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Examination of The Cognitive Structures of The Secondary School Eighth-Grade Students Regarding Some Concepts In Electricity Through The Word Association Test

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Abstract. This study aims to reveal the cognitive structures of secondary school eighth-grade students regarding the concepts of current, voltage, and resistance which take place within the subject of electricity by using word association test (WAT). Correlational survey method was used in the study. The study included 100 eighth-grade students who receive education in a state school under the Ministry of National Education in the city center of Eskişehir province in the spring semester of the 2016-2017 academic year. In the research, the word association test was used as a data collection tool. The words obtained as a result of the study regarding the concepts were studied in detail, repeated words are taken into consideration and conceptual networks are created in line with the determined breakpoints. Pursuant to the results, it was seen that secondary school eighth-grade students mostly repeat "electricity", "fear", and "force" for the concepts of current, voltage, and resistance, respectively. The distinctive feature of the study is using the word association test (WAT) for the first time in determining the cognitive structures of secondary school eighth-grade students towards the concepts of current, voltage, and resistance.

Keywords. Word association test, current, voltage, resistance, secondary school student, cognitive structure.

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INTRODUCTION

Children discover the world at their young age with their own experience and create a different process of thinking in their minds than scientific facts. Children begin to learn and structure many basic concepts early in their lives and they come to school with various concepts formed in their minds (Treagust, 1988). After this stage, correction of wrong concepts that children have and teaching new concepts happen in schools. In this process, it is understood that how important teaching the concept correctly. Before teaching the concept, we need to know what the concept is. The concepts constitute the building blocks of information, whereas relationships between concepts constitute scientific norms. The concepts are units of thought (Yıldız, 2000). In other words, concepts are definitions of some relationships or arrangements within the realities of a group and they are represented by some signs or symbols (Ongun, 2006). Concepts enable us to make sense of the world we live in. They are the cornerstones of the information we learn or we will learn. Concept learning is regarded as an important phenomenon that provides a basis for learning in the years ahead, especially in primary and secondary education (Ülgen, 2004). Teaching concepts in a meaningful and effective way can be accomplished by getting the students off the memorization. Because the memorized information cannot be kept in the mind for a long time and new concepts cannot be fully engraved in the student's cognitive structure. In short, meaningful learning needs to happen. Meaningful learning is a learning technique in which students are structured by blending their old knowledge with new information (Dykstra, 1982).

Learning of concepts is a process that begins with learning to distinguish (Ayvacı and Çoruhlu, 2009). Therefore, the concepts included in the subjects of science courses should be separated from each other and the relationships between them should be expressed correctly by individuals. This, on the other hand, is related to the cognitive structures of individuals. Asubel (1963) defines the cognitive structure as a mental scheme or framework that organizes and holds the elements that make up the information in a learning situation. Cognitive structure and perception, on the other hand, constitute the cognition. The main function of the cognitive structure is to determine the general framework in which new information fuses and how the connection between information is. Knowing students' cognitive structures is important in making meaningful learning effective.

It is seen that secondary school students face many concepts in science classes. How students create these concepts in their minds and how they relate to each other is very important for

their learning situations. To find out this structuring, students' cognitive structures need to be revealed. For this purpose, there is a need for techniques that determine the cognitive structures of students, and whether the links between the concepts in these structures and the relationships between the concepts in their memories are sufficient. There are many techniques that serve this purpose, such as concept maps, mind maps, structural grids, diagnostic trees, etc. One of these techniques is the Word Association Test (WAT). WAT is one of the alternative measurement and evaluation techniques that enables us to determine the cognitive structure of the student and the connections between the concepts in this structure, in other words, that can reveal the information network and helps us to determine whether the relationships between concepts in long-term memory are sufficient or meaningful. In the alternative measurement and evaluation approach, it is important to evaluate an interdependent and well-structured information network rather than evaluating pieces of information that are independent and disconnected from each other (Bahar, Alex, Johnstone & Sutcliffe, 1999).

There are many studies in the literature that aim to reveal the cognitive structures between concepts using the word association test (Deveci, Köse & Bayır, 2014; Işıklı, Taşdere & Göz, 2011, Balbağ, 2018a; Balbağ, 2018b; İnel&Ünal, 2018; Balbağ & Kaymak, 2018; Başar & Göncü, 2018; Ercan et al., 2010; Taşdere et al., 2014; Balbağ & Kaya, 2019; İnel et al., 2016).

How the cognitive structure between concepts is formed and whether these structures are sufficient and correct is important for all sciences. Science education, on the other hand, helps individuals to interpret nature and life, to change their attitude to life, to question and try to explain each concept they encounter. Therefore, a good science education that individuals will receive at school age, inside and outside the school will help individuals to interpret life positively (Atılğanlar, 2014).

In this study, cognitive structures between the concepts of current, voltage, and resistance that take place within the subject of electricity were examined. It is possible to simply define these concepts as follows: Electric current (I) is defined as the movement of electric charges through a conductor as a result of the potential difference (voltage) effect. Voltage (voltage) (V) is defined as the work needed per unit of charge to move a test charge between the two points. Resistance (R), on the other hand, is the coercive effect against electric current. As can be seen from the definitions, these three concepts are highly interrelated. One law that these three concepts are related to is

ohm's law. Ohm's law states that the voltage (V) of a circuit element is directly proportional to the current (I) and resistance (R) across the two points (Serway & Beichner, 2008).

It is important to determine the cognitive structures of some terms and concepts used in sciences in our daily life and the links between the concepts in this structure. Observing the cognitive structure formed by the concepts of current, voltage, and resistance that takes place within the subject of electricity in eighth-grade students is important in terms of understanding whether students are learning the subject better and what the concepts remind in their minds. Besides, since the level of eighth-grade is a passing phase to high school, revealing the cognitive structures of the students who will study in science departments in high school regarding the concepts of current, voltage, and resistance on electricity is important to determine their readiness.

In the light of these, this study aims to reveal the cognitive structures of secondary school eighth-grade students regarding the concepts of current, voltage, and resistance which take place within the subject of electricity. In line with this basic purpose, the following question was sought:

•   How do the cognitive structures of secondary school eighth-grade students regarding the concepts of current, voltage, and resistance, which take place within the subject of electricity, shape?

METHOD

Research Model

This study, which aims to reveal the cognitive structures of secondary school eighth-grade students regarding the concepts of current, voltage, and resistance which take place within the subject of electricity, was performed in the correlational survey method. As is known, correlational survey methods are research approaches aiming to describe a situation that exists in the past or still exists as it exists, and event, individual, or object subject to the research are tried to be defined in their own conditions and as they are (Karasar, 1999). The word association test was used to determine the cognitive structures of secondary school students regarding these concepts.

Participants

The study included 100 eighth-grade students who receive education in a state school under the Ministry of National Education in the city center of Eskişehir province. The reason for choosing these students in the research is to observe the cognitive structure formed by the concepts of

current, voltage and resistance in eighth grade students and to determine what these concepts evoke in their minds. While 47 students (47%) participating in the study were female, 53 (53%) of them were male.

Data Collection Tools

The word association test (WAT) was used to determine the cognitive structures of secondary school students regarding the concepts of current, voltage and resistance. In the research, besides the concepts of current and voltage that are used interchangeably as a concept, the concept of resistance associated with these concepts was also chosen. In the alternative measurement and evaluation understanding, it is important to evaluate an interdependent and well-structured information network rather than evaluating pieces of information that are independent and disconnected from each other. There are many techniques that serve this purpose (Concept Maps, Mind Maps, Structural Grid, Diagnostic Tree, etc.).

One of these techniques is the Word Association Test (WAT). WAT is one of the alternative measurement and evaluation techniques that enables us to determine the cognitive structure of the student and the connections between the concepts in this structure, in other words, that can reveal the information network and helps us to determine whether the relationships between concepts in long-term memory are sufficient or meaningful (Bahar, Alex, Johnstone & Sutcliffe, 1999). The words obtained as a result of the study regarding the concepts were studied in detail, repeated words are taken into consideration and conceptual networks are created in line with the determined breakpoints. The data collection tool consists of two sections: the gender information of the pre-service teachers was included in the first section, whereas the concepts were given a place in the second section. The section covering the concepts was prepared as follows:

Current …………………………….

Current …………………………….

Current …………………………….

Current …………………………….

Current …………………………….

Related Sentence ………………………

Voltage …………………………….

Voltage ……………………………

Voltage ……………………………

Voltage …………………………….

Voltage ……………………………

Related Sentence ……………………

Resistance …………………………..

Resistance …………………………..

Resistance …………………………..

Resistance …………………………..

Resistance …………………………..

Related Sentence …………………..

In the research, prior to practice, explanations were made for the WAT, and examples from different practices were given. Students were given one minute for each concept. Within this time given, the students wrote the answer words that they thought were related to the key concept. Each key concept was written on a single page, one under the other, and across the page. At the end of the answer words corresponding to each key concept, there is the 'relevant sentence' part. In this section, students were asked to write sentences that come to their mind about the key concept. Because the answer word associated with the key concept can only be at the level of recall and it can also be an association product that does not have a meaningful relationship with the key concept.

Data Analysis

In the research, a frequency table was created to show which words or concepts are repeated many times for which key concept. The conceptual network was created based on this frequency table formed. To reveal the cognitive structure, the breakpoint (BP) technique introduced by (Bahar, Alex, Johnstone & Sutcliffe, 1999) was used to create the conceptual network. A certain number

below of the most given answer word for any key concept involved in the Word Association Test is used as a breakpoint. Answers that are above a certain frequency are written in the first part of the conceptual network. Then the breakpoint is brought down at regular intervals and the process continues until all the keywords appear on the conceptual network (Bahar & Özatlı, 2003).

RESULTS

The results of the study were introduced through tables and figures. Table 1 shows the frequencies of the most produced words related to the concepts of current, voltage, and resistance.

Table 1. *Most Produced Words Regarding the Concepts of Current, Voltage, and Resistance*

CURRENT		VOLTAGE		RESISTANCE	
Concepts	Current	Concepts	Voltage	Concepts	Resistance
Electricity	*57*	*Fear*	*40*	*Force*	*46*
Volts	*15*	*Electricity*	*30*	*Electricity*	*39*
Ammeter	*11*	*Film*	*22*	*Power*	*36*
Circuit	*11*	*Cable*	*16*	*Endurance*	*19*
Battery	*10*	*Current*	*13*	*Difficulty*	*19*
Power	9	*Excitement*	*10*	*Current*	*19*
Energy	9	Voltage line	8	*Circuit*	*13*
Bulb	9	Bulb	7	*Science*	*13*
Science	9	Circuit	6	*Bulb*	*12*
Voltage	9	Volts	6	*Pressure*	*10*
Switch	8	Wire	5	Resist	9
Resistance	7	Resistance	5	Sciences	7
Wire	5	Connection	5	Ω	7
Current	5	Resistance	4	Battery	5
Socket	5	Power	4	Ammeter	5

As seen in Table 1, while the most repeated word on the concept of current was electricity (f=57), the most repeated word on the concept of voltage was fear (f=40), and the most repeated word on the concept of resistance was force (f=46). Secondary school students produced the following words with a frequency of 10 or more for the concepts of current, voltage, and resistance: electricity, volts, ammeter, circuit, and battery for the concept of current; fear, electricity, film, cable, current, and excitement for the concept of voltage; force, electricity, power, endurance, difficulty, current, circuit, science, bulb, and pressure for the concept of resistance. In this context, words with a frequency of 10 and above according to the specified breakpoints are shown in Table 1 in italics. In this study, 134 words were produced in total for the concepts of current, voltage, and resistance.

The words under the concepts are presented below with figures, according to the breakpoints. Accordingly, the conceptual network created for breakpoint 50 and above is shown in Figure 1.
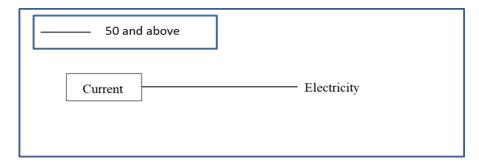

Figure 1. *Conceptual Network Created for Breakpoint 50 And Above*

Breakpoint 50 and above: As seen in Figure 1, secondary school eighth-grade students produced the word electricity in this range for the concept of current. They could not produce any word for other concepts, voltage and resistance.

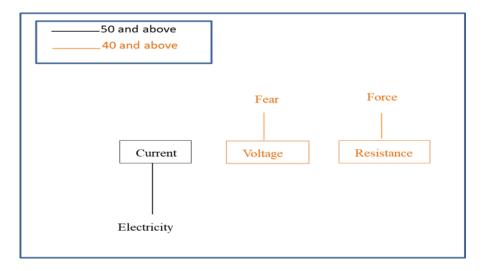Figure 2 shows the conceptual network created for breakpoint between 40-49.

Figure 2*. Conceptual Network Created for Breakpoint Between 40-49*

Breakpoint from 40 to 49: As seen in Figure 2, in this range, unlike the previous breakpoint, words are produced for the concepts of voltage and resistance. While the word "fear" was produced regarding the concept of voltage, the word "force" related to the concept of resistance was produced.

Figure 3 shows the conceptual network created for breakpoint between 30-39.
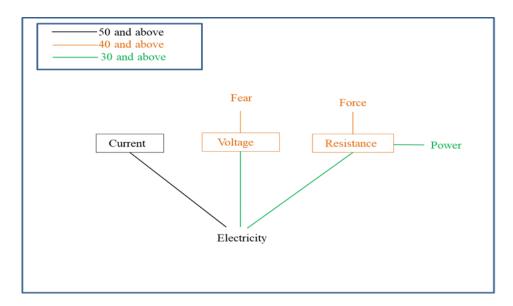
Figure 3. *Conceptual Network Created for Breakpoint Between 30-39*

Breakpoint between 30-39: As seen in Figure 3, in this range, unlike the previous breakpoint, secondary school eighth-grade students seem to associate the concepts of voltage and resistance with the word electricity. In this range, all concepts were commonly associated with the word electricity. Besides, it is seen that the concept of resistance was associated with the word power in this range.

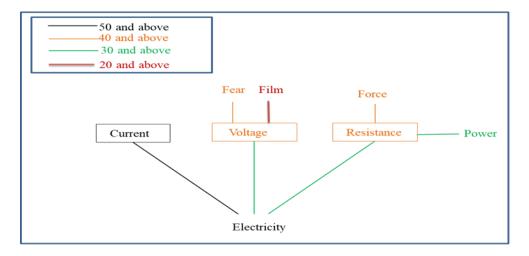Figure 4 shows the conceptual network created for breakpoint between 20-29.

Figure 4. *Conceptual Network Created for Breakpoint Between 20-29*

Breakpoint between 20-29: As seen in Figure 4, in this range, unlike the previous breakpoint, secondary school eighth-grade students seem to associate the concepts of voltage with the word film.
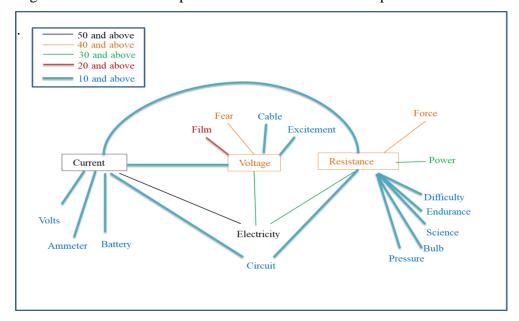
Figure 5 shows the conceptual network created for breakpoint between 10-19.

Figure 5. *Conceptual Network Created for Breakpoint Between 10-19*

Breakpoint between 10-19: As seen in Figure 5, the whole conceptual network for the words the secondary school eighth-grade students produce for the concepts of current, voltage, and resistance was revealed in this range. In this range, unlike the previous breakpoint, the concept of current was associated with the concepts of both voltage and resistance. In other words, associations of secondary school eighth-grade students between the concepts started in this range. At this point, no relation was made between the concepts of voltage and resistance by the secondary school eighth-grade students. In this range, unlike the previous breakpoint, the concepts of current and resistance were associated with the word circuit. In addition, again in this range, it was seen that the concept of current was associated with the word battery, the concept of voltage with excitement and cable, and the concept of resistance was associated with the words pressure, bulb, science, endurance and difficulty.

DISCUSSION AND CONCLUSION

The main objective of this study was to reveal the cognitive structures of secondary school eighth-grade students regarding the concepts of current, voltage, and resistance which take place within the subject of electricity by using word association test. The distinctive feature of the study was examining the concepts of current, voltage, and resistance by using the word association test (WAT). Because there was no other study in the literature examining these concepts through the

WAT. The reason for choosing the secondary school eighth-grade students for the research was the fact that they studied the concepts researched in the study in their lessons and because they are at the stage of transition to high school, to determine how they structure these concepts cognitively. In the study, it was seen that while the most repeated word by the secondary school eighth-grade students on the concept of current was "electricity" (f=57), the most repeated word on the concept of voltage was "fear" (f=40), and the most repeated word on the concept of resistance was "force" (f=46). Again in this study, 134 words were produced in total for the concepts of current, voltage, and resistance. Among the three concepts, the most repeated word in common was the word electricity. This shows that the secondary school eighth-grade students cognitively relate that these three concepts were related to the subject of electricity. The secondary school eighth-grade students produced the word electricity only for the concept of current at the breakpoint 50 and above. No words could be produced in this range related to other concepts, voltage, and resistance. Unlike the previous breakpoint, words for the concepts of voltage and resistance were produced in the breakpoint range of 49-40. While the word fear was produced regarding the concept of voltage, the word force related to the concept of resistance was produced. It was observed that they associate the concepts of voltage and resistance with the word electricity in the breakpoint of 39-30. In this range, all concepts were commonly associated with the word electricity, but the concepts of current, voltage, and resistance were still not associated with each other. From this perspective, failure of the secondary school eighth-grade students to associate these three concepts with each other may indicate that they were not able to sufficiently create the connection of these concepts with each other cognitively. The study of Shipstone et al. (1988) supports the results of this study. It was seen, besides, in this range that the concept of resistance was associated with the word power. Associating the concept of resistance with the word power is interesting. Because these two expressions have different meanings. It is thought that a misconception may have occurred here. In this range of 29-20 breakpoint, unlike the previous breakpoint, secondary school eighth-grade students seem to associate the concepts of voltage with the word film. In the range of 19-10, the whole conceptual network for the words the secondary school eighth-grade students produce for the concepts of current, voltage, and resistance was revealed. In this range, unlike the previous breakpoint, the concept of current was associated with the concepts of both voltage and resistance. In this range, the concept of current was also associated with the words volts, ammeter, battery, and circuit, too. Here, the interesting point was associating the concept of current with the word volts. Because, although the volt is the unit of the voltage, it was associated with the current. Here again,

it is thought that there may be a lack of knowledge or misconception. The study of Yeşilyurt (2006) supports the results of this study. In this range, both current and resistance concepts were associated with the word circuit. However, in the breakpoint of 19-10 range, the concept of voltage was associated with the words excitement and cable. In addition to all this, again in this range, the concept of resistance was associated with the words pressure, bulb, science, endurance, and difficulty. The study of Minas and Gündoğdu (2013) supports the results of this study. In this range, again, it was interesting to associate the concept of resistance with the word pressure. At this point, the secondary school eighth-grade students were thought to have a lack of knowledge or misconception. According to all these results, many words associated with the concepts of current, voltage, and resistance appear to be associated with these concepts, however, it was seen that there are difficulties in associating some words (volts, power, pressure) with these concepts. It is thought that the reason for this may be the deficiencies or misconceptions in the knowledge levels of the secondary school eighth-grade students (Minas & Gündoğdu, 2013; Yeşilyurt, 2006; Akdeniz et al., 2000). There are many studies that reveal the lack of knowledge level regarding the concepts of current, voltage, and resistance, and misconceptions (Yıldırım et al., 2008; Minas & Gündoğdu, 2013; Shipstone et al., 1988; Dykstra, 1982; Akdeniz et al., 2000; Cohen et al., 1983; Millar&King, 1993; Yeşilyurt, 2006; Sencar et al., 2001).

Recommendations

Depending on the results of this research, the following recommendations can be made:

• To determine the cognitive structures of the secondary school eighth-grade students on different topics in sciences such as the concepts of current, voltage, and resistance, WTS can be used.

• This study can also be performed at the sixth and seventh-grade level of secondary school and how the cognitive structure for these concepts has been changed can be examined.

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Conflict of Interest

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