International Journal of Earth Sciences Knowledge and Applications
journal homepage: http://www.ijeska.com/index.php/ijeska

Research Article

e-ISSN: 2687-5993

Prospective Science Teachers' Opinions on The Plasma State of Matter

Suleyman Aydin[1]*, Pinar Ural Keles[2]

[1]*Agri Ibrahim Cecen University, Educational Faculty, Department of Mathematics and Sciences Education, Agri, Turkey*

INFORMATION

Article history
Received 19 November 2023
Revised 30 December 2023
Accepted 31 December 2023

Keywords
Plasma State of Matter
Prospective science teachers
Prospective teachers' opinions
Plasma state of matter
Phenomonographic research method

Contact
*Suleyman Aydin
yupul@hotmail.com

ABSTRACT

The purpose of this study was to determine the opinions of preservice science teachers about the plasma state of matter. The sample of this research consisted of 79 preservice science teachers. The research method of this study was determined as a phenomonographic research method, and two different data collection tools were used in the study. Interviews were conducted with nine science teacher candidates selected with the snowball sampling method. The other data of the study was obtained with the completion of the statement in the questionnaire form "To me, the plasma state of matter is ....." by 79 teacher candidates. Content analysis was used in the analysis of the interviews, and the phenomonographic analysis method was used in the analysis of sentence completion. As a result of the study, it was found that almost the entire science teacher candidates participating in the interviews didn't have enough information about the concept although they know the plasma is the 4th state of matter. In the study, it was also determined that the results obtained from the sentence completion, support the results obtained from the interviews. It can be recommended that subjects related to the plasma state of matter should be involved more in the undergraduate courses of the Department of Science Teaching.

1. Introduction

Mankind's information about the solid, liquid, and gaseous states of matter dates back to 300 BC. However, the fire that is different from these three forms of matter is considered to be merely a state of energy, which could not be included in any of the substances (Akan, 2016). The development of steady-state discharges by Sir Humphry Davy in 1808 and the development of a high-voltage electrical discharge tube by Michael Faraday and his colleagues in the 1830s are known as the first studies on the discovery of the fourth state of matter. In 1879, Sir William Crookes stated that an ionized gas is the "fourth state of matter" in the studies on electrical discharge in gases (Akan, 2016; Balbağ and Yılmaz Erdoğan, 2018). Ionized gas cluster was first called as "Plasma" by Irving Langmuir in 1929 (Tonks and Langmuir, 1929; Akan, 2016).

Apart from the solid, liquid, and gas states of matter, the fourth state is called plasma. The plasma state of matter is the most common state in the universe and its rate in the universe is more than 99% (MoNE, 2018b). Plasma is defined as "a collection of positively and negatively charged particles that are fully electrically neutral and move in random directions" (Akan, 2016).

According to the same researcher; at a sufficiently high temperature, the molecules in the gas dissociate to form freely moving gas atoms in random directions. If the temperature is further increased, one or more electrons break off from the gas atoms and the gas atoms decompose into freely moving charged particles, i.e. positive ions and electrons, to form the fourth form of the substance called plasma. In the plasma form of matter, the atoms forming the matter have become a system formed by positively charged ions and electrons that are fragmented and constantly in motion (Akan, 2016; MoNE, 2018b).

In plasma, however, the electrons are liberated from the atoms and acquire complete freedom of motion. With the loss of some of their electrons, atoms, and molecules acquire a positive electric charge; they are then called ions. Thus a plasma is a gas consisting of positively and negatively

charged particles in such proportions that the total charge is equal to zero. Freely moving electrons can transport electric current; in other words, a plasma is a conducting gas (Frank-Kamenetskii, 1972).

Today, the plasma state of matter-based technology applications is used in extremely different applications due to their high energy particles and the collective movement properties of these particles. Plasma is used in biology and biomedical, paper industry, aerospace industry, textile industry, electronic chip making, communication technology, coating, and decoration technology, sterilization and water treatment systems, dangerous waste treatment, solar energy and optical industry, automobile and aircraft industry, and in new technology. It is used in a wide range of applications from construction, defense industry, radar and fusion research, to launching rockets in space technology, to orbit protection. The most interesting application of plasma technology in recent years is in the field of medicine and biomedical. With the discovery that cold plasma can kill bacteria that cause different kinds of diseases in a very short time, it is stated that shortly a new type of plasma sterilization method and a very new bacterial infection treatment method can be used (Akan, 2016). Considering the usage areas of plasma in our daily lives, the importance of the opinions of the students at each level of education related to this concept emerges.

On the other hand, the importance of science education given in our schools is increasing day by day. Therefore, the Science course updated in 2017 aims to educate students as science-literate individuals. To achieve this goal, students are expected to" have skills in "Knowledge, Skills, Affection, and Science - Engineering - Technology - Society - Environment dimensions. It is emphasized that in the dimension of knowledge which is one of these dimensions, students must have basic concepts and principles in the fields of Astronomy, Biology, Physics, Chemistry, and Earth Sciences (MoNE, 2018a). However, when the curriculum of science is examined, it is seen that the plasma concept is not given at the primary and secondary school level (MoNE, 2018a). This concept comes first in the 9th grade (MoNE, 2018b).

However, as mentioned above, the concept of plasma constitutes almost all of the universe in which we live, as we are faced with different applications every day in our daily lives. The sun we see when we get up in the morning, the stars we observe at night, the thunderbolts and lightning that we notice on rainy days, the flame we see in the single. The fluorescent and neon lamps we use to enlighten our houses, the zenon lamps we use in the vehicles, the flames of the lighters and matches, all the plasma televisions used in our homes are based on the plasma concept (Balbağ, 2018). The 9th grade is too late for students to learn this concept since the plasma state of matter is at every stage of our lives from the universe we live in to the different plasma technology applications we use (Bülbül, 2009).

In this case, probably, students who do not have any correct infrastructure in this concept during primary and secondary school will frequently produce misconceptions about the events and phenomena based on the plasma concept and how these are formed. In a study by Balbağ (2018), it was reported that almost all of the 358 students from different classes ranging from third grade to eighth grade considered the concepts of sun, star, fire, and lightning as the gaseous state of matter. However, it is known that learning the basic science concepts in the primary education process in a good and correct way is very important for learning to take place in the following years (Çiçek, 2008). The above-mentioned points reveal the importance of providing the subjects of plasma matter in terms of meaningful science education at the level of primary and secondary school considering the students' developmental levels.

It is known that the most important factors in giving meaningful science education to the students are teachers and hence teacher candidates (Kaya ve Bacanak, 2013; Yetişir ve Kaptan, 2007). It is reported that if the subject knowledge, which is one of the required qualifications of teachers, is sufficient. They enter the classroom with confidence and answer the students' questions about the subject promptly to ensure that the students enjoy learning and to make the subject easier to understand by establishing relationships between the concepts (Küçükahmet, 2008).

It is stated that the opposite situation restricts students' conceptual understanding of the subject (Sinan, 2007). In the related literature, besides the importance of increasing the knowledge level of teachers about their fields, it is reported that the persons who conduct the lessons should be more sensitive in the institutions that train teachers (Güler ve Şahin, 2017; Pardhan ve Mohammad, 2005; Uyanık ve Serin, 2016). This makes science teachers' and teacher candidates' views on the plasma state of matter important. In addition, the fact that the plasma state of matter is encountered in the whole universe and the increasing use of the applications based on this concept is increasing day by day increasing the importance of the opinions of teachers and teacher candidates about the concept.

When the related literature is examined, it is seen that the studies about the plasma concept are quite limited. In the study conducted by Balbağ (2018) with the science teacher candidates, on the placement of the concept of plasma in a science program, it was determined that the concept of plasma should be included in the program due to the spiral structure of the course. In the same study, it is emphasized that the plasma concept can be included in the program in the units of different class levels by defining, classifying, and associating with everyday life and the other states of matter by the cognitive development of the students.

In another study conducted by Bülbül (2009) on the subject. It was stated that not giving the concept of plasma starting from the level of primary school will cause some difficulties in science teaching, and based on the cognitive approach, some opinions are presented to give the concept of plasma most simply and effectively to primary school students. In a study conducted by Balbağ and Yılmaz Erdoğan (2018). To determine how primary and secondary school students perceive the concepts related to plasma in our daily lives, it has been found that almost all of the students in each class level cannot classify or misclassify the concepts related to

plasma they see constantly in their environments. In the study conducted by Korkmaz et al. (2018) with 18 gifted eighth-grade students showed that the plasma demonstration experiments supported by simulations on the understanding of the plasma stage of the subject significantly increased the level of knowledge about students. In another study conducted by Korkmaz et al. (2015) with 32 science prospective teachers, it is reported that plasma demonstration experiments supported by simulations significantly increase the knowledge level of teacher candidates about the subject.

Additionally, Korkmaz (2015) also designed an experimental study for the plasma state, which is the fourth state of matter. This experimental study was carried out with the participation of university students. The study conducted by Nıroj and Srısawasdi (2014) with 50 12th-grade students in the north-eastern region of Thailand found that all of the students had non-scientific knowledge about plasma concepts.

When the literature on the subject given above is examined, it is seen that the number of studies in the area related to the plasma state of matter is very limited. In addition, it is observed that none of the studies directly focused on the opinions of the prospective science teachers on the subject of plasma. Also, as mentioned above, this concept is a concept that is frequently encountered in our daily lives and constitutes almost all of the universe. Therefore, the opinions of prospective science teachers about the plasma form of matter are a matter of curiosity. In light of the literature and the explanations mentioned above, this study aimed to determine the science teacher candidates' opinions on the plasma state of matter.

2. Method

In this study, the phenomonographic research method was used. Phenomenography is a research method that deals with what people perceive, understand, and experience about the phenomena they encounter in the universe they live in (Çekmez et al., 2012). The basis of this approach is based on defining the different ways in which people experience, interpret, understand, or conceptualize a particular aspect of a phenomenon (Çepni, 2012). In this way, it is possible to explain qualitatively how the various phenomena are understood in different ways and systematically differentiate different insights according to the resulting categories (Ashworth and Lucas, 1998). In the phenomenography research approach, interviews are often used as data collection tools (Beaulieu, 2017; Çepni, 2012; Khan, 2014). On the other hand, open-ended survey questions, observations, and written reflective expressions are other data collection tools that can be used in phenomenography studies (Rands and Gansemer-Topf, 2016).

In this study, it was understood that it was appropriate to use the phenomenography research method since it was wanted to investigate the opinions of prospective science teachers about plasma and how science teacher candidates perceive the concept.

2.1. Sample of the Study

The study was carried out in Ağrı İbrahim Çeçen University Faculty of Education Department of Mathematics and Science Teaching. The sample of the study consisted of 79 science teachers. Prospective teachers were interviewed by snowball sampling method. Taking advantage of the questions "Who knows more about this subject?" and "Who should I interview?" that Patton (1987) used in his study, the sample of the study was formed by directing the researcher and teacher candidates to each other. This sampling method has been reported to be effective in detecting individuals or situations that may be rich sources of information regarding the problem of the investigator (Yıldırım and Şimşek, 2011).

2.2. Data Collection Tools

To better understand science teacher candidates' opinions on the plasma state of matter and how science teachers perceive the concept of plasma, two data collection tools suitable for the nature of the phenomenography approach have been utilized. The first one was the interview have been done with nine science teacher candidates. Within the scope of the study, five questions were asked to the students about the plasma in the face-to-face interviews. In the study, first of all, the topics of questions and levels of the interview questions to be asked to prospective teacher candidates about the plasma are tried to be determined in consultation with the related field experts. After that, the literature was examined and a question pool was formed in which the interview questions were asked to the science teacher candidates. Five of the 11 questions in the question pool were determined to be used. Interview questions were determined by making necessary arrangements by the opinions of two academicians and field experts who are doing master's degrees. After making the final arrangements, five questions about the plasma state of the matter were asked to nine science teacher candidates. The secondary source of the data obtained from the study is a semi-structured questionnaire. Studies that use similar forms to determine how individuals perceive the concept, and what they think about the phenomenon or the concept to be investigated, are found in the literature (Kelleci, 2014; Mutlu, 2013; Özgen, 2013; Yıldırım Hacıibrahimoğlu, 2016). 79 science teachers were asked to complete the sentence "To me, plasma state of matter means ……." in the questionnaire form. The teacher candidates were given five minutes to complete this statement with their handwriting.

2.3. Data Analysis

The data obtained from the students' responses to the interview questions about the plasma were subjected to content analysis. The information obtained from the content analysis is examined and divided into sections to make sense of each section. In this context, coding can be performed within a general framework according to the concepts extracted from the data while coding (Çepni, 2012). In this study, the similarities of the science teacher candidates' answers to the questions were gathered under the same title, their frequencies were determined and the headings were coded and presented to the reader by tables. In the study, they were not written the quotations directly as the answers given by preservice science teachers to the interview questions related to 'the plasma state of the matter' were quite short. While analyzing the interviews, the students were coded as S1, S2, …, S9.

The sentence completion question "To me, the plasma state of matter mad means ……." which is one of the data collection tools of the study was evaluated by the phenomonographic analysis method. In the analysis of the answers, similarities and differences of the expressions used to complete the sentence were taken into consideration. The answers of the pre-service teachers were divided into temporary pre-categories before coding. The preliminary categories obtained from the regulations were reviewed for the second time descriptive categories were created and the expressions included in the categories were rearranged. The reliability of the analysis of the data obtained from the interviews and sentence completion questions in the study was calculated by using the Reliability = Consensus Union / (Consensus + Opinion) formula (Miles and Huberman, 1994).

In the analysis of the data obtained from the interviews, the mean reliability between the researchers (prospective teachers and a specialist faculty member) was found to be 93% and 88% for the analysis of the sentence completion question. Research is accepted as reliable if the reliability calculations are over 70% (Miles and Huberman, 1994). The data obtained from the results of the analyses are presented with frequencies in the tables.

3. Findings

In this part of the study, the results obtained within the scope of the research are given under two headings.

3.1. Findings from Interviews

In this section, the findings obtained from the analysis of the interviews conducted with nine science teacher candidates were included. The similarities of the teacher candidates' answers to each question asked about the plasma were collected under the same headings and their frequencies were determined and then codes given to each heading were presented to the reader by tables. Table 1 presents the findings regarding the answers given to the first question "What do you think of when talking about the plasma state of matter?" of the interview.

As seen in Table 1, four different expressions related to the question "What do you think of when talking about the plasma state of matter?", have been formed from the opinions of prospective teachers. It is seen that eight of the nine teacher candidates interviewed answered this question with the expression "fourth state of matter". In second order the expression "The state of matter composed of neutral atoms" comes with four frequencies. In the final order the expression "The state of matter composed of light particles" comes with only one frequency.

Table 2 presents the findings regarding the answers given to the second question "What are the properties of plasma state of matter?" of the Interview.

As seen in Table 2, intern teachers asked "What are the properties of plasma?" When their views on the question were examined, it was determined that five of the nine trainee teachers who participated in the interview answered the question by using the expression "The plasma state of matter is uncharged." In Table 2, the expression "ıt has high temperature" was found in the second order with three frequencies. In the last order, the expression "plasma is heat conductive" was found with only one frequency.

The answers to the third question of the interview "what do you know about plasma classification?" were given in the Table 3.

Tablo 1. The expressions of teacher candidates about the "plasma state of matter"

Expressions	Teacher candidates (N=9)
The fourth state of matter	S1, S2, S3, S4, S5, S6, S8, S9 *(8)*
The state of matter is composed of neutral atoms	S2, S4, S5, S7 *(4)*
The state of matter is composed of free electrons	S3, S7 *(2)*
The state of matter is composed of light particles	S5 *(1)*

** The opinions of some teacher candidates were included in more than one statement*

Table 1. Prospective teachers' opinions on the properties of plasma state of matter

Expressions	Teacher candidates (N=9)
The plasma sample of the substance is uncharged	S2, S4, S6, S8, S9 *(5)*
It has a high temperature	S1, S3, S7 *(3)*
It is the best electrical conductor	S5, S8 *(2)*
The plasma state of matter is heat conductive	S5 *(1)*

**The opinions of some teacher candidates were included in more than one statement*

Table 3. The opinions of prospective teachers about plasma classification

Expressions	Teacher candidates (N=9)
I do not know.	S1, S2, S3, S6, S7, S8, S9 *(7)*
Hot-cold plasma.	S4, S5 *(2)*
Natural- artificial plasma	S5 *(1)*

**The opinions of some teacher candidates were included in more than one statement*

Table 4. The opinions of prospective teachers about the examples of the plasma state of matter in the universe

Expressions	Teacher candidates (N=9)
Universe	S1, S2, S5, S6, S7, S8 *(6)*
Sun	S1, S7, S5, S9 *(4)*
Stars	S3, S5 *(2)*
Lightning and thunderbolt	S4 *(1)*
Auroras	S6 *(1)*

**The opinions of some teacher candidates were included in more than one statement*

Table 5. The prospective teachers' opinions about the places where plasma technology is used today

Expressions	Teacher candidates (N=9)
Plasma TVs	S1, S2, S3, S4, S5, S6, S7, S8 *(8)*
Fluorescent lamps.	S3, S6, S9 *(3)*
Neon Lamps	S2, S3 *(2)*
The air conditioners	S8, S5 *(2)*
Nuclear power plants	S2 *(1)*

**The opinions of some teacher candidates were included in more than one statement*

As can be seen from Table 3, the opinions of the prospective teachers about the question "What do you know about the classification of plasmas?" are examined. It was seen that seven of the 9 teacher candidates who participated in the interview answered the question by using the expression "No Knowledge". In the second order the expression "Hot-cold plasma" is represented with two frequencies. Finally, the expression of "natural-artificial plasma" was placed with only one frequency.

The findings related to answers given to the 4th question "What can you give as an example of plasma from the universe?" In the interview was given in Table 4.

In Table 4, when the opinions of the prospective teachers about the question "What can you give as an example of plasma from the universe?" were examined. Ican be seen that six of the nine teacher candidates who participated in the interview seem to answer the question by using "Universe" and four of them using "Sun". In the third order, the word "stars" takes place with the two frequencies. In the third place, the word "stars" came with two frequencies. And finally, the expressions "Lightning" and "Aeroas" came each with only a frequency.

In Table 5, when the opinions of the prospective teachers about the question "Where is plasma technology used today?" were examined it can be seen that eight of the nine teacher candidates participating in the interview seem to answered the question by using the expression "Plasma TVs". Secondly, the term "Fluorescent lamps" with three frequencies and the expression "Nuclear power plants" have taken place with only one frequency in the last order.

3.2. Findings from Sentence Completion Questions

In this section, the findings obtained from the sentence "To me, the plasma state of matter means ……." that science teacher candidates completed were included. Three different perception categories were obtained from the expressions used in the study. The categories and the frequencies related to these categories were presented in tables by calculating the frequencies at each class level. In the study, the categories in which the students' expressions were most used to complete the sentence were the category of *"Plasma state of the matter as a definition"*. The expressions and frequencies of this category are given in Table 6.

At each class level, the first category of science teachers used to complete the sentence completion question was the "Plasma state of matter as a definition" category with 51 frequencies. Table 6 shows that this category consisted of four statements. In this category, the "fourth state of Matter" ranks first with 40 frequencies at each class level. This was followed by statements "Neutral state", "light particles" and "not free electrons". In the study, the second category, which was formed from the expressions used by the students to complete the sentence, was the category of "Plasma state of the substance as usage areas ". Expressions and frequencies of this category are given in Table 7. The category of "Plasma state of substance as a field of use" was the second category that consisted of the teacher candidates' responses with 20 frequencies.

Table 2. Findings related to the category of "Plasma state of the matter as a definition"

Defined Category	Expressions	1st Class (f) (N=8)	2nd Class (f) (N=32)	3rd Class (f) (N=25)	4th Class (f) (N=14)	Total (f)
The definition of plasma state of matter	4th state of matter	4	17	13	6	40
	Notr state of matter	-	2	3	-	5
	Free electrons	-	1	-	1	2
	Light particles	1	1	-	2	4
Total		5*	21*	16*	9*	51*

**The opinions of some teacher candidates were included in more than one statement*

Table 7. Findings from the expressions related to the category of "plasma state of the matter as usage areas"

Defined category	Expressions	1st Class (f) (N=8)	2nd Class (f) (N=32)	3rd Class (f) (N=25)	4th Class (f) (N=14)	Total (f)
Usage areas of plasma technology nowadays	Plasma TV	2	9	5	3	19
	Fluorescent lamp	1	-	-	-	1
Total		3*	9*	5*	3*	20*

*The opinions of some teacher candidates were included in more than one statement

Table 8. Findings from the expressions related to the category of, "The plasma state of matter as a property"

Defined Category	Expressions	1st Class (f) (N=8)	2nd Class (f) (N=32)	3rd Class (f) (N=25)	4th Class (f) (N=14)	Total (f)
Properties of plasma state of matter	High temperature	2	5	4	4	15
Total		2*	5*	4*	4*	15*

*The opinions of some teacher candidates were included in more than one statement

Table 7 shows that this category consisted of two expressions. In this category, the expression "Plasma TV" ranks first with 19 frequencies at each class level. The expression of "Fluorescent lamp", was only found in freshman class. In the study, the third category, which was formed by the expressions used by the students to complete the sentence, was the "Plasma state of the substance as a property" category. The expressions and frequencies of this category are given in Table 8.

The "Plasma state of the substance" category was the third category formed from the expressions of prospective science teachers with a frequency of 15. When Table 8 was examined, it was seen that this category had 15 frequencies at each class level.

4. Discussions and Conclusions

When the data obtained from the interviews were examined in this study which was conducted to determine the opinions of the prospective science teachers about the plasma state of matter, it was determined that eight of the nine science teacher candidates who participated in the study answered the question that was the first question of this study of "What do you think when the plasma state of matter was mentioned?" as "fourth state of matter". The expression "The state of matter that is composed of neutral atoms." of the same question was found to have four frequencies, another expression "The state of matter that is composed of free electrons." had two frequencies, and the last expression of "The state of matter that is composed of light particles." had only one frequency.

According to Akan (2016), molecules in the gas at elevated temperatures are decomposed to form freely moving gas atoms in random directions. If the temperature is increased further, one or more electrons break off from the gas atoms and the gas atoms decompose into freely moving charged particles, i.e. positive ions and electrons, to form the fourth form of the substance. Plasma contains a large number of electrons, electrons that break off atoms, such as ions, and a lot of light photons that give off the flame of the fire. Therefore, it can be said that all of the statements obtained from the answers of the science teacher candidates are scientific expressions that express the concept of plasma. Starting from the height of the frequency of the phrase "fourth state of matter", it can be concluded that the plasma state of matter is thought to be the "fourth state of matter" by nearly all of the prospective science teachers. The fact that the frequencies of the answers given to the question, except for the expression "fourth state of the matter" were quite low, may indicate that the "fourth state of matter" is a general knowledge of the concept.

In a study by Korkmaz et al. (2015), it is stated that although a total number of 32 prospective science teachers used the phrase "the fourth state of matter" for the plasma form of the substance in a multiple-choice test, their fundamental knowledge related the subject is insufficient. Therefore, it can be said that this result is supported by the literature.

In the study, it can be seen from Table 2 that the opinions of the prospective science teachers on the characteristics of "properties of the plasma state of the matter "consisted of four statements. From these expressions, the phrase "Plasma state of matter is uncharged" was among the teacher candidates' answers to the question with five frequencies. This is followed by the expression "It has a high temperature." with three frequencies, "Best electrical conductor with two frequencies, and the expression "Plasma state is a heat conductor." with one frequency. Both the quality and the quantity of the expressions used by science teacher candidates to answer the question were found to be quite low as in the other questions. It was found that only five of the nine science teacher candidates expressed the "Plasma state of matter is uncharged." and the frequencies of the other expressions were much lower.

On the other hand, in the study, it was determined that seven of the nine science pre-service teachers answered using the expression "no knowledge" about the classification of plasmids. Based on these findings, it can be concluded that science teacher candidates do not have sufficient knowledge about the properties of plasma and the classification of plasma.

This result supports the notion that the aforementioned view "fourth state of matter" is a general knowledge of the concept. When examining both the 2010 and 2018 science undergraduate programs applied by Council of Higher Education (CoHE), it is seen that pre-service teachers learned this concept at a basic level in physics courses in the first two years of their education (CoHE, 2010; CoHE, 2018).

In a study conducted by Korkmaz et al. (2015), with science teacher candidates, it was reported that it is not easy to perceive the subjects related to the properties of the plasma. In the same study, the questions about the characteristics of the plasma and the classification of plasmids in the pre-test and post-test indicate that the correct response rate is quite low.

In a study conducted by Korkmaz (2015) with 48 ninth-grade students, it was reported that the students' academic achievement in the subjects related to the plasma state and properties of the substance was quite low. Similar results were obtained by Korkmaz et al. (2018) from 18 eighth-grade students attending the weekend program given for gifted students in the field of science and mathematics.

In the study, among the examples that science teacher candidates gave to as an example for the plasma from the universe the expressions "The Universe" came with six frequencies in the first order and "The Sun" with four frequencies in the second order. The frequencies of the Expressions "stars, "lightning" and arsenic were found to be lower. The frequencies of the expressions "stars", "lightning" and "auroras" were found to be lower. Considering the opinions of prospective science teachers about where plasma technology is used nowadays; Eight of the nine science teacher candidates were asked to use the phrase "Plasma TV". The expression "Fluorescent lamps" came in the second order with three frequencies. This is followed by "neon lamps" and "air conditioners" with two frequencies each, and "nuclear power" plants" with one frequency. When the data obtained from the study were examined; It was seen that the frequency of the expressions and expressions formed from the responses of the prospective science teachers about the use of plasma technology in our daily lives as well as the samples they gave from the universe to the plasma and the frequencies of these expressions were limited. These findings support the above-mentioned conclusion that prospective science teachers have a lack of knowledge about the plasma state of matter.

Indeed, in the study conducted by Korkmaz et al. (2015) and Korkmaz (2015) similar results were obtained in the result of this study. On the other hand, this situation is likely to be caused by the misconfiguration of previous learning on the subject.

In a study by Balbağ (2018), it is stated that a very important part of elementary and secondary school students considers the concepts that can be given as examples to the plasma, for example, sun, stars, lightning, flame, and so on. They accept the substance they see in their environment as a gaseous or solid state. In the study conducted by Niroj and Srısawasdi (2014) with fifty-second-grade students; it was reported that all of the students participating in the study had non-scientific information about the plasma.
In addition to the interviews, the findings obtained from the sentence completion "To me, the plasma state of matter mad means ……." were used to determine the prospective science teachers' opinions about the plasma. In the analysis of the sentence completion questions used in the study, three different detection categories were determined. These were; "Plasma state of matter as definition", "Plasma state of matter as application areas" and "Plasma state of matter as property". The first of these categories is the category "Plasma state of the matter as definition", which consists of four different expressions and has the highest frequency with 51 frequencies in total at all grade levels (Table 6).

Among the expressions, the expression "Fourth state of matter" had the highest frequency with 40 frequencies in the total of all grade levels. This finding supports the conclusion obtained from the interviews "the fourth state of the matter" which first came to the mind of the prospective science teachers when plasma was mentioned. Other expressions included in the category were the Expressions "Notr state of matter", "light particles", and "free electrons" with fewer frequencies. When Table 7 and Table 8 in which "Plasma state of matter as application areas" and "Plasma state of matter as property" expressions were in, it was seen that the number of expressions in these categories, as well as the frequencies of these expressions, were quite low.

On the other hand, in the study, the number of categories formed from the sentence completion questions directed to the prospective science teachers, the number of expressions in the categories, and the frequencies of these expressions were low. Also indicating that teacher candidates' perceptions on the "plasma state of matter" were quite limited. This is due to a lack of knowledge about the subject. This finding consists of a general knowledge that almost all of the prospective teachers who participated in the research have the opinion, "The plasma state of matter is the fourth state of matter" and this result shows that the interior of this knowledge was not scientifically full. Similar results were obtained in the limited studies on the subject (Korkmaz et al., 2015; Balbağ, 2018; Korkmaz, et al. 2018; Niroj and Srısawasdi, 2014).

On the other hand, in the study, it was determined that the highest total frequencies were in 2nd and 3rd-grade levels in all three categories. This may be because physics courses given to undergraduate students in the first two years of their studies. It can include subjects related to the plasma state of matter at a basic level and their effects can be seen mostly at the 2nd and 3rd grade level (CoHE, 2018; CoHE, 2010).

As a result of this study, it was determined that science teacher candidates did not have enough knowledge about the plasma state of matter except the general knowledge of "the fourth state of matter". However, the plasma state of matter is the universe itself, the plasma technology is now used in a myriad of fields, from health to space research. Therefore, it is necessary to overcome the shortcomings of pre-service science teachers with more effective courses at the undergraduate level. On the other hand, in primary and secondary school programs issues related to the plasma state of matter are never included. Considering that the basic objective of the Science course is 'to educate students as science literate individuals', this situation is thought to hamper the realization of the goal of the program. Therefore, the plasma conceptually should be placed on the science curriculum depending on the cognitive development of students.

In addition, the plasma concepts can be given in science courses with effective activities. In addition, concepts related to plasma can be given in science courses with effective activities.

References

Akan, T., 2016. Evrenin her yerinde plazma hayatımızın her yerinde plazma. http://dx.doi.org/10.13140/RG.2.1.2321.4960.

Ashworth, P., Lucas, U., 1998. What is the 'world' of phenomenography? Scandinavian Journal of Educational Research 42 (4), 415-431.

Balbağ, M.Z., 2018. Views of prospective science teachers on including the concept of plasma in science curricula. International Journal of Instruction 11 (2), 569-584.

Balbağ, M.Z., Yılmaz Erdoğan, S., 2018. İlkokul ve ortaokul öğrencileri günlük yaşamımızdaki plazmaya yönelik kavramları nasıl algılamaktadır, Eğitim ve Öğretim Araştırmaları Dergisi 7 (2), 123-131 (in Turkish).

Beaulieu, R., 2017. Phenomenography: implications for expanding the educational action research lens, Canadian Journal of Action Research18 (2), 62-81.

Bülbül, F., 2009. Plazma kavramına dair… Kastamonu Eğitim Dergisi 17 (1), 279-288 (in Turkish).

CoHE, 2010. Yükseköğretim kurulu, Eğitim Fakültesi Öğretmen Yetiştirme Lisans Programları (Eski Programlar) (in Turkish).

CoHE, 2018. Yükseköğretim Kurulu, Öğretmen Yetiştirme Lisans Programları, Fen Bilgisi Öğretmenliği Programı (in Turkish).

Çekmez, E., Yıldız, C., Bütüner, S.Ö., 2012. Fenomenografik araştırma yöntemi. Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi 6 (2), 77-102 (in Turkish).

Çepni, S., 2012. Araştırma ve proje çalışmalarına giriş. Ankara (in Turkish).

Çiçek, Ş., 2008. Lise II Öğrencilerinin kimya dersinde başarıları ve tutumları üzerine bilim şenliklerinin etkisinin incelenmesi. Yüksek Lisans Tezi, Gazi Üniversitesi, Fen Bilimleri Enstitüsü, Ankara (in Turkish).

Frank-Kamenetskii, D.A., Frank-Kamenetskii, D.A., 1972. Introduction. In Plasma: The Fourth State of Matter; Springer: Berlin, Germany, pp. 1-8.

Güler, B., Şahin, M., 2017. Fen bilgisi öğretmen adaylarının "elektrik ve manyetizma" konusundaki kavramsal anlamalarının incelenmesi, Buca Eğitim Fakültesi Dergisi 44, 179-193 (in Turkish).

Kaya, M., Bacanak, A., 2013. Fen ve teknoloji öğretmen adaylarının düşünceleri: fen okuryazarı birey yetiştirmede öğretmenin yeri. Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi,21, 209-228 (in Turkish).

Kelleci, D., 2014. Sınıf öğretmeni adaylarının iklim kavramına iliÇkin algılarının metafor yoluyla incelenmesi. Giresun Üniversitesi Sosyal Bilimler Enstitüsü (, Yüksek Lisans Tezi (Basılmamış), Giresun (in Turkish).

Khan, S.H., 2014. Phenomenography: a qualitative research methodology in Bangladesh. International Journal of New Trends in Education and Their Implications 5 (2), 34-43.

Korkmaz, S.D., Aybek, E.C., Pat, S., 2015. The effect of new experimental system design related to the plasma state on achievement of candidate elementary science teachers. Universal Journal of Educational Research 3 (10), 735-741.

Korkmaz, S.D., 2015. A new experimental system design related to the plasma state. Educational Research and Reviews. 10(17), 2501-2511. https://doi.org/10.5897/ERR2015.2452.

Korkmaz, S.D., Ayas, B., Aybek, E.C., Pat, S., 2018. Evaluating the gifted students' understanding related to plasma state using plasma experimental system and two-tier diagnostic test. Journal of Education in Science, Environment and Health 4 (1), 46-53.

Küçükahmet, L., 2008. Etkili öğretimin ilkeleri. Türkiye Özel Okullar Birliği Dergisi 3, 28-35 (in Turkish).

Miles, M.B., Huberman, A.M., 1994. Qualitative data analysis: an expanded sourcebook (2nd ed.). Thousand Oaks, California, SAGE.

MoNE, 2018a. Türkiye Cumhuriyeti, Millî Eğitim Bakanlığı, Fen Bilimleri Dersi Öğretim Programı (İlkokul ve Ortaokul 3, 4, 5, 6, 7 ve 8. Sınıflar), Ankara (in Turkish).

MoNE, 2018b. Türkiye Cumhuriyeti, Millî Eğitim Bakanlığı, Ortaöğretim 9. sınıf kimya ders kitabı, Ankara (in Turkish).

Mutlu, M., 2013. Recycling" concepts perceptions of grade eight students: phenomenographic analysis. Anthropologist 16 (3), 663-669.

Niroj, S., Srısawasdı, N., 2014. A blended learning environment in chemistry for promoting conceptual comprehension: A journey to target students' misconceptions. Proceedings of the 22nd ınternational conference on computers in education. Japan: Asia-Pacific Society for Computers in Education, November, 307-315.

Özgen, N., 2013. Öğretmen adaylarının erozyon kavramına yönelik algıları: fenomenografik bir araştırma. Hacettepe Üniversitesi Eğitim Fakültesi Dergisi 28 (2), 321-334 (in Turkish).

Pardhan, H., Mohammad, R.F., 2005. Teaching science and mathematics for conceptual understanding? Eurasia Journal of Mathematics, Science and Technology Education 1 (1), 1-20. https://doi.org/10.12973/ejmste/74658.

Patton, M.Q., 1987. How to use qualitative methods in evaluations. Newbury Park, California: Sage.

Rands, M., Gansemer-Topf, A.M., 2016. Phenomenography: a methodological approach for assessment in student affairs. Education Publications 45, 1-22.

Sinan, O., 2007. Fen bilgisi öğretmen adaylarının enzimlerle ilgili kavramsal anlama düzeyleri. Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi 1-22 (in Turkish).

Tonks, L., Langmuir, I., 1929. Note on" Oscillations in Ionized Gases. Physical Review 33 (6), 990.

Uyanık, G., Serin, M.K., 2016. Sınıf öğretmeni adaylarının bazı temel fen konularındaki kavram yanılgılarının belirlenmesi, Amasya Üniversitesi Eğitim Fakültesi Dergisi 5 (2), 510-538 (in Turkish).

Yetişir, M.I., Kaptan, F., 2007. Sınıf öğretmeni adaylarının fen ve teknoloji okuryazarlığının önemi hakkındaki görüşleri. Hacettepe Üniversitesi Eğitim Fakültesi ve Azerbaycan Devlet Pedagoji Üniversitesi Uluslararası Öğretmen Yetiştirme Politikaları ve Sorunları Sempozyumu, 12-14 Mayıs, Bakü (in Turkish).

Yıldırım-Hacıbrahimoğlu, B., 2016. Okul öncesi öğretmen adaylarının "Uygulama öğretmeni" kavramına ilişkin zihinsel imgeleri. Turkish Online Journal of Qualitative Inquiry 7, (3), 245-278 (in Turkish).

Yıldırım, A., Şimşek, H., 2011. Sosyal Bilimlerde Nitel Arastirma YOntemleri (8. Baskı) Seckin Yayinevi, Ankara, (in Turkish).