DETERMINATION OF THE OPINIONS AND ALTERNATIVE CONCEPTS OF PRE-SERVICE SCIENCE TEACHERS ABOUT THE FUNCTIONS OF THE ELEMENTS OF A SIMPLE ELECTRIC CIRCUIT

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Abstract

The purpose of the current research was to determine the opinions and alternative concepts of the pre-service science teachers about the functions of the elements found in a simple electric circuit. The current research was carried out with the participation of the first-year students attending the Science Teaching Department of a state university located in the western part of Turkey in 2016-2017, 2017-2018 and 2018-2019 academic years. As the data collection instrument of the current research, a qualitative research-based questionnaire was used. In the analysis of the collected data, the content analysis method was used. As a result, it can be said that; the pre-service science teachers have alternative concepts about the functions of the elements found in a simple electric circuit. It can be also said that the simple electric circuit and the functions of the elements found in this circuit have not been thoroughly understood by the pre-service science teachers.

Keywords: Alternative concept, electric circuits, pre-service science teachers.

INTRODUCTION

The question “Is simple electric circuit is really simple" is, in fact, one of the most difficult questions to be answered by many of us. Electricity, which is one of the basic concepts in physics, can be used in meanings highly different from its scientific meaning in daily life. Beaty (1996) stated that nearly ten different definitions of electricity can be made including scientific definition, daily definition, primary school definition, classification of phenomena involving electric charges, a field of physics, etc. The example the researcher provided in relation to this is interesting. In this example; Mrs. McCave, created by Dr. Seuss as a fictional character, has 23 sons the name of each of whom is “Dave”. Thus, if you ask Mrs. McCave the question “Who is Dave?”, you may have great difficulty in receiving a clear answer because there is no single answer to be given to this question by Mrs. McCave. In fact, the same holds true for the question

"What is electricity?". Therefore, instead of the question "What is electricity?", questions such as "What is electric charge?", "What is electric energy?", "What is electric current?" etc. need to be asked. When these questions are asked, it is evident that their answers will be different.

In Turkey, students encounter the concept of "electricity" for the first time at a primary level within the context of the 3rd grade natural sciences course. Primary school 3rd-grade students are instructed about electric devices and equipment, sources of electricity and secure use of electricity within the unit "Electric Tools"; moreover, at all the levels of compulsory education, students are introduced to the subjects of electricity in a cyclical manner. Though the subjects of electricity are encountered by students at every level of formal education from primary education to tertiary education, they seem to be highly difficult for students to understand. When the relevant literature is reviewed, it is seen that individuals have many alternative concepts in the subjects dealing with the concept of electricity. Within the context of the current research, only the alternative concepts related to electric circuits will be addressed. The most notable alternative concept encountered in relation to electric circuits in the literature is the consumption of electric current by circuit elements (Chen & Kwen 2005; Frederiksen, White & Gutwill, 1999; Görecek Baybars, 2018; Osborne, 1983; Psillos, Tiberghien & Koumaras, 1988; Setyani, Suparmi, Sarwanto & Handhika, 2017; Shipstone, Rhöneck, Jung, Karrqvist, Dupin, Joshua & Licht, 1988; Yurumezoglu & Cokelez, 2010;). In this model, which is expressed as the consumed current model, students are of the opinion that the current flows in a single direction in the circuit and is consumed by the circuit elements. For this reason, students think that the bulb closer to the battery will be the brightest and the bulb relatively more distant to the battery will yield less bright light.

Another alternative concept related to electrical circuits is "the unipolar model". Students who have this model think that the current is flowing in one direction in the circuit and according to these students, the current comes from the positive pole of the generator, enters through the bottom of the lamp and all the current is consumed in the lamp (Chambers & Andre, 1997; Heller & Finley, 1992). In addition, these students thought that there is no need for a closed circuit to generate the current (Chambers & Andre, 1997). Another alternative concept encountered in the literature is "the colliding currents model". According to this model, students thought that there are two types of currents and that the positive current coming from the positive pole of the battery and the negative current coming from the negative pole of the battery collide in the bulb and release energy (Chambers & Andre, 1997; Heller & Finley, 1992; Osborne, 1983). As different from the literature, Satır (2007) attempted to determine the alternative concepts of 3 different groups (high school students, pre-service teachers, and teachers) related to simple electric circuits. As a result of this research, while alternative concepts parallel to the ones reported in the literature have been elicited, one different alternative concept which is "the current gets lost after it has gone over the open switch" has been obtained. It is possible to increase the number of the examples from the literature but what is important to emphasize here is that the data collected from different countries, from different age groups, from different genders and through different data collection tools regarding simple electric circuits lead us to the same conclusion.

Alternative concepts are structures that are highly resistant to change and make conceptual learning difficult. Alternative concepts may originate from individual experiences, observations, culture, language and formal education (textbooks, teachers, etc.) (Wessel, 1999). Therefore, it is very important to determine these alternative concepts and their origins in individuals. When the literature is reviewed, it is seen that there are some studies proving that the roots of alternative concepts lie in teachers and textbooks (Gorecek Baybars, 2018; Kapucu & Yıldırım, 2012). In creating an effective and productive classroom environment, the teacher's pedagogical qualifications and individual competencies are very important (Huyuguzel Cavas & Cavas, 2016). It should be noted that teachers teach as they have learned (Hestenes, 1996). Given the delineations above, training of pre-service teachers who will work in the field in the future attains special importance. Given that current pre-service teachers will be responsible for the design of the learning environment in the future, it seems to be necessary to investigate their knowledge and competencies pertinent to the subject of "simple electric circuit" and the current research can serve this purpose. Thus, the purpose of the current research was to determine the opinions and alternative concepts of the pre-service science teachers about the functions of the elements found in a simple electric circuit. In this connection, answers to the following research questions were sought:

- What are the opinions of the pre-service science teachers about the functions of the elements found in a simple electric circuit?
- What are the alternative concepts of the pre-service science teachers about the functions of the elements found in a simple circuit?

METHODOLOGY

The current research was descriptive research conducted by using the special case method and qualitative data collection tools. The research also employs the purposive sampling method. The purposive sampling method allows the comprehensive investigation of the situations believed to include rich data (Patton, 2004). The current research was carried out with the participation of the first-year students attending the Science Teaching Department of a state university located in the western part of Turkey in 2016-2017, 2017-2018 and 2018-2019 academic years. While the university where the current research was conducted accepted 80 students into the Science Teaching Department in 2016-2017 and 2017-2018 academic years, this number was reduced to 40 in the 2018-2019 academic year. In order to keep the sampling of the current research larger and to reach more data, the research was conducted in different academic years. The total number of students accepted to the Science Teaching Department of the university within this three-year period is 200. As participation in the current research was on a volunteer basis, the research was conducted on a total of 166 pre-service science teachers. Moreover, the reason for the selection of the first-year students for the current research is they’re not having taken any course about electricity in their undergraduate education.

As the data collection instrument of the current research, a qualitative research-based questionnaire developed by Yurumezoglu & Cokelez (2010) was used. In the questionnaire developed by Yurumezoglu & Cokelez (2010), there were 7 open-ended questions. Out of these 7 questions, 6 complying with the purpose of the current research were selected and used.

The questions in the data collection instrument used in the current research were as follows;

- *Imagine that you have a bulb, a battery, and a cable at a certain length. You are asked to make a circuit by using these materials and to light the bulb. Please, draw the circuit you will make.*
- *Explain the following;*
- *What lights the bulb?*
- *What happens in the battery while the bulb is lighting?*
- *What happens in the cable while the bulb is lighting?*
- *Up to which time does the bulb light?*
- *When the bulb lights, what is electricity converted to?*

In order to establish the internal validity of the current research, the opinions of an academician specialized in the field of physics education and an academician specialized in science teaching were sought and pilot research was conducted with 30 second-year students attending the department of science teaching in the same university. The reason why the pilot research was conducted is to check whether the questions are comprehensible or not and to determine the time needed to respond to the items in the data collection tool. As a result of the pilot research, it was decided that the items in the data collection tool are clear and comprehensible and that 30 minutes are enough to respond to them. In order to establish the external validity of the research, samples derived from the data collected from the pre-service teachers are presented to the reader in a detailed manner in the findings section. As for the reliability of the research, the agreement between the data obtained from the codes produced by two independent observers were tested. To this end, the formula proposed by Miles and Huberman (1994); Reliability = Agreement / (Agreement + Disagreement) was used. In this way, the reliability of the research was found to be 90%. This value shows that the research is reliable.

The data collection tool was administered to the participants at the beginning of each academic year in the academic years stated above within the context of the Physics I course. The author of the current research is an academician in the university and teaches the Physics courses.

In the analysis of the collected data, the content analysis method was used. The content analysis method is one of the methods widely used particularly in the analysis of written and visual data (Silverman, 2001). In the content analysis, various techniques depending on the subject of research (frequency analysis, categorical analysis, evaluative analysis, correlation analysis) can be used (Bilgin, 2006). In the current research, the categorical content analysis method was used. One of the key features of this analysis technique is the coding of the collected data. In the data coding; according to Strauss and Corbin (1990), there are 3 paths to be followed. These are; coding performed on the basis of the pre-determined concepts, coding performed on the basis of the concepts derived from the data and coding performed within a general framework. In the current research, coding was performed on the basis of the concepts derived from the data. The path followed in data analysis is as follows: coding of the data, determination of the categories of the coded data, organization of the codes and categories and description and interpretation of the findings (Yıldırım & Simsek, 2008). In the data analysis stage, first all the data were examined by the researcher without doing any analysis and the researcher determined the codes for the research. While determining the codes, particular attention was paid to the common features found in the drawings and explanations of the pre-service teachers. Then, the categories for the codes were determined. The researcher went back to the research data from time to time to check the coding of the data.

The data collected through the data collection tool were digitized and entered into SPSS 20 program package. The results of the analysis are presented in the form of percentages and frequencies in the findings section. As demanded by the rules of ethics, the participating pre-service teachers are coded as S1, S2. Here, “S” stands for pre-service teacher and the number shows the order of the students in the sampling.

RESULTS

Findings obtained from the analysis of each question are presented in the below tables.

Findings obtained for the 1st question

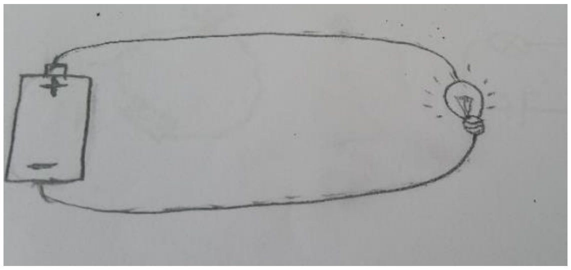
In the first question, the pre-service science teachers were asked to draw a simple electric circuit by using the materials provided. When the pre-service teachers’ responses to this question were analyzed, it was decided that their drawings could be grouped into three categories as correct drawing, symbol drawing, and false drawing.

Table 1. *Pre-service teachers’ drawings of simple electric circuit*

Categories	**f**	**%**
Correct Drawing (bulb, battery, and cable)	98	59
Symbol Drawing	60	36.1
False Drawing	8	4.8
Total	166	100

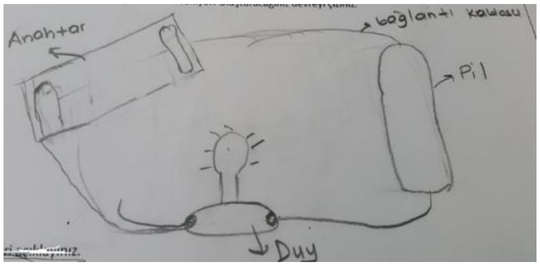
As can be seen in Table 1, only 59 % of the 166 pre-service teachers are able to produce correct drawings. In the drawings accepted in this category, the pre-service teachers are able to draw a simple electric circuit by using a bulb, battery, and cable. An example drawing from this category is presented below.

S36:

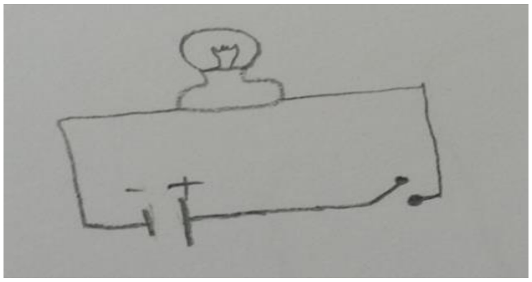


As can be seen in Table 1, the responses of 36.1% of the 166 pre-service teachers are evaluated in the symbol drawing category. In the drawings included in this category, the pre-service teachers draw circuits by using extra materials aside from the given elements of a circuit such as a switch. In some drawings in this category, it is seen that the pre-service teachers produce their simple circuit drawings with symbols. Though the responses given in this category are scientifically correct, they are not the required responses. Some sample drawings from this category are presented below.

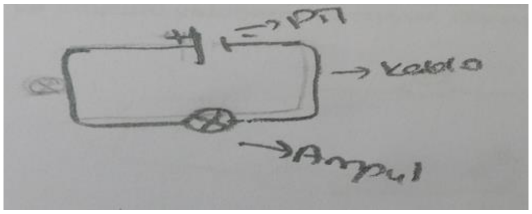
S1:



S80:

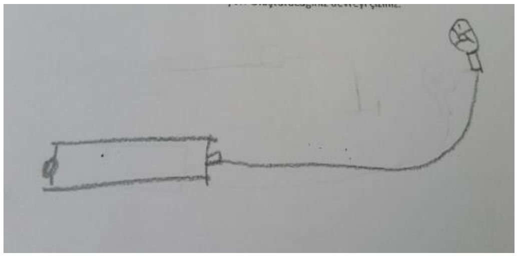


S13:



As can be seen in Table 1, the drawings of the 4.8 % of the 166 pre-service teachers are evaluated in the category of false drawing. An example from this category is given below.

S142:



When the responses evaluated in this category are examined, it is seen that the pre-service teachers think that only one cable between the battery and the bulb is enough to light the bulb.

Findings obtained for the 2nd question

The second question in the data collection instrument was “What lights the bulb?” The findings obtained from the analysis of the responses given to this question by the pre-service teachers are given in Table 2.

Table 2. *The distribution of the pre-service teachers' responses to the 2nd question across the categories*

Categories	f	%
The current coming from the battery	56	33.7
The battery	36	21.7
The energy inside the battery	23	13.9
The current flowing through the cable	21	12.7
The cable	11	6.6
Resistance	7	4.2
Electric current	6	3.6
Negative charges	6	3.6
Total	166	100

As can be seen in Table 2; 33.7 % of the pre-service teachers think that what lights the bulb is the current coming from the battery. This might indicate that the pre-service teachers see the battery as the source of current. Some sample responses from this category are given below.

S44: *“What lights the bulb is the current coming from the battery. That is, the battery lights it.”*

S25: *“What lights the bulb is the current coming from the battery. Via the conductive cable, the current reaches the bulb and then turns into electric energy and lights the bulb.”*

When the pre-service teachers' responses to the question “What lights the bulb” are examined, the number of the pre-service teachers establishing a connection with the battery is found to be only 59. Of the pre-service teachers, 21.7 % use only the term “battery” and make no other explanations. One sample response from this category is given below.

S13: *“What lights the bulb is the battery.”*

As can be seen in Table 2; 13.9 % of the pre-service teachers respond to the question “What lights the bulb” as the energy inside the battery. This response is accepted to be scientifically correct. A sample response from this category is given below.

S39: *"The battery is the source of energy. The energy in the battery lights the bulb."*

As can be seen in Table 2; 19.3 % of the pre-service teachers connected the lighting of the bulb with the cable. While 12.7 % of this 19.3 % of the pre-service teachers are of the opinion that the current flowing through the cable lights the bulb, 6.6 % use only the term "cable" in their responses. A sample response from this category is given below.

S18: *"What lights the bulb is the current flowing through the cable."*

As can be seen in Table 2, when compared to the other responses, a smaller percentage of the pre-service teachers stated that what lights the bulb is resistance, electric current and negative charges. Some sample responses from these categories are given below.

S37: *"Negative charges coming from the battery flow through the connecting cable and lights the bulb."*

S60: *"The bulb lights as a result of the warming of electricity in resistance."*

Findings obtained for the 3rd question

The 3rd question in the data collection instrument was "What happens in the battery while the bulb is lighting?" The findings obtained from the analysis of the responses given to this question by the pre-service teachers are presented in Table 3.

Table 3. *The distribution of the pre-service teachers' responses to the 3rd question across the categories*

Categories	**f**	**%**
Current is released	60	36.1
Energy loss occurs	49	29.5
Electrons move	24	14.4
Charge is released	13	7.8
Energy is generated	10	6.0
It gets warmer	10	6.0
Total	166	100

As can be seen in Table 3; 36.1 % of the 166 pre-service teachers are of the opinion that while the bulb is lighting, a current is released from the battery. The ratio of the pre-service teachers giving this response is the highest. Some sample responses from this category are given below.

S19: *"Electric current comes from the positive pole of the battery and circulates through the whole circuit."*

S58: *"Current is released from the positive pole of the battery towards the negative pole."*

S64: *"While the bulb is lighting, current passes through the battery."*

As can be seen in Table 3; 29.5 % of the 166 pre-service teachers are of the opinion that energy loss occurs while the bulb is the lighting. Some sample responses from this category are given below.

S38: *"As the bulb lights with the energy of the battery, energy loss occurs in the battery."*

S41: *"The energy in the battery is transmitted to the bulb, leading to a reduction in the energy of the bulb."*

As can be seen in Table 3; 14.4 % of the 166 pre-service teachers respond to this question as electrons move. A sample response from this category is given below.

S6: *"Electrons in the battery move, while the bulb is the lighting."*

As can be seen in Table 3, a relatively smaller ratio of pre-service teachers think that charge is released while the bulb is lighting, that while the bulb is lighting, energy is generated, and that the battery gets warmer while the bulb is the lighting. Some sample responses from these categories are given below.

S21: *"While the bulb is lighting, the battery provides the current in the circuit by generating electric energy."*

S45: *"Charge is released from the battery. The charges coming from the positive pole of the battery go through the circuit and reach the negative pole. The battery starts this cycle."*

S22: *"The battery gets warmer as long as the bulb lights."*

Findings obtained for the 4th question

The 4th question in the data collection instrument is "What happens in the cable while the bulb is lighting?". The findings obtained through the analysis of the responses given to this question by the pre-service teachers are presented in Table 4.

Table 4. *The distribution of the pre-service teachers' responses to the 4th question across the categories*

Categories	**f**	**%**
The current flows through	93	56.0
Electrons are released	24	14.5
Current occurs	20	12.0
Q charge circulates	11	6.6
Energy transfer occurs	6	3.6
It gains resistance	5	3.0
Heat energy is emitted	5	3.0
Nothing happens	2	1.2
Total	166	100

As can be seen in Table 4; 56 % of the 166 pre-service teachers respond to this question as current flows through the cable. Some sample responses from this category are given below.

S8: *"Current passes through the cable, when the current circulates the whole cable, the bulb lights."*

S140: *"Current passes through the cable. With the current passing through the cable, the bulb lights."*

As can be seen in Table 4; 14.5 % of the 166 pre-service teachers are of the opinion that electrons move through the cable while the bulb is the lighting. A sample response from this category is given below.

S6: "While the bulb is lighting, electrons move through the cable and then the bulb lights."

As can be seen in Table 4; 12 % of the 166 pre-service teachers are of the opinion that while the bulb is lighting, current occurs in the cable. A sample response from this category is given below.

S158: *"While the bulb is lighting, energy is released from the cable as current."*

As can be seen in Table 4, a smaller percentage of pre-service teachers are of the opinion that while the bulb is lighting q charge is circulating, that there is energy transfer, that cable gains resistance and that heat energy is emitted in the cable. Two of the pre-service teachers think that nothing happens in the cable while the bulb is the lighting. Some responses from these categories are given below.

S42: "*The conducting wire inside the cable enables the transfer of energy together with electrons.*"

S5: *"Before the construction of the circuit, the cable not having conducting quality, serves the function of transmitting the current coming from the battery to the bulb and gains resistance while the bulb is the lighting."*

S160: *"While the bulb is lighting, there is a slight increase in the heat of the cable but not as much as in that of the battery."*

Findings obtained for the 5th question

The fifth question in the data collection instrument is "*Up to which time does the bulb light*". The findings obtained from the analysis of the responses given to this question by the pre-service teachers are presented in Table 5.

Table 5. *The distribution of the pre-service teachers' responses to the fifth question across the categories*

Categories	**f**	**%**
Until the battery goes dead	88	53.0
Until the energy of the battery runs out	36	21.7
Until the power of the battery runs out	28	16.9
Until the current in the battery runs out	7	4.2
Until the current in the circuit runs out	7	4.2
Total	166	100

As can be seen in Table 5; 95.8 % of the 166 pre-service teachers give battery-related responses to the question "Up to which time does the battery light?". Of the participating pre-service teachers, 53% gave the answer "until the battery goes dead". A sample response from this category is given below.

S67: *"The bulb continues to light until the existing battery in the circuit goes dead."*

As can be seen in Table 5, the most popular answer given above is followed by these answers; "until the energy of the battery runs out", "until the power of the battery runs out". Some sample responses from this category are given below.

S4: *"Until the energy inside the battery runs out, it lights. When the energy in the battery runs out, the bulb gives up producing light."*

S120: *"When the bulb first lights, its brightness is too much. As over time the power of the battery decreases, the brightness is also reduced and when all the power in the battery runs out, then the bulb fades. "*

As can be seen in Table 5, there is some pre-service teacher establishing a connection between the bulb lighting and the current. While 4.2 % of the participating pre-service teachers said that until the current in the battery runs out, 4.2 % of them said until the current in the circuit runs out. Some sample responses from this category are given below.

S44: "*The lighting of the bulb depends on how many ammeters is the battery and ammeter of the bulb is also important. Though not very long, the bulb can go on lighting for a while. When all the current in the battery runs out, it fades."*

S69: *"It goes on lighting until the current in the battery runs out."*

S62: *"The bulb lights until the current in the circuit runs out."*

Findings obtained for the 6th question

The 6th question in the data collection instrument is "*When the bulb lights, what is electricity converted to?"* The findings obtained from the analysis of the responses given to this question by the pre-service teachers are presented in Table 6.

Table 6. *The distribution of the pre-service teachers' responses to the 6th question across the categories*

Categories	**f**	**%**
It is converted to light energy	99	59.6
It is converted to heat and light energy	30	18.1
It is converted to heat energy	15	9.0
It is converted to energy	14	8.4
It is converted to electric current	8	4.8
Total	166	100

As can be seen in Table 6; 95.1 % of the 166 pre-service teachers relate their responses to the question "When the bulb lights, what is energy converted to?" to energy. Of the teacher relating their responses to energy, 59.6 % state that it is converted into light energy, 18.1 % state that it is converted to heat and light energy, 9 % state that it is converted to heat energy and 8.4 % state that it is only converted to energy. Some sample responses from this category are presented below.

S5: *"As the electric energy gives light to the bulb when the bulb starts to light, it is converted into light energy."*

S20: *"When the bulb lights, electric energy is converted to light energy and a bit to heat energy."*

S13: "*Electric over time is converted to heat. When we touch on the lighting bulb after a while, we feel the heat."*

As can be seen in Table 6, the ratio of the teachers stating that when the bulb lights, electricity is converted to electric current is 4.8 %.

S48: *"When the bulb lights, the electricity in the battery is converted into current."*

DISCUSSION

The current research was conducted to determine the opinions and alternative concepts of the pre-service science teachers about the functions of the elements found in a simple electric circuit.

When the findings obtained from the first question are generally evaluated, it can be argued that the drawing of a simple electric circuit has not been thoroughly understood by the pre-service teachers. Though it is not required in the question, the pre-service teachers seem to have produced symbolic drawings. From the pre-service science teachers' responses considered in the "symbolic drawing" category, it was determined that they produced their drawings on the basis of their own knowledge and experiences. This finding concurs with the finding reported by Yurumezoglu & Cokelez (2010). When the findings obtained from the first question are examined, it is seen that there are responses, though few in number, in the category of "wrong drawing". The drawings of the students evaluated in the "wrong drawing" category are expressed as "unipolar model" in the literature. According to this model, when a circuit element is connected to the power supply, it works; that is, the bulb gives light. "Unipolar model" is a model that has been encountered in many studies in the literature (Asomi, King & Monk, 2000; Chambers & Andre, 1997; Duit & Rhöneck, 1997; Demirezen, 2010; Kucukozer, 2003; McDermott & Shaffer, 1992; Sencar & Eryılmaz, 2002; Sonmez, Geban & Ertepinar, 2001).

When the findings obtained from the second and third questions are evaluated together, it can be argued that the pre-service teachers have not precisely understood what lights the bulb and what happens in the battery when the bulb is the lighting. Majority of the participating pre-service teachers gave wrong responses to the question "What lights the bulb?" Only 23 pre-service teachers gave correct answers to this question by stating that it is the energy inside the battery. In general, wrong answers are intensified in the categories of the battery, the current coming from the battery and the current going through the cable. In a similar manner, the number of the pre-service teachers relating their answers to the question "What happens in the battery while the bulb is lighting" to energy is very small while the number of the pre-service teachers relating their answers to this question to current and thinking that current comes from the battery while the bulb is lighting is considerably high. Moreover, these findings show that pre-service science teachers have the alternative concept "battery is the source of current". These findings of the current research are parallel to the findings reported in the literature. When the relevant literature is reviewed, it is seen that consideration of the battery as a source of current is an alternative concept widely encountered (Cohen, Eylon & Ganiel, 1983; Duit & Rhöneck, 1997; Heller & Findley, 1992; Karal, Alev & Yigit, 2009; Karakuyu & Tuysuz, 2011; Lee & Law, 2001; Yıldırım, Yalcın, Sensoy & Akcay, 2008).

When the findings obtained from the fourth question are generally evaluated, it is seen that the pre-service teacher associate what is happening in the cable with current and provide explanations such as “current occurs / current flows”. This finding is parallel to the findings reported by Borges & Gilbert (1999) and Yurumezoglu & Cokelez (2010). When the pre-service teachers' responses are examined, it is seen that the number of pre-service teachers associating what is happening in the cable with energy transmission is very small. This finding indicates that the function of the cable in a simple electric circuit has not been precisely understood by the pre-service science teachers.

When the findings obtained from the fifth question are generally evaluated, it is seen that the number of the pre-service science teachers creating a link between the bulb’s lighting and the energy of the battery is very small. Majority of the pre-service science teachers provided responses to this question such as “until the battery goes dead, until the energy of the battery runs out, until the current in the battery runs out”. This might indicate that the pre-service teachers have not thoroughly understood “what is provided by the battery for the circuit” and that they use the concepts such as energy, power and current interchangeably outside their actual meanings.

When the findings obtained from the sixth questions are generally evaluated, it can be said that the pre-service science teachers have understood that there is some kind of conversion happening in the battery when the bulb lights. The great majority of the pre-service teachers are of the opinion that this conversion is towards light energy. The number of pre-service teachers thinking that this conversion becomes towards both heat energy and light energy is even much smaller. There are also some pre-service science teachers stating that this conversion is towards only heat or only energy. This finding of the current research concurs with the finding reported by Yurumezoglu & Cokelez (2010), indicating that the pre-service teachers do not have clear minds about the forms of energy conversion.

When all the findings of the current research are generally evaluated, the results of the research can be summarized as follows:

1. The simple electric circuit and the functions of the elements found in this circuit have not been thoroughly understood by the pre-service science teachers.
2. The pre-service science teachers have alternative concepts about the functions of the elements found in a simple electric circuit.
3. The pre-service science teachers have not thoroughly understood what is needed for electric current to occur in an electric circuit.
4. The pre-service science teachers have alternative concepts about the production, transmission, and consumption of the electric current occurring in the electric circuit.

In light of the results of the current research, the following suggestions can be made. First, it is known that until they start their undergraduate education, pre-service science teachers encounter simple electric circuits at different stages of their schooling. It is also known that concepts such as current, electric current, electric energy, etc. are frequently encountered in the daily lives of individuals. Thus, it seems to be natural for pre-service science teachers to acquire alternative concepts from many sources such as their daily life experiences, informal sources of learning and environment until they start their undergraduate education. It has been revealed by many studies that alternative concepts are resistant to change, and they may survive even after correcting concepts have been taught. It should be remembered that individual can come to the learning environment with their alternative concepts; thus, the learning environment should be designed to eliminate these alternative concepts.

Given that the functions, symbols, and names of the elements found in electric circuits provide the basis for further learning, they should be taught correctly and precisely to students. Particular emphasis should be put on the alternative concept "the battery is the source of the current" and in this regard, the fact that the battery is not a source of current should be taught to students by doing simple experiments to show that electric current can occur in the circuit without a battery. Similarly, particular emphasis should be put on the alternative concept “current is used by the elements of a circuit” and students should be taught that current is not used up by the elements of a circuit by using simple circuits to be established and an ammeter.

Given that the pre-service science teachers making up the sampling of the current research will work as teachers and that the alternative concepts possessed by teachers will negatively affect their students’ conceptual development, it is clear that they need to learn simple electric circuits correctly. Thus, future research can use questions to determine the roots of alternative concepts. Moreover, larger samplings and students from different grade levels can be used in future research.

REFERENCES

Asomi, N., King., J., & Monk, M. (2000). Tuition and memory: Mental models and cognitive processing in Japanese children’s work on D.C. electrical circuits. *Research in Science and Technological Education, 18*(2), 141-155.

Beaty, W. J. (1996). What is “Electricity”? Retrieved on 15-Sep.-2018, URL:http://amasci.com/miscon/whatis.html

Bilgin, N. (2006). *Sosyal bilimlerde içerik analizi.* Siyasal Kitabevi: Ankara.

Borges, A., & Gilbert, J. (1999). Models of electricity. *International Journal of Science Education, 21*(1), 95-117.

Chambers, S. K., & Andre, T. (1997). Gender, prior knowledge, interest, and experience in electricity and conceptual change text manipulations in learning about direct current, *Journal of Research in Science Teaching, 34*(2),107-123.

Cheng, A. K., & Kwen, B. H. (1998). *Primary pupils' conceptions about some aspects of electricity*, Australian Association for Research in Education Conference, Adelaide, Australia. Retrieved on 15-Nov.-2018, https://repository.nie.edu.sg/bitstream/10497/4610/1/ang98205_a.pdf

Cohen, R., Eylon, B., & Ganiel, U. (1983) Potential difference and current in simple electric circuits: A research of students' concept. *American Journal of Physics, 51*(5), 407-412.

Demirezen, S., & Yagbasan, R. (2013) The effect of the 7E model on misconceptions about simple electrical circuits, *Hacettepe University Journal of Education, 28*(2), 132-151.

Duit, R., & Rhöneck, C. (1997). Learning and understanding the key concepts of electricity. Retrieved on 15- Oct.-2018. URL:https://www.univie.ac.at/pluslucis/Archiv/ICPE/C2.html

Frederiksen, J., White, B., & Gutwill, J. (1999). Dynamic mental models in learning science: the importance of constructing derivational linkages among models, *Journal of Research in Science Teaching, 36*(7), 806–836.

Görecek Baybars, M. (2018). The determination of the mental models of pre-service science teachers about electrical conductivity of the metals, *Journal of Theory and Practice in Education, 14*(1), 36-47.

Hestenes, D. (1996). *Modeling methodology for physics teachers*. Proceedings of the International Conference on Undergraduate Physics Education, College Park. Retrieved on 15- Oct.-2018. URL:http://modeling.asu.edu/modeling/MODELING.PDF

Huyuguzel Cavas, P., & Cavas, B. (2014). *Affective features in science education: attitude and motivation*. S. S. Anagun & N. Duban (Ed.), Science Teaching. Ankara: ANI Publishing.

Heller, P. M., & Finley, F.N. (1992) Variable use of alternative conceptions: a case research in current electricity, *Journal of Research in Science Teaching, 29*(3), 259-275.

Karakuyu, Y., & Tuysuz, C. (2011). Misconceptions in electricity and conceptual change strategy. *Gaziantep University Journal of Social Sciences, 10*(2), 867-890.

Karal, I. S., Alev, N., &Yigit, N. (2009) Student teachers' content knowledge on electricity, *e-Journal of New World Sciences Academy Education Sciences, 4*(4), 1450-1467.

Kapucu, S., & Yıldırım, U. (2012). Prospective physics teachers' views on their knowledge about the new concepts in Turkish high school physics curricula. *European Journal of Physics Education, 3*(3), 1-14.

Kucukozer, H. (2003). Misconceptions about high school students' simple electric circuits, *Hacettepe University Journal of Education Faculty,25,* 142-148.

Lee, Y., & Law, N., 2001, Explorations in promoting conceptual change in electrical concepts via ontological category shift, *International Journal Science Education, 23*(2), 111-149

McDermott, L. C., & Shaffer, P. S. (1992). Research as a guide for curriculum development: an example from introductory electricity, part I: an investigation of student understanding. *American Journal of Physics, 60*(11), 994-1003.

Miles, M, B., & Huberman, A. M. (1994). *Qualitative data analysis: An Expanded Sourcebook. (2nd Ed).* Thousand Oaks, CA: Sage.

Setyani ND., Suparmi S., Sarwanto S., & Handhika, J. (2017). Journal of Physics Conference Series. 909 012051. Retrieved on 15-Nov.-2018, URL:http://iopscience.iop.org/article/10.1088/1742-6596/909/1/012051/pdf

Orgun, E. (2002). *The effect of constructivist teaching approach on high school students' misconceptions about electric current,* Marmara University, Institute of Educational Sciences, Unpublished Master Thesis, Istanbul.

Osborne, R. (1983). Towards modifying children's ideas about electric current. *Research in Science and Technology Education, 1*(1), 73-82.

Psillos, D., Tiberghien, A., & Koumaras, P. (1988). Voltage presented as a primary concept in an introductory teaching sequence on DC circuits. *International Journal of Science Education, 10*(1), 29-43.

Shipstone, D.M., Rhöneck, C.V., Jung, W., Karrqvist, C., Dupin, J.-J., Joshua, S., & Licht, P. (1988). A study of students understanding of electricity in five European countries. *International Journal of Science Education, 10* (3): 303-316.

Sencar, S., & Eryılmaz, A. (2002). Ninth grade students' misconceptions about simple electric circuits, *V. National Science and Mathematics Education Congress, METU,* Ankara, 577-582.

Silverman, D. (2001). *Interpreting qualitative data: methods for analyzing talk, text, and interaction.* London: SAGE Publication.

Sonmez, G., Geban, O., & Ertepinar, H. (2001). The effect of conceptual change in sixth-grade students' understanding of electrical concepts. *Proceedings of the Symposium on Science Education*, 7-8 September, Istanbul, 35-38.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: techniques and procedures for developing a grounded theory* (2rd Ed.). London: Sage

Patton M. Q. (2014). *Qualitative research and evaluation methods* (M. Butun, S.B. Demir, Trans.). Ankara: Pegem Academy.

Wessel, W. (1999). *Knowledge construction in high school physics: a study student-teacher interaction*. Retrieved on 15-Sep.2018. http://www.saskschoolboards.ca/old/ResearchAndDevelopment/ResearchReports/Instruction/99-04.htm.

Yıldırım A., & Simsek H. (2008). *Qualitative research methods in the social sciences*. Ankara: Seçkin Publishing.

Yurumezoglu, K., & Cokelez, A. (2010). Student opinions' about what happened in a simple electric circuit. *Turkish Journal of Science Education, 7*(3), 147-166.