higher-ordered thinking skills. Science process skills (SPS) are among the most frequently used thinking skills (Gagne, 1965: 145; Aydoğdu, Tatar, Yıldız-Feyzioğlu & Buldur, 2012), and their acquisition is one of the most important aims of science teaching (Bybee & Deboer, 1993). Myers, Washburn & Dyer (2004) stated that SPS form the basis of science, enabling individuals to discover the results at their research and inquiries results, so enabling students to acquire these skills in science education is extremely important. SPS are not only used in the learning-teaching process at school, but are also used in daily life (Rillero, 1998; Karslı & Şahin, 2009). Therefore, everyone, not only scientists, should acquire these skills (Huppert, Lomask & Lazarowitz, 2002). Rillero (1998) emphasized that individuals who cannot use SPS will have difficulty succeeding in daily life. Therefore, these skills affect the personal, social, and global lives of individuals (Aktamış & Ergin, 2008). Similarly, Roth & Roychoudhury (1993) stated that students who frequently used SPS to solve open-ended questions were more academically successful. Harlen (1999) and Ferreira (2004) highlighted the importance of science process skills to the acquisition of scientific literacy in science teaching. Science teaching thus needs to be redesigned in a way that emphasizes science process skills (Saat, 2004).

SPS are defined as tools for acquiring information about the world and for ordering this knowledge (Osborne & Freyberg, 1985; Ostlund, 1992). Harlen (1999) claimed that students who cannot adequately learn SPS may not understand the world around them and form the necessary connections. Tobin & Capie (1982) defined SPS as identifying a problem, formulating a hypothesis about the problem, making valid predictions, identifying and defining variables, designing an experiment to test the hypotheses, gathering and analyzing data, and presenting rational findings that support the data. These skills are handled in the related literature in two categories: basic and integrated SPS (Yeany, Yap, & Padilla, 1984; Burns, Okey & Wise, 1985; Carey, Evans, Honda, Jay & Unger, 1989; Rubin & Norman, 1992; Germann, 1994; NRC, 1996; ;Martin, 2003; Saat, 2004). Basic SPS form the basis of integrated science process skills. Therefore, the basic SPS are designed to provide a foundation for learning the more complex integrated SPS (Padilla, 1990; Rubin & Norman, 1992; Rambuda & Fraser, 2004). While basic SPS includes skills like: observing, classifying, communicating, measuring, using space/ time relationships, using figures, inferring and predicting, integrated SPS include skills like identifying the problem, identifying and controlling variables, formulating hypotheses, interpreting data, defining operationally, reading/constructing graphs and experimenting (Yeany, Yap, & Padilla, 1984; Padilla, 1990; Germann, Aram & Burke, 1996; Martin, 2003; Turiman, Omar, Daud & Osman, 2011; Chabalengula, Mumba, & Mbewe, 2012). Generally, basic SPS can be acquired from the preschool period onward while integrated SPS can begin to be acquired in secondary (5^{th} through 8^{th} grades) school (Ergin, Şahin-Pekmez & Öngel-Erdal, 2005: 7), as students are in the concrete operational stage during preschool and primary school (1^{st} through 4^{th} grades). On the other hand, the formal operational stage starts in secondary school. A study conducted by Padilla, Okey & Dillashaw (1983) found that there was a positive and high correlation (r=0.73) between students' integrated SPS and formal operational skills. In this context, when students go to secondary school they are expected to acquire integrated SPS. Acquisition of SPS becomes deeper in higher stages (Çepni & Çil, 2009: 52).

This study aims to examine preservice science teachers' skills of formulating a hypothesis and identifying variables in detail. Since only preservice science teachers' skills of formulating a hypothesis and identifying variables shall be examined in this study, those skills are given in detail below.

Formulating Hypotheses

It is easier for any individual who has developed the skill of formulating hypotheses to create conceptual knowledge (Lawson, 2001). For this reason, individuals' skill of formulating a hypothesis must be developed. A hypothesis is defined as describing possible results of a study suppositionally (Abruscato, 2000:46; Fraenkel & Wallen, 2006:46). Turgut, Baker, Cunningham, Piburn, & Roger Cunningham (1997) described a hypothesis as a possible explanation of events or a possible solution to a problem, whereas Martin (2003:132) described it as a statement of the best anticipation of correlation between two variables. Sittirug (1997) indicated that the formed hypothesis should reflect the research design. While constructing a hypothesis, the relationship between variables should be considered (Martin, 2003: 133). In this study, the stated definitions of hypotheses were accepted. Abruscato (2000:46) specified that any hypothesis to be formulated should depend on observations or arguments. For example, students may observe that a cube of sugar will melt faster in hot water than it will in cold water. On the basis of this observation, the students may formulate the hypothesis that all substances that can dissolve in water will dissolve faster in hot water than in cold water. A hypothesis may also be produced from an argument. For example, if a glass jar is put on a burning candle, the candle will be extinguished in a short time. One may formulate the argument on the basis of this observation that the candle was extinguished due to lack of oxygen. Later, the students may formulate the hypothesis that the candle covered by the glass jar will be extinguished when the oxygen the in jar is depleted (Abruscato, 2000:46). Since hypotheses can be formulated in different structures, probable structures of hypotheses are examined in detail in this section. Hypotheses can be constructed in two different ways: as a null hypothesis and as an alternative (research) hypothesis. A null hypothesis (H_0), indicates that there is no difference or relationship between two variables; an alternative (research) hypothesis (H_1) indicates that there is a difference or relationship between variables (Gay, Mills & Airasian, 2009:6). Alternative hypotheses are examined in two groups: H_1 (one-directional) and H_1 (non-directional). In an H_1 (one directional) hypothesis, the direction of the difference or correlation between the variables is stated while in H_1 (non-directional) hypothesis, the direction of the correlation between the variables is not stated (Fraenkel &Wallen, 2006).

Identifying and Controlling Variables

One of the most significant components of research is the variables. Variables can be divided into three categories: dependent, independent and control (Lawson, 1995: 43). Independent variables are any factors or conditions in an experiment voluntarily changed by a researcher; dependent variables are any factors or conditions that may be affected as a result of this change. Finally, control variables are the variables that should be kept fixed in an experiment (Ramig, Bailer, & Ramsey, 1995). In order to conduct a controlled experiment, identifying dependent, independent and control variables is very important (Saat, 2004). When variables can be clearly defined and controlled, better results are achieved (Turgut et al., 1997) because the ability of any researcher to make any research question open depends on his/her ability to determine the variables and control them (Ramig, Bailer, & Ramsey, 1995). When conducting an experiment, only one independent variable's effect on the dependent variable should be examined, and depending on the study's aim, other variables should be kept unchanged (Padilla, 1990; Abruscato, 2000:45; Martin, 2003:127). Children cannot intuitively know that they are required to identify and control variables in any research. This requires ability to perceive which there is more than one attribute to given object and which could not only be seen in object's physical properties but also in the behaviors of objects. For example when we think about a toy truck, the children should be able to perceive that the same toy truck may go faster or slower. This requires perception of interaction between the two occurrences (for example, affecting the speed of the toy truck, roughness of the surface etc.) (Martin, 2003:127). In such an experiment, the dependent variable may be determined as the speed of the truck and the independent variable may be determined as the roughness degree of the surface and the control variable may be determined as the initial speed of the truck.

Importance of the Study

As it is known, the questions for measuring basic and integrated science process skills of students are given in Trends in International Mathematics and ScienceStudy (TIMSS) which allow international comparisons. Turkey participates in those TIMSS examinations in certain periods with 4th and 8th grade students. It is extremely significant to determine the level of students studying in Turkey in terms of science process skills through TIMSS examinations. In the general ranking the TIMSS-1999 and TIMSS-2007, Turkey was 33rd of 38 and 31st of 50 countries, respectively. In the TIMSS-2011 results, 4th and 8th grade were ranked 36th of 50 and 21st of 42, respectively.

An analysis of the TIMSS-1999 questions showed that some of the questions were intended to evaluate students' knowledge about scientific research and the nature of science. The headings under scientific research and the nature of science are the scientific method (formulating a hypothesis, making observations, inference, generalization), designing experiments (experimental control, materials and processes), scientific measurements (validity, repetition, experimental mistakes, consistency, scale), using scientific equipment, carrying out routine experimental processes, data collection, organization, representation (units, tables, images and graphics), and describing data and interpretation (Bağcı-Kılıç, 2003). An analysis of the content of the TIMSS-2007 questions showed that there were reasoning questions. Questions evaluating reasoning skills consist of problem solving skills, conducting analysis and synthesis, formulating a hypothesis, making predictions, designing experiments, and the planning, deducing and generalizing, and evaluating stages of an experiment (National Center for Education Statistics-NCES, 2007; Bayraktar, 2010; NCES, 2011). TIMSS-2011 was adapted from the content of TIMSS-2007. These results indicate that in Turkey, primary school students' knowledge of science process skills is low (NCES, 1999; 2007; 2011). In the TIMSS-2011 examination, questions for assessing students and teachers are given. Teachers were asked what kind of practice exercises they prepared for the students. When the answers given by the teachers participating in Turkey were examined, it was determined that they generally had the students perform practice exercises containing knowledge and understanding in the classes (80%), and less frequently hypothesis formulation and scientific study design (20%). Those results indicate that the teachers commissioned in Turkey are over the international average in terms of giving attention to activities containing knowledge and understanding (78%), but they are lower than the international average for hypothesis formulation and scientific study design (21%). In fact, the statements of the teachers are parallel to the low scores that the students studying in Turkey gained in the TIMSS-2011 examination.

Some studies about primary school students' knowledge of science process skills in Turkey observed that the students' average scores were low (Temiz, 2001; Tan & Temiz, 2003; Aydoğdu, 2006; Çakar, 2008; Hazır & Türkmen, 2008). Studies conducted in Turkey show that high school students have poor science process skills

(Dönmez & Azizoğlu, 2010; Şen & Nakipoğlu, 2012). The same is true at the university level. These studies identified that the science process skill of preservice science teachers are weak (Akar, 2007; Aydoğdu, Yıldız, Akpınar & Ergin, 2007; Bağcı-Kılıç, Yardımcı & Metin, 2009; Karslı & Ayas, 2010; Aydoğdu, Buldur & Kartal, 2012; Demarrias & Tanrıverdi, 2012; Çelik & Özbek, 2013). However, the acquisition of sufficient science process skills is very important for preservice science teachers. Studies have shown that teachers who have stronger science process skills were more successful in teaching science process skills as compared to teachers with poorer science process skills (Aydoğdu, 2006). Therefore, it is extremely important that preservice science teachers (who will soon be teaching) should both have strong science process skills and be able to transfer these skills to their students. Previous studies have examined preservice science teachers' skills of formulating a hypothesis and, found that their skills were low (Aydoğdu, Yıldız, Akpınar & Ergin, 2007; Bağcı-Kılıç, Yardımcı & Metin, 2009; Tatar, Karakuyu & Tüysüz, 2011). Other studies analyzed preservice science teachers' skills of identifying and controlling variables and found that these skills were also low (Ateş, 2005; Aydoğdu, Yıldız, Akpınar & Ergin, 2007; Bağcı-Kılıç, Yardımcı & Metin, 2009; Saka, 2012). Other studies conducted in this field showed that preservice science teachers' science process skills were poor, but the reasons for this poor performance were not analyzed in detail.

In this study, preservice science teachers were first given two scenarios (Scenario-1 & Scenario-2) containing two different research problems, which examined in detail preservice science teachers' skills of formulating a hypothesis and identifying variables. Then, pre-service science teachers were divided into three groups, and three pre-service science teachers were selected from each group. They were asked to teach formulating a hypothesis and identifying variables based on two scenarios (Scenario-3 & Scenario-4) and observed for confirmation. Therefore, this study is limited to formulating a hypothesis and identifying variables, which is two of the integrated science process skills that preservice science teachers should gain.

Aim of the study: The aim of this study is to examine preservice science teachers' skills of formulating hypotheses and identifying variables.

The research question and sub-research question related to the study performed for this aim are given as follows.

Research Question

How well can preservice science teachers formulate a hypothesis and identify variables?

Sub-Research Questions

1. What is the accuracy level of preservice science teachers in formulating hypotheses and identifying variables skills?
2. While formulating a hypothesis, which hypothesis structure (H_0, H_1-non-directional and H_1-directional) do preservice science teachers use?
3. What are preservice science teachers' mistakes in identifying variables?
4. According to preservice science teachers, what causes their mistakes in identifying variables and formulating a hypothesis?

Research Methodology

Research Design

This is a phenomenological research design because it provides opportunities to explore, describe, and analyze the meaning of an individual lived experience (Marshall & Rossman, 2006) which herein are two of the integrated science process skills, namely formulating hypotheses and identifying variables.

Participants

Two hundred and five (205) senior students studying science teacher education at a state university in Turkey participated in the study. This study used a convenience sampling method. Convenience sampling uses the most available sample for analysis (Cohen, Manion & Morrison 2000:102). Senior students were chosen for the study because they have teaching experience and they would have acquired some science process skills by that point in their education.

Science Education in Turkish Preservice Teacher Education

Preservice science teachers in Turkey take science, science education and general education courses for their degree. Some of their science courses are General Physics, General Physics Laboratory, General Chemistry, General Chemistry Laboratory, General Biology, and General Biology Laboratory. General Physics, General Chemistry, and General Biology courses focus on theory, while General

Physics, Chemistry and Biology Laboratories courses focus on practical experiments. The content of the laboratory courses is intended to parallel the content of the theoretical courses. However, which experimental techniques (e.g. closed-ended or open-ended experiments) are taught in laboratory courses is not specified and is up to the discretion of the instructors. During their four years in the education in the Science Education Department where this study was conducted, preservice science teachers mostly learned close-ended experiments.

Data Collection

In this study, data were collected through document analyses (Scenario-1 and Scenario-2), individual observations and individual interviews. Preservice science teachers were asked to teach formulating a hypothesis and identifying variables based on Scenario-3 & Scenario-4 and observed for confirmation. The gathered data were analyzed using both descriptive (Scenario-1 & Scenario-2) and content analyses (Scenario-3 & Scenario-4).

Scenario-1 and Scenario-2: The "Science Process Skills Test (SPST)" was used as the data collection instrument. SPST was adapted towards assessing the science process skills of preservice science teachers by Aydogdu (2006). SPST has two parts. The SPST is composed of 7 scenarios and 9 multiple choice items whose answers must be explained with reasons, and it has a 0.70 reliability level. In this part, there are 9 multiple choice items that require explanations in the first part and there are 7 scenarios ending with open ended questions. The 9 multiple choice items from the SPST were developed by Enger & Yager, (1998) and adapted into Turkish by Aydoğdu (2006). The scenarios were prepared by Aydoğdu (2006) after an examination of different researchers' studies (Anonymous, 2006; Dana, 2001; Enger & Yager, 1998; Ergin et al., 2005). These seven scenarios were then sent to two academics, who are expert in science teaching. Aydoğdu (2006) stated that final revisions were made and used in the SPST after he received the academics' comments regarding whether the scenarios include and assess the science process skills of teachers. The SPST is composed of questions that measure basic science process skills like observation, classification, measurement, inference, and integrated science process skills like formulating a hypothesis, identification and controlling variables, conducting an experiment, collecting data, and assessing and interpreting results. However, this study only examined preservice science teachers' skills of formulating a hypothesis and identifying and controlling variables. Within the scope of this study, only two scenarios (Scenario-1 and Scenario-2) were used from the SPST.

Scenario-3 and Scenario-4: After administering the two scenarios (Scenario-1 and Scenario-2) mentioned above to the preservice science teachers, their responses were examined. On the basis of those answers, three preservice science teachers who determined both the hypothesis and the variables as correct, partially correct and incorrect (totally 9 preservice teachers) were selected. Later the selected preservice teachers were sent to real classroom environment in order to apply an activity containing Scenario-3 and Scenario-4 (prepared by researcher) for hypothesis formulation and variable determining skills to 7th grade students.

Observation data: Two observers watched and analyzed how the preservice teachers taught the activities (Scenario-3 and Scenario-4) prepared for hypothesis formulation and variables determination of 7th grade students in detail through the video records lasting for 45-minutes.

Interview data: Moreover, interviews were conducted with preservice science teachers who incorrectly identified both the hypothesis and the variables. In the interview, preservice science teachers were asked "What factors contributed to your incorrect identification of the hypothesis, dependent and independent variables?", and their responses were analyzed.

Administration of Data Collection Instrument

Scenario-1 and Scenario-2: Within the scope of this study, only two scenarios were used from the SPST and, per the research question, the author tried to identify preservice science teachers' skills of formulating a hypothesis and identifying and controlling variables through these scenarios. Although the two scenarios used in the study had different research problems, preservice science teachers were expected to use similar skills, such as formulating a hypothesis and identifying and controlling variables.

The two scenarios used in the study and the research question based on the scenario are given as an example below and the possible answers for hypothesis, dependent, independent and control variables that preservice science teachers were supposed to provide are given in Box 1.

Box 1: Two sample scenarios (Scenario-1 and Scenario-2) which were adapted by Aydoğdu (2006) from the SPST.

Scenario 1: Hasan and Ahmet are playing in a park. Ahmet releases marble down the slide. Hasan claims that if the marble is slid from a higher slide it can move faster. This debate causes the following research question. After reading the research question and hypothesis find the dependent, independent and control variables.

Research question: If marble is released (go down) from slides with different heights, how does its speed change?
Hypothesis: *if the height of the slide increases, the speed of the marble increases.*
Dependent variable: *the speed of the marble*
Independent variable: *the height of the slide*
Control variable: *the size, type and surface of the marble, the surface and slope of the slide.*

Scenario 2: Melisa is a highly curious 6th grade student. She notices that a lorry is scattering salt over the road on a snowy day. After the lorry passes Melisa's house, she puts on her boots, hat, and gloves, and goes to the road to make an observation. From her observation she designs a research question for an experiment she carries out later. Find the hypothesis, in addition to the dependent, independent and control variables.

Research Question:If salt is added to ice what will happen?
Hypothesis: *if salt is added to ice, the melting speed of ice increases*
Dependent variable: *.the melting speed of ice*
Independent variable: *Adding salt*
Control variable: *Amount of ice and ambient temperature, etc…*

Scenario-3 and Scenario-4: Examples of scenarios (Scenario-3 and Scenario-4) included in the activities prepared for hypothesis formulation and variable determining to be taught to 7th grade students within the scope of teaching practice of preservice science teachers are given in Box 2.

Box2: The sample activities involving two scenarios (Scenario-3 and Scenario-4)

Scenario 3: Ahmet and Hasan release the marbles in their hands into flour from a certain height. Ahmet's marble sank in the flour deeper. Which factors do you think were effective in the fact that Ahmet's marble sank deeper? In order to find a solution to this problem, formulate appropriate hypothesis/hypotheses and test the experiment determining the variables.

Hypothesis 1: *If the height from which the marble is released increases, the rate of the marble sinking in the flour increases.* ***Dependent variable:*** *Amount of the marble sinking in the flour* ***Independent variable:*** *Height from which the marble is released* ***Control variable:*** *Mass of the marble, volume of the marble*	***Hypothesis 2:****.If the mass of the marble, increases the amount of the marble sinking in the flour increases* ***Dependent variable:*** *Amount of the marble sinking in the flour* ***Independent variable:*** *Mass of the marble* ***Control variable:*** *Height from which the marble is released*
Designing experiment Preservice science teachers release two identical marbles into flour from different heights, and later measure the amount of sinking of the marbles into the flour for Hypothesis-1. And for Hypothesis-2, preservice science teachers release two marbles with different masses from identical heights and measure the amount of sinking of the marbles into the flour.	
Scenario 4: Mert and Arda race identical toy cars on an the inclined plane and Mert's car wins the competition. Which factors do you think were effective on Mert's winning the competition? In order to find a solution to this problem, formulate appropriate hypothesis/hypotheses and test the experiment determining the variables.	
Hypothesis1: *Speed of the toy car increases if the slope of the inclined plane increases.* ***Dependent variable:*** *Speed of the toy car* ***Independent variable:*** *Slope of the inclined plane* ***Control variable:*** *The toy car, slope of the inclined plane, the place where the car is released*	***Hypothesis 2:*** *If the material used for the inclined plane changes, the speed of the car changes* ***Dependent variable:*** *Speed of the toy car* ***Independent variable:*** *Material used for the inclined plane* ***Control variable:*** *The toy car, slope of the inclined plane, the place where the car is released*
Designing experiment Preservice science teachers release the toy car without initial speed from identical points by increasing the slope of the inclined plane for Hypothesis-1 and measure the speed of the toy car (the way taken). And for Hypothesis-2, preservice science teachers release the toy cars without initial speed changing the grounds in the inclined planes with identical slope and measure the speed of the toy cars. Lather they test the hypothesis they formulate.	

Data Analysis

The qualitative data from documents and interviews were descriptively analyzed while the data from observations were subjected to content analysis. The descriptive analysis technique evaluates the data, creating themes for each question. The collected data were summarized according to predefined themes and interpreted. In descriptive analysis, the aim is to present gathered data in an ordered and interpreted way to the reader. For that purpose, the gathered data is first described systematically and clearly (Yıldırım & Şimşek, 2013: 256). In order to ensure consistency, another expert's analysis was also done. The observational data were analyzed through content analysis (Miles & Huberman, 1994; Patton, 2002; Yıldırım & Şimşek, 2013), in which themes, which are not pre-determined, are generated from codes assigned to the whole data.

Trustworthiness of the Data

1. Ensuring the trustworthiness of the answers given to the scenarios

The qualitative data gathered from the scenarios was analyzed by two researchers and the consistency between the researchers was 0.83. Moreover, the two researchers discussed their differences and reached a consensus. Finally, all the data (205 preservice science teachers answered two scenarios so totally a hundred scenarios' data were analyzed) were analyzed by two researchers individually and the fittingness percentage between the two researchers was calculated to be 0.92. This fittingness percentage is quite reliable (Miles & Huberman, 1994). In the calculation of the fittingness percentage, the formula suggested by Miles and Huberman was used (Fittingness percentage= Agreement / (agreement+ disagreement)).

Table 1 displays the initial differences between the two researchers concerning the response of the preservice science teachers to Scenario-1 and Scenario-2 and in an adjacent column displays how these differences were resolved.

Table 1. Initial differences between the two researchers concerning preservice science teachers' responses to Scenario-1 and Scenario-2, how these differences were resolved.

Scenarios	Integrated Science Process Skills	Statements of Students	Initial Differences		Consensus Result	
			Field expert-1	Field expert -2	Field expert -1	Field expert -2
Scenario-1	Formulating Hypothesis	*The speed of marble changes according to the height of a slide*	Correct	Partially correct	Correct	Correct
	Dependent variable	*Marble*	Partially correct	Correct	Partially correct	Partially correct
	Independent variable	*Friction*	Partially correct	Incorrect	Incorrect	Incorrect

	Control variable	*The length of the slope*	Correct	Partially correct	Correct	Correct
Scenario-2	Formulating Hypothesis	*Salt melts the ice*	Correct	Partially correct	Partially correct	Partially correct
	Dependent variable	*Salt*	Partially correct	Incorrect	Incorrect	Incorrect
	Independent variable	*Ice*	Partially correct	Incorrect	Partially correct	Partially correct
	Control variable	*Melting ice*	Incorrect	Partially correct	Incorrect	Incorrect

Table 2 presents the final rubric for evaluating preservice science teachers' answers to Scenario-1 and Scenario-2.

Table 2. Scoring rubric for preservice science teachers (PST) responses to the research questions of Scenario-1 and Scenario-2.

Integrated Science Process Skills	**Categories**	**Indicators**	**Sample statements of preservice science teachers for Scenario-1**	**Sample statements of preservice science teachers for Scenario-2**
Formulating Hypothesis	Correct	Appropriate both to the problem situation and the structure of hypothesis.	*PST_4:If the height of the slide increases, the speed of the marble piece will increase.* *PST_{14}: If the height of the slide changes, the speed of the marble will change.*	*PST_7:If salt is added to ice it melts* *PST_{39}: The more salt added to ice the faster it melts.*
	Partially Correct	Appropriate to given problem but inappropriate to hypothesis structure.	*PST_{29}: The change in the speed of the marble according to the height of the slide.* *PST_{37}: According to the steepness of the long and short slide the speed of the marble changes.*	*PST_{23}: Salt melts the ice.* *PST_{11}: Ice melts in the places where salt is scattered.*
	Incorrect	Inappropriate to given problem but appropriate to hypothesis structure.	*PST_{33}: The smoother the slide the faster the item slides.* *PST_{22}: If the slope of the slide increases, the speed of the marble piece will increase.*	*PST_{21}: If the quality of the salt increases, the ice melts faster* *PST_{12}: The thinner the salt the faster the snow melts*

Dependent variable	Correct	The dependent variable is both appropriate to the given problem and stated correctly.	*PST_8: The speed of marble piece* *PST_{50}: The speed of marble*	*PST_8: Melting speed of ice* *PST_{50}: Ice melting*
	Partially Correct	The dependent variable is appropriate to the given problem but the statement is missing.	*PST_{41}: Marble* *PST_{35}: Speed*	*PST_{43}: Ice* *PST_{25}: Melting*
	Incorrect	The dependent variable is inappropriate to the given problem or dependent variable is stated incorrectly.	*PST_{15}: Height* *PST_{37}: The length of the slide*	*PST_{20}: Salt* *PST_{29}: Pressure*
Independent variable	Correct	The independent variable is both appropriate to the given problem and correctly stated.	*PST_8: The height of the slide* *PST_{50}: The height of the slope*	*PST_8: Adding salt* *PST_{50}: The amount of the salt*
	Partially Correct	The independent variable is appropriate to the given problem but the statement is missing.	*PST_{17}: Slide (Slope)* *PST_{31}: Height*	*PST_{26}: Salt* *PST_{36}: Little/a lot salt*
	Incorrect	The independent variable is inappropriate to the given problem or the independent variable is stated incorrectly.	*PST_{19}: Marble* *PST_{23}: Friction*	*PST_{12}: Ice/ Snow* *PST_{30}: Gloves*
Control Variable	Correct	The control variable is both appropriate to the given problem and correctly stated.	*PST_8: the size, type and surface of the marble, the surface and slope of the slide* *PST_{50}: The place where the marble was left; Slope*	*PST_8:The amount of salt and environment temperature* *PST_{50}: Quality of ice environment*
	Partially Correct	The control variable is appropriate to the given problem but the statement is missing.	*PST_7: The surface of the slope/Friction, surface of the marble* *PST_{48}: The place of the marble, slope of the slide*	*PST_8: Ice* *PST_{17}:Environm ent*
	Incorrect	The control variable is inappropriate to the given problem or the control variable is stated incorrectly.	*PST_{13}: Items, speed of the marble* *PST_{44}: Wideness of the slope*	*PST_{26}:Scattering salt, Melisa* *PST_{48}: melting ice /ice melting*

2. Ensuring the trustworthiness of the observation data

Two observers watched and analyzed how the preservice teachers taught the activities (Scenario-3 and Scenario-4) prepared for hypothesis formulation and variables determination of 7^{th} grade students in detail through the video records lasting for 45-minutes. The consistency between the two researchers was calculated as 0.88. The differences between the researchers were then discussed and a consensus was reached. After reaching a consensus, the observation data was individually analyzed by two researchers; the fitting percentage between the two researchers was 0.96. The reason for selecting two observers is to increase reliability of observation notes (agreement percentage). The aim of observing preservice science teachers is to support the skills in formulating hypothesis and determining variable in the Scenario-1 and Scenario-2.

3. Ensuring the trustworthiness of the interview data

After administering the two scenarios mentioned above to the preservice science teachers, their responses were examined, and their correct answer percentage was calculated. Preservice science teachers who misidentified both the hypothesis and the variables (n=58) were interviewed. Qualitative data gathered from the interviews was analyzed by two researchers; the consistency between the two researchers was calculated as 0.94. The differences between the researchers were then discussed, and a consensus was reached. After reaching a consensus, the interview data was individually analyzed by two researchers; the fitting percentage between the two researchers was 0.98.

Results of the Research

Table 3 presents preservice science teachers' responses to the research questions in Scenario-1&2 and the percent of these responses that were correct, partially correct, incorrect, and incomplete.

Table 3. Preservice science teachers' responses to the research questions in Scenario-1 and Scenario-2.

Integrated Science Process Skills	Categories	Indicators	Scenario-1	Scenario-2
Formulating Hypothesis	Correct	It is both appropriate to the problem and the structure of the hypothesis.	83 (40%)	66 (32%)
	Partially Correct	It is appropriate to the given problem but inappropriate to the structure of the hypothesis.	33 (17%)	38 (19%)
		It is inappropriate to the given problem but appropriate to the structure of the hypothesis.	6 (3%)	7 (3%)
	Incorrect	It is inappropriate to both the problem and the structure of the hypothesis	78 (38%)	83 (40%)
	No Response	No hypothesis was written for the given problem.	5 (2%)	11 (6%)
Dependent Variable	Correct	The dependent variable is both appropriate to the given problem and stated correctly.	41 (20%)	38 (19%)
	Partially Correct	The dependent variable is appropriate to the given problem but its statement is missing.	35 (17%)	36 (18%)
	Incorrect	The dependent variable is inappropriate to the given problem or it is stated incorrectly	119 (58%)	124 (60%)
	No Response	No dependent variable is written for the given problem	10 (5%)	7 (3%)
Independent Variable	Correct	The independent variable is both appropriate to the problem and stated correctly.	19 (9%)	22 (11%)
	Partially Correct	The independent variable is appropriate to the given problem but its statement is missing.	61 (30%)	66 (32%)
	Incorrect	The independent variable is inappropriate to the given problem or it is stated incorrectly	116 (57%)	107 (52%)
	No Response	No independent variable is written for the given problem	9 (4%)	10 (5%)
Control Variable	Correct	The control variable is both appropriate to the problem and stated correctly.	10 (5%)	8 (4%)

	Partially Correct	The control variable is appropriate to the given problem but its statement is missing	70 (34%)	61 (30%)
	Incorrect	The control variable is inappropriate to the given problem or it is stated incorrectly	113 (55%)	123 (60%)
	No Response	No control variable is written for the given problem	12 (6%)	13 (6%)

Table 3 shows that in Scenario-1, 83 Preservice science teachers formed a hypothesis correctly, 39 formed a partially correct hypothesis, 78 formed it incorrectly, and 5 gave no response. Similarly, in Scenario-2, the required hypothesis was correctly formed by 66, 45 formed a partially correct response, 83 formed it incorrectly, and 11 gave no response.

Three preservice science teachers who detected the hypotheses and variables correctly according to the research question in Scenario-1 and Scenario-2 (PST-1, PST-2 and PST-3), three preservice science teachers who were partially correct (PST-4, PST-5 and PST-6) and three preservice science teachers who were incorrect (PST-7, PST-8 and PST-9) were selected for the purpose of performing observation. Observation findings regarding those preservice teachers are given below in detail.

Observation findings of PST-1, PST-2 and PST-3: Observation findings indicated that PST-1, PST-2 and PST-3 determined hypotheses correctly according to problem statuses in Scenario-3 and Scenario-4 within the scope of teaching practice. The hypotheses formulated by those three preservice teachers are given as follows:

"The higher you drop the marbles, the deeper it will sink into the flour." (PST-1, PST-2)

"The higher the mass of the marble increases, the deeper it will sink into the flour." (PST-1, PST-3)

"If the slope of the inclined plane increases the toy car will slide faster." (PST-1, PST-2, PST-3)

"If the ground of the inclined plane changes, the speed of the toy car will change as well." (PST-1, PST-3)

"If the height from which the marble is dropped changes, the amount of sinking in the flour will change." (PST-3)

"If the mass of the marble changes, the amount of sinking in the flour will change." (PST-2)

"The toy car will change faster on smooth inclined planes." (PST-2)

PST-1, PST-2 and PST-3 defined the hypothesis correctly while they were teaching the hypothesis to 7th grade students in real class environment. Definitions of hypothesis of those three preservice teachers have been given as follows:

"It is the temporary solution brought for a scientific problem." Or "It is a proposed explanation for a phenomenon." (PST-1)

"It is an explanation with the nature of proposition that allows performing more examination on a scientific problem" (PST-2)

"It is a proposition designed and deemed valid for formulating relations between events in scientific method and to associate the events with a reason." (PST-3)

Furthermore, PST-1, PST-2, and PST-3 gave examples of hypothesis to 7th grade students in order to enable them to learn the hypothesis better and formulated the examples of hypothesis they gave correctly. Those examples have been given as follows:

"The more water is given to the plant the higher the plant will grow." (PST-1)

"If density changes in the liquids, buoyancy changes." (PST-2)

"The higher vitamin C in the body of a human gets the longer human lifetime will be." (PST-3)

It was found out from the observation results that PST-1 and PST-3 determined all three variables namely dependent, independent, and control variables according to the statuses in Scenario-3 and Scenario-4 problem correctly, but PST-2 could determine dependent and independent variables correctly and determined the control variable partially correctly. The variables determined by those preservice teachers according to the hypothesis they formulated are given as follows:

*"**Hypothesis**: If the slope of the inclined plane increases the toy car will slide faster."* (PST-1, PST-2, PST-3) **(Correct)**

*"**Dependent Variable**: Speed of the car"* (PST-1, PST-2, PST-3) (**Correct**)

*"**Independent Variable**: Slope of the inclined plane* (PST-1, PST-2, PST-3)**(Correct)**

*"**Control Variable**: Surface of the inclined plane, toy car* (PST-1, PST-3)**(Correct)**

*"**Control Variable:**Toy car* (PST-2) **(Partially correct)**

PST-1 and PST-3 defined the variable correctly while they were teaching the variables to 7th grade students in real class environment. Variable definitions of those preservice teachers are given as follows:

*"**Independent Variable**: The variable which can be changed, which is required to be changed, which we change. **Dependent Variable**: Refers to the variable changing depending on the one we change. **Control Variable**: Refers to the variable kept fixed." (PST-1)*

*"**Independent Variable**: It refers to the condition changed voluntarily by a researcher in an experiment performed. **Dependent Variable**: It refers to the condition that could be affected depending on the change made by the researcher. **Control Variable**: It refers to the variable to be kept fixed in an experiment." (PST-3)*

In addition to the observation notes given above, PST-1 and PST-3 taught the 7th grade students showing that it is necessary to research the effect of only one independent variable on dependent variable for a controlled experiment both as a theoretical knowledge and by showing on the experiment system. The information given by those preservice teachers with regard to the controlled experiment are given as follows.

"The effect of only one independent variable on the dependent variable is researched for a controlled experiment." (PST-1)

"Two variables are effective in the amount of sinking of the marble in the flour. Those variables are the height from which the marble is dropped and the mass of the marble. Those two independent variables have an effect on the dependent variable examined in the research. And the effect of only one independent variable on the dependent variable should be examined. For this reason, firstly the effect of the height from which the marble is dropped in the flour and later the effect of the mass of the marble should be researched. Because it cannot be understood on which variables (height and mass) are effective in the amount of sinking of the marble in the flour." (PST-3)

Observation findings of ***PST-4, PST-5, and PST-6***: Observation findings indicated that while PST-4 and PST-5 formulated hypotheses partially correctly according to the problem statuses in Scenario-3 and Scenario-4 within the scope of teaching practice, PST-6 formulated the hypothesis sometimes correctly and sometimes partially correctly. The hypotheses formulated by those three preservice teachers are given as follows:

"Weight of the marble effects it falling on the ground"; "If the marble is dropped from a height, the marble accelerates and sinks"; "The car slides fast on an inclined plane"; (PST-4) (**Partially correct**)

"Height and weight of the marble may have an effect on sinking of the marble in the flour" (PST-5) (**Partially correct**)

"*Mass of the marble is effective on sinking deep."* (PST-6) (**Partially Correct**) *;*

"If the slope of the inclined plane increases, the speed of the toy car increases." (PST-6) (**Correct**)

PST-5 and PST-6 could make the definition of the hypothesis partially correctly while performing teaching in the real class environment. And PST-4 did not give place the definition of hypothesis in the teaching environment.

"It is a foresight." (PST-5)

"It is information accuracy of which is not evidenced." (PST-6)

It was detected from another observation finding that PST-4, PST-5, and PST-6 could determine the variables as partially correct in general. The variables determined by those preservice teachers according to the hypothesis they formulated are given as follows.

*"**Hypothesis**: The car slides fast in the inclined plane"* (PST-4) (**Partially correct**)

*"**Dependent Variable**: Sliding of the car"* (PST-4) (**Partially Correct**)

*"**Independent Variable**: Inclined plane* (PST-4)(**Partially Correct**)

*"**Control Variable**: Toy car* (PST-4)**(Partially Correct)**

*"**Hypothesis**: Mass of the marble is effective on sinking deep."* (PST-5) (**Partially correct**)

"***Dependent Variable**:: Depth that the marble sinks"* (PST-5*) **(Correct)***

*"**Independent Variable**: Marble* (PST-5) ***(Partially Correct)***

*"**Control Variable**:: Height* (PST-5) **(Partially Correct)**

*"**Hypothesis**: Speed of the toy car increases if the slope of the inclined plane increases."*(PST-6) (**Correct**)

*"**Dependent Variable**: Speed of the car"* (PST-6) (**Correct**)

*"**Independent Variable**: Inclined plane* (PST-6)(**Partially Correct**)

*"**Control Variable**:: Type of the ground* (PST-6)**(Partially Correct)**

Observation findings of ***PST-7, PST-8, and PST-9***: It was determined on the basis of observation findings that PST-7, PST-8, and PST-9 generally determined or caused to determine the hypotheses according to the problem statuses in Scenario-3 and Scenario-4 incorrectly within the scope of teaching application. The hypotheses formulated by those three preservice teachers are given as follows:

"Fall of the marble due to its weight";"Surface depends on speed" (PST-7) (**Incorrect**)

"Effect of height on sinking of the marble in flour" (PST-8) (**Partially correct**)

"*It is the connection between the weight of the marble and its fall on the ground" "Surface has effect"* (PST-9) (**Incorrect**)

It was found out from the observation findings that PST-8 and PST-9 made a definition of hypotheses incorrectly while teaching in the class environment. And PST-7 did not make a definition of the hypothesis in the teaching environment.

"It is information accuracy of which is evidenced." (PST-8)

"It is putting forward an idea about the study." (PST-9)

PST-8 gave an example of hypothesis while teaching 7th grade students the subject of hypothesis. And the hypothesis example given by this preservice teacher has an incorrect structure. Those examples are given as follows.

"We hit the ball, it went to the goal post"; "If we put the water in the refrigerator, the water will freeze." (PST-8)

Furthermore, it was observed that PST-7, PST-8 and PST-9 generally determined variables incorrectly. Particularly PST-7 and PST-9 were observed not to be able to determine control variables any time. The variables determined by those preservice teachers according to the hypothesis they formulated are given as follows.

*"**Hypothesis**: Fall of the marble due to its weight"*(PST-7) (**Incorrect**)

*"**Dependent variable**: Weight of the marble"* (PST-7) (**Incorrect**)

*"**Independent variable**: Falling* (PST-7)(**Incorrect**)

*"**Control variable**: …..* (PST-7)(**No response**)

*"**Hypothesis**: Effect of height on sinking of the marble in flour"* (PST-8) (**Partially correct**)

*"**Dependent variable**: Height* (PST-8) (**Incorrect**)

*"**Independent variable**: Marble* (PST-8)(**Incorrect**)

*"**Control variable**: Marble* (PST-8)(**Partially correct)**

"***Hypothesis**: Fall of the marble due to its weight"* (PST-9) (**Incorrect**)

*"**Dependent variable**: ….* (PST-9) (**No Response**)

*"**Independent variable**: Marble* (PST-9)(**Incorrect**)

*"**Control variable**: .....* (PST-9)(**No Response)**

Table 4 presents the structures of the correct hypotheses formulated for Scenario-1 (of which there are 83) and Scenario-2 (of which there are 66).

Table 4. Frequency of Different Hypothesis Structures among the Correct Responses to Scenario-1 and Scenario-2.

Scenarios	Research question		Hypothesis	Frequency/per centage
Scenario-1	If a piece of marble is slid from slopes with different heights, how does its speed change?	H_0	*PST_{42}: If the height of the slope changes, the speed of the piece of marble doesn't change*	*2 (2%)*
		H_1 (one-directional)	*PST_4: If the height of the slope increases, the speed of the piece of marble increases*	*57 (69%)*
		H_1 (non-directional)	*PST_{14}: If the height of the slope changes, the speed of the piece of marble changes*	*24 (29%)*
Scenario-2	If salt is added to ice, does ice melt?	H_0	*PST_2: If salt is added to ice, it does not melt*	*2 (3%)*
		H_1 (one-directional)	*PST_{39}: The more salt is added to the ice, the speed of melting ice increases more*	*21 (32%)*
		H_1 (non-directional)	*PST_7: If salt is added to ice, ice melts.*	*43 (65%)*

Table 4 shows that among the preservice science teachers who formed a hypothesis correctly in Scenario-1 (n=83), 2 formed a H0 hypothesis, 57 formed a H1-one-directional hypothesis and, 24 formed a H1-non-directional hypothesis. Among preservice science teachers who formed a hypothesis correctly in Scenario-2 (n=66), 2 formed H0 hypothesis, 21 formed a H1-one-directional hypothesis and, 43 formed a H1-non-directional hypothesis.

Similarly, observation findings indicated that 4 preservice science teachers observed in the real class environment (PST-1, PST-2, PST-3 and PST-6) could determine the hypothesis correctly according to the problem status in Scenario-3 and Scenario-4 and that they formulated those hypotheses in H1-one-directional and H1-non-directional structures. It was detected that none of the nine preservice teachers observed formulated H0 hypothesis. The structures that those preservice teachers formulate are given as follows:

*"**H1 (one- directional):** The more height from which the marble is dropped, the deeper it will sink in the flour."* (PST-1, PST-2)

*"**H1 (one- directional):** The higher the mass of the marble is, the deeper it will sink in the flour."* (PST-1, PST-3)

*"**H1 (one- directional):** If the slope of inclined plane increases, toy car slides faster."* (PST-1, PST-2, PST-3)

*"**H1 (non- directional):** If the ground of inclined plane changes, the sleep of the toy car changes as well."* (PST-1, PST-3)

"***H1 (non- directional):*** If the height from which the marble is released the amount of sinking in the flour changes." (PST-3)

"***H1 (non- directional):*** If the mass of the marble changes, the amount of sinking in the flour changes." (PST-2)

"***H1 (one- directional):*** Toy cars move faster in smooth inclined surfaces." (PST-2)

*"**H1 (one- directional):** If the slope of inclined plane increases, the speed of the toy car increases."* (PST-6)

Table 5 displays the different mistakes made by preservice science teachers while identifying variables in Scenario-1 and Scenario-2.

Table 5. Types of mistakes made by preservice science teachers while identifying variables in Scenario-1 and Scenario-2

Mistakes made while identifying variables	**Scenario-1**	**Scenario-2**
Dependent variable mistakes	**Frequency (percentage)**	**Frequency (percentage)**
Writing off-topic variables instead of the dependent variable	30 (25%)	28 (23%)
Writing more than one variable as the dependent	6 (5%)	7 (6%)
Writing the independent variable instead of the dependent variable	72 (60%)	75 (60%)
Writing the control variable instead of the dependent variable	3 (3%)	5 (4%)
Writing the hypothesis instead of the dependent variable	8 (7)	9 (7%)
Total	119 (100%)	124 (100%)
Independent variable mistakes	**Frequency (percentage)**	**Frequency (percentage)**
Writing off-topic variables instead of the independent variable	23 (20%)	12 (11%)
Writing more than one variable as the independent variable	13 (11%)	8 (7%)
Writing the dependent variable instead of the independent variable	65 (56%)	71 (67%)
Writing the control variable instead of the independent variable	9 (8%)	7 (7%)
Writing the hypothesis instead of the independent variable	6 (5%)	9 (8%)
Total	116 (100%)	107 (100%)
Control variable mistakes	**Frequency (percentage)**	**Frequency (percentage)**

Writing off-topic variables instead of the control variable	48 (42%)	43 (35%)
Writing the dependent variable instead of the control variable	39 (35%)	52 (46%)
Writing the independent variable instead of the control variable	14 (12%)	19 (15%)
Writing the hypothesis instead of the control variable	12 (11%)	9 (7%)
Total	113 (100%)	123 (100%)

Table 5 shows that for the dependent variable, preservice science teachers wrote off-topic variables instead of the dependent variable (30 in Scenario-1 and 28 in Scenario-2), wrote more than one variable as the dependent variable (6 in Scenario-1, 7 in Scenario-2), wrote the independent variable instead of the dependent variable (72 in Scenario-1, 75 in Scenario-2), wrote the control variable instead of the dependent variable (3 in Scenario1, 5 in Scenario-2), and wrote the hypothesis instead of the control variable (8 in Scenario1, 9 in Scenario-2).

Similar mistakes occurred for the independent variable: preservice teachers wrote off-topic variables instead of the independent variable (23 in Scenario-1 and 12 in Scenario-2), write more than one variable as the independent variable (13 in Scenario-1 and 8 in Scenario-2), wrote the dependent variable instead of independent variable (65 in Scenario-1 and 71 in Scenario-2), wrote the control variable instead of the independent variable (9 in Scenario-1 and 7 in Scenario-2), and wrote the hypothesis instead of the control variable (6 in Scenario1, 9 in Scenario-2).

The answers for the control variable contained similar mistakes: preservice teachers wrote off-topic variables instead of the control variable (48 in Scenario-1, 43 in Scenario-2), wrote the dependent variable instead of the control variable (39 in Scenario-1 and 52 in Scenario-2), wrote the independent variable instead of the control variable (14 in Scenario-1 and 19 in Scenario-2) and wrote the hypothesis instead of the control variable (12 in Scenario1, 9 in Scenario-2).

Similarly, as to the observation findings, it was discovered that PST-7, PST-8 and PST-9 determined the variables incorrectly in Scenario-3 and Scenario-4. It was observed that the preservice teachers who determined variables incorrectly confused dependent and independent variables with each other. The variables that preservice teachers determined according to the hypotheses given are given as follows.

*"**Hypothesis**: Fall of the marble due to its weight";* (PST-7)

*"**Dependent variable**: Weight of the marble" (PST-7) (**Incorrect**)*

*"**Independent variable**: Falling down (PST-7) (**Incorrect**)*

*"**Control variable**: ..... (PST-7) (**No Response**)*

*"**Hypothesis**: Effect of height on sinking of the marble in flour*" (PST-8)

*"**Dependent variable**: Height (PST-8) (**Incorrect**)*

*"**Independent variable**: Marble (PST-8) (**Incorrect**)*

*"**Control variable**: Marble (PST-8) (**Partially correct**)*

In addition to the observation notes given above, it was shown that PST-7 did not know to control an experiment. Because, in a controlled experiment should be researched the effect of only one independent variable on the dependent variable. The information given by this preservice teacher related to the controlled experiment (Scenario-3: The experiment of sinking a marble in flour according to its height and mass) are given as follows.

"Student: Sir, can we see how sinking amount changes if we release marbles with different masses into flour from different heights?"

"PST-7: Of course you can see, children."

One may conclude from the result of this observation that the preservice teacher here (PST-7) did not know exactly how to perform a controlled experiment. Because it is observed that this preservice teacher is not aware of the necessity to research the effect of only one independent variable on the dependent variable for a controlled experiment.

Fifty-eight (58) preservice science teachers identified the wrong hypothesis and the wrong variables in both Scenario-1 and Scenario-2. These teachers were interviewed to identify factors that might explain preservice science teachers' mistakes. These preservice science teachers' views were recorded and grouped.

Table 6 provides information about the 58 preservice science teachers' responses to the question "what caused your mistakes in identifying variables and formulating a hypothesis?"

Table 6. Preservice science teachers' excuses for their mistakes in identifying a hypothesis and dependent, independent and control variables in Scenario-1 and Scenario-2.

Excuses given for the mistakes	**Example statement**	**Frequency**
Courses do not teach enough science process skills	"*I think, In fact, the most important reason for why we make mistakes while identifying the hypothesis and the variables is that the courses carried out here do not include science process skills.*" *"In the courses given to us, science process skills are not used, so how can we learn these skills?"* *"In my opinion if science process skills had been included more in the courses we would have learned these skills better by now."*	49
In experiments conducted in laboratories science process skills are not often included	"*I think science process skills can be learned in laboratories better but we do not cover science process skills very much.*" "*In laboratories we generally do close-ended experiments, in my opinion this prevents us from improving our science process skills.*" "*We could have learnt these skills much better if we had identified the problem and designed the experiments ourselves in the laboratories but we have always engaged in traditional experiments, which is why we couldn't improve our skills such as formulating a hypothesis and identifying variables.*"	37
Not to be aware of significance of science process skills	"*In fact, I did not know that science process skills are so important.*" *"The reason for failure of learning those skills is me because if I wanted I would learn those skills completely."* *"I failed to learn science process skills since I thought they would not be useful for me in the future."*	23
Courses use traditional teaching methods	*"In our lessons our teachers do the lessons in front of the board and we listen to them, it's very normal that our science process skills haven't developed."* *"In the lessons the subjects are given through narration or using PowerPoint. This situation may have caused the non-development of these skills."* *"I think the biggest reason why these skills haven't developed is the structure of the courses. That is, the courses are always traditional."*	21
Instructors have inadequate science process skills	*"Maybe our hypothesis formulating and identifying variables skills are low but I don't believe our instructors know these skills either."* *"I think instructors are responsible for this situation, they as*	7

	do not know these skills, so it's very normal that we do not know them." *"I think if instructors had had strong integrated science process skills, they would have taught us in some way."*	

*Preservice science teachers have given more than one answer to this question.

Table 6 shows that preservice science teachers who misidentified the hypothesis and variables are partially aware of their mistakes and blame others for this situation. In this context, preservice science teachers made some references to the education they received at the university and stated that it was inadequate. Preservice science teachers' awareness of their mistakes might be valuable as they demonstrate reflective teacher characteristics. Reflective teachers are ideal because they are careful about their teaching methods and materials, and they control their professional development (Duban & Yanpar-Yelken, 2010).

Conclusion and Discussion

After the study was completed, preservice science teachers' skills of formulating a hypothesis and identifying variables were investigated in detail. The study also examined preservice science teachers' preferences on hypothesis structure (H0, H1-non-directional and H1-directional) while formulating a hypothesis. Additionally, the types of mistakes made by preservice science teachers while identifying variables were examined, along with what they believed caused their mistakes. In addition, in this study were what causes their mistakes in identifying variables and formulating a hypothesis according to preservice science teachers. The results obtained for each sub-problem are as follows:

1. The study examined preservice science teachers' skill formulating hypotheses and identifying variables in Scenario-1 and Scenario-2. The study results show that preservice science teachers' skill formulating hypotheses correctly was quite poor. Those results are supported by observation findings; three preservice teachers (PST-7, PST-8 & PST-9) selected among preservice teachers with poor hypothesis formulating skills failed to formulate their hypotheses correctly according to Scenario-3 and Scenario-4 in a real classroom environment. Scenario-1 and Scenario-2 were used in this study and other studies for the purpose of assessing science process skills of both teachers and preservice teachers. The same scenarios were used by Aydoğdu, Erkol and Erten (2013) to evaluated elementary school

teachers, as well as by others (Aydoğdu, Yıldız, Akpınar & Ergin, 2007; Bağcı-Kılıç, Yardımcı and Metin, 2009) to evaluate preservice science teachers. All of these studies found low levels of hypothesis-forming skills. Other studies that just identified the skill of preservice science teachers to formulate a hypothesis found that their hypothesis formulating skills were poor (Saka, 2012; Çelik & Özbek, 2013). Formulating hypotheses depends on perception and interpretation of abstract concepts (Taşkın and Koray, 2006: 99). This situation may be one of the reasons for deficiency of formulating hypothesis of preservice science teachers. The reason for this deficiency in formulating hypothesis of preservice science teachers should be analyzed further in future studies. The study also examined preservice science teachers' identifying and controlling variables in a given scenario. The study results show that preservice science teachers' skill in this area was quite poor. The same scenarios (Scenario-1 and Scenario-2) were used by Aydoğdu, Erkol and Erten (2013) for elementary class teachers and the study results indicated that the skills of elementary class teachers were poor. In the studies where the same scenarios were used again to evaluated preservice teachers (Aydoğdu, Yıldız, Akpınar & Ergin, 2007; Bağcı-Kılıç, Yardımcı & Metin, 2009), it was found that their skills were quite poor. Furthermore, the same scenarios were used for preservice elementary class teachers, and the study results indicated low level skills (Aydoğdu & Buldur, 2013; Bağcı-Kılıç, Yardımcı & Metin, 2009). Many other studies have found that preservice science teachers lack the skill to identify and control variables (Ateş, 2005; Saka, 2012; Çelik & Özbek, 2013). Similar results were found in studies conducted at the high school level. These study results demonstrated that high school students' skills of identifying and controlling variables were low (Beaumont-Walters & Soyibo, 2001). In their study, Aziz and Md Zain (2010) compared the science process skills in 10th, 11th, and 12th grade students' physics books in Yemeni schools. Their studies' results showed that physics books included little on formulating hypotheses or identifying variables. This study, along with other study results, indicates that generally, preservice science teachers' skills of formulating hypotheses and identifying and controlling variables were low. Different activities to improve preservice science teachers' science process skills should be administered. Ünal-Çoban (2013) revealed that the curricula should be supported by practice in order to have a significant gain in science process skills. Other studies found that laboratory work improved students' science process skills (Tamir, Doran & Chye, 1992; Germann, Aram, Burke, 1996; Zuzovsky, 1999; Hofstein &Lunetta, 2003). For this purpose it is very important that students should study in laboratories until the end of improving their science process skills.

2. The preservice science teachers who formed a correct hypothesis used both H1-one-directional and H1-non-directional structure. The data from observations also confirmed that observed pre-service science teachers did not formulate a single Ho hypothesis. Preservice science teachers used a H1-non-directional hypothesis because they thought the dependent variable may change with the independent variable but could not guess in which direction (linear or reverse) this change would occur. Abruscato (2000:46) says that the hypothesis to be formulated should depend on observations or arguments. Since students make many observations in daily life, they actually have pre-understanding about most issues to be researched. For example, students came across many times in their daily lives that a cube of sugar dissolved faster in hot water than in cold water. Students may then formulate the hypothesis that all substances that can dissolve more quickly in hot water than they do in cold water. A hypothesis may also be produced from an argument at the same time. For example, if a glass jar is put over a burning candle, the candle will be extinguished in a short time. One may formulate the argument on the basis of this observation that the candle was extinguished due to lack of oxygen. Later the students may formulate the hypothesis that the candle surrounded with glass jar will be extinguished when the oxygen is the jar is used. Similarly, Ateş (2005) specifies that creation of conceptual knowledge by individuals depend on their formulating hypotheses and testing them. Furthermore, it is necessary to withdraw the first hypothesis and formulate a new hypothesis to test if they encounter any disconformity between the initial expected results and the experimental results. In this study, preservice science teachers generally tend to formulate alternative hypotheses, probably owing to observations and arguments they encounter in their daily lives. Preservice science teachers may be inclined toward alternative hypotheses when they consider that an independent variable may have effect on a dependent variable based on those observations and arguments. In addition to this, preservice teachers may also think the change in the independent variable may lead to change in dependent variable while they are formulating alternative hypothesis. Why preservice science teachers prefer H1-non-directional hypotheses should be studied in another study in detail.

3. The types of mistakes preservice science teachers made was examined in detail. In particular, preservice science teachers wrote off-topic variables instead of the relevant variable, wrote more than one variable, or mistook one variable for another variable. The data from observations also confirmed that pre-service science teachers confused the independent variable with dependent variable. During observation,

seven pre-service science teachers did not indicate any control variables while doing a controlled experiment. Other studies have identified that variables are taught similar to statistics in science teaching as dependent, independent and controlled variables (Bağcı-Kılıç, Yardımcı & Metin, 2009), and that this terminology might be confusing (Ateş, 2005; Bağcı-Kılıç, Yardımcı & Metin, 2009). For this reason, some researchers have stated that its better to use "observed variable" instead of "dependent variable," "changed variable" instead of "independent variable" and "controlled or whose effect can be controlled variable" instead of "control variable" (Bağcı-Kılıç, Yardımcı & Metin, 2009).

4. This study also interviewed 58 preservice science teachers who had identified both the hypothesis and the variables incorrectly. They gave the following reasons for their poor performance: their courses do not teach science process skills, experiments done in the laboratories do not include enough science process skills, unaware of the importance of science process skills, the traditional teaching methods used in their courses and instructors did not have enough science process skills. These findings indicate that preservice science teachers accept their mistakes. Moreover, the excuses provided by the preservice science teachers are attention drawing, but not surprising because theory is not really put into practice. Although pre-service science teachers should acquire science process skills through open-ended experiments which include those skills, contemporary methods of instruction, and well-equipped instructors, who have already developed science process skills and are able to transfer these to their students through science laboratory activities (Nantarat Kruea-In and Orawan Thongperm, 2014), it is not the case. Therefore, it is necessary to redesign science teaching in a way that it helps preservice science teachers develop those skills (Huppert, Lomask & Lazarowitz, 2002; Saat, 2004). In science teaching, laboratories have an important effect (Lawson, 1995). Moreover, laboratories can greatly contribute to the acquisition of science process skills (Renner, Abraham, Birnie, 1985; Bryant & Edmunt, 1987; Germann, Aram & Burke, 1996; Tamir, 1997; Zuzovsky, 1999). However the experimental techniques used in the laboratories are significant as well. Many studies have found that open-ended experiments are more effective than closed-ended experiments in terms of science process skills (Renner, 1986; Tsai, 1999; Reid & Shah, 2006; Aktamış, 2007; Aydoğdu, 2009; Özgelen, Yılmaz-Tüzün & Hanuscin, 2012). Because close-ended experiments have a limited role in teaching science process skills, open-ended (i.e. inquiry based experiments) experiments, which help students to acquire science process skills, are preferred. Open-ended

experiments will also help students be in the center of the teaching-learning process. Other courses should also be taught with methods that enable students to more actively develop science process skills. Some students might not attach any meaning to those skills or those skills do not make any sense to them and hence, they might not give importance to learn those skills. This finding is also not surprising because one can meaningfully learn unless s/he has an already cognitive structure with which the new information can be associated. In other words, learning will not be meaningful if a learner lacks that cognitive structure (Ivie, 1998).

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