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Determination of Middle School Students' Mental Models about Science through Mind Maps

Zihin Haritaları İle Ortaokul Öğrencilerinin Bilime İlişkin Zihinsel Modellerinin Belirlenmesi

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ABSTRACT: Mind maps that contain visual and verbal elements can be thought of as an effective graphical tool that can be used to reveal the existing knowledge, opinions and perceptions of individuals about a concept through mental association. In this study, the aim was to determine the mental models of middle school students related to science by using mind maps in terms of their gender and grade levels. 104 middle school students who were studying at different grade levels participated in the study. The study takes the form of a case study supported by qualitative data. First of all, students were given training on how to make mind maps, and sample implementations were carried out. Later, students were asked to prepare a mind map about the concept of science. Students' mind maps were first scored by experts by taking into consideration the evaluation criteria with regard to mind maps. In the data analysis process, each mind map was examined by using a descriptive analysis technique, while the frequency and percent values of the most common expressions were calculated. The results of the analyses revealed that the students' mind maps scores did not differ significantly in terms of their gender. It was concluded that the fifth grade students' mind map scores were significantly lower than those of other grade students. Thematic analyses showed that students mostly associate science with technology, and offer more examples of natural sciences in mind maps.

Keywords: mind map, mental model, science.

ÖZ: Görsel ve sözel öğeler içeren zihin haritaları, zihinsel çağrışım yoluyla bireylerin bir kavrama ilişkin var olan bilgilerini, görüşlerini ve algılarını ortaya çıkarmada kullanılabilecek etkili bir grafiksel araç olarak tanımlanabilir. Bu çalışmada ortaokul öğrencilerinin bilim kavramına ilişkin zihinsel modellerini zihin haritaları yoluyla belirlemek ve cinsiyetlerine, sınıf düzeylerine göre karşılaştırmak amaçlanmıştır. Araştırmaya farklı sınıf düzeylerinde öğrenim görmekte olan 104 ortaokul öğrencisi katılmıştır. Araştırma nitel veriler ile desteklenmiş bir durum çalışmasıdır. Çalışma verilerinin elde edilmesinde öncelikle, öğrencilere zihin haritalarının nasıl yapılacağına ilişkin eğitim verilmiş ve örnek uygulamalar gerçekleştirilmiştir. Daha sonra ise öğrencilerden bilim kavramının zihinlerinde yapmış olduğu çağrışımlara ilişkin zihin haritası hazırlamaları istenmiştir. Öğrencilerin yapmış oldukları zihin haritaları öncelikle uzmanlar tarafından zihin haritaları değerlendirme kriterleri dikkate alınarak puanlanmıştır. Daha sonra her bir zihin haritası betimsel analiz tekniği kullanılarak incelenmiş, en sık karşılaşılan ifadelerin frekans ve yüzde değerleri hesaplanmıştır. Yapılan analizler sonucunda öğrencilerin zihin haritaları puanlarının cinsiyetlerine göre anlamlı düzeyde farklılaşmadığı belirlenmiş, sınıf düzeyine bağlı olarak yapılan karşılaştırmada ise beşinci sınıf öğrencilerinin zihin haritaları puanlarının anlamlı düzeyde diğer sınıf seviyelerindeki öğrencilerden düşük olduğu sonucuna ulaşılmıştır. Tematik analizler ise öğrencilerin bilim kavramını en fazla teknoloji ile ilişkilendirdiklerini ve zihin haritalarında daha çok fen bilimlerine ilişkin örnekler sunduklarını göstermiştir.

Anahtar kelimeler: zihin haritası, zihinsel model, bilim.

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Introduction

Nowadays, since science and technology play an important role in the development of countries, the determination and development of individuals' awareness, perceptions, attitudes and views about science, technology and scientific developments are frequently subject to research (Ardies, De Maeyer, Gijbels, & van Keulen, 2015; Demir & Akarsu, 2013; Shi & Wang, 2017; Turgut, Öztürk, & Eş, 2017; Ünlü & Dökme, 2018; van Griethuijsen et al., 2015; Yenice, Özden, & Hiğde, 2017). In particular, the importance of ensuring that students learn scientific process skills and are knowledgeable about scientific concepts through the provision of courses in schools, directing them to follow scientific developments, and engendering positive attitude towards science, is highlighted. Yoon, Suh, and Park (2014), with a similar view, stress that perceptions and knowledge gained in courses greatly affect students' attitudes towards science. In this process, teachers are important in that students imitate their behavior, idealize them, and take on board their views and feelings as role models (Alam & Farid, 2011). In addition, students' experiences of science in courses affect their views about the nature of science (Tan, Jocz, & Zhai, 2017). As we know, learning is a complex process and attempts have been made to explain it by different scientists over the centuries, and this has led to discussions about how an individual can best learn (Taber, 2006). Different methods and techniques are used to teach students the nature of science. In some cases, concepts related to science are presented to the students by integrating them into the course content; in some cases, teachers adopt a direct approach to teaching the nature of science. It is very difficult to teach and learn the nature of science, because science is multidimensional and is being constantly renewed, a problem to be faced no matter which approach is used.

Science that is collective and universal can be described as an important way to obtain information in the simplest and most reliable form (Inel-Ekici, 2015). In other words, science is the most effective way to observe what is happening in the world and to obtain information about the world (Altun & Yıldız-Demirtaş, 2013). In general, the nature of science is used by researchers to explain the science epistemology (Abd-El-Khalick, Bell, & Lederman, 1998). Since natural science learning means also the process of learning the language of science (Almendingen & Tveita, 2009), studies on the nature of science concentrate on natural sciences education. However, scientific researchers emphasize that the nature of science should not be explored in only a single area, and that science is for everyone (Altındağ, Tunç-Şahin, & Saka, 2012). It is especially important to create conceptual diagrams about the nature of science in children's minds, especially from an early age, without the need for specific course content, because this helps them to understand the characteristics of science. In interviews with children, researchers have concluded that it is difficult to create changes in the understanding of scientific concepts on the part of young children (Novak & Canas, 2006). However, if an individual's scientific knowledge and the image of a scientist are created in the early years, the researcher spirit will develop, and the belief that knowledge is constantly changing will be strengthened (Kaya, Afacan, Polat, & Urtekin, 2013).

It is thought that it is necessary to determine the knowledge, perceptions and opinions of students about the characteristics of science in order to enrich the conceptual understanding of the nature of science on the part of primary and secondary

school students. As we know, one of the most important factors affecting the learning of the individual is the previous knowledge of that individual. In the learning process, learners are expected to bond new and previous information, and to make sense of what they have learned with the help of these links (Kalaycı, 2001). In this context, in terms of structuring new information on the part of learners, it is necessary to identify any deficiencies and misunderstandings in the student's previous knowledge, and to ensure that the learner is aware of these deficiencies (Balım, Evrekli, & İnel, 2011). Therefore, it is important to determine the opinions and perceptions of students related to the nature of science in early childhood. Various studies about the solving of this problem are included in the literature. Kaya, Afacan, Polat, and Urtekin (2013) investigated the views of primary school students on scientists and scientific knowledge. Camcı-Erdoğan (2013) determined the perceptions of gifted students towards scientists by using a drawing method. Tan, Jocz, and Zhai (2017) investigated how the popular media influenced the young students' perception of scientists and science, and used a 'draw a scientist test' in their study.

In this research, an attempt has been made to determine middle school students' mental models about the nature of science through the use of mind maps. Drawings are often used in research because they give students the opportunity to present their ideas freely. The most important advantage of mind maps, which can be considered as a drawing technique, is that they provide the individual with the opportunity to think freely. When used as a teaching material, mind maps guide students to discuss, generate questions, develop thoughts and make research (Muhlisin, Susilo, Amin, & Rohman, 2016). Mind maps also allow students to express their existing knowledge by providing them to remember it through mental association (Muhlisin, 2019). The main concept is placed in the center of a mind map created on a horizontal plane and ideas related to this concept are spread around the page, with branches in different colors and of different thicknesses (Merchie & Keer, 2016). Apart from words in mind maps, symbols, codes or visuals associated with these words in the individual's mind must also be included (Buzan, 1988). Mind map applications can be made by students individually or in collaborative groups as part of the learning process, with simple materials consisting of colored pencils and paper (Smith, DuBois, & Corwin, 2016). There is no limit to the ideas and connections to be made in the mind map, and there is no need to follow a certain structure or form (Davies, 2011). In their study, Wheeldon & Faubert (2009) stated that visual tools such as concept maps and mind maps offer a good way to gather more unexpected results by forcing participants out of the writing mode.

In this research, middle school students transferred information on the concept of science in their minds to their mind maps without any intervention on the part of the teacher. Therefore, in this research, the mind maps of the students were scored by taking into consideration the evaluation criteria. As a result, the verbal and visual statements they provided determined their perception of science quantitatively. The mind maps were then analyzed in terms of the specified themes, and qualitative data were obtained. With both quantitative and qualitative data obtained, the mental models of middle school students related to science were determined, and were evaluated in terms of their gender and class levels. It is thought that the mental models of secondary school students about nature of science determined by the qualitative and quantitative data obtained from the research will contribute to the discovery of the students' knowledge,

perceptions and views about the nature of science. Thus, research can be carried out to enrich the students' incomplete knowledge and ideas about the nature of science. In addition, teachers can support learning environments by developing activities aimed at eliminating deficiencies and misconceptions in the students' existing knowledge about the nature of science. The research questions determined according to the purpose of the research are listed below.

1. How do middle school students' mind map scores related to science differ in terms of their gender and grade levels?

2. How are middle school students' mental models about science?

3. How do middle school students' mental models differ in terms of their gender?

Method of Research

The research approach used in this study is a case study using descriptive research methods. In descriptive research, the researcher tries to determine the situation without any intervention. In this process, the researcher can benefit from both qualitative and quantitative data. In this study, the aim was to determine middle school students' mental models with regard to science by including their knowledge, opinions, and experiences, and to conclude by analyzing them.

Participants

104 middle school students who were enrolled in a secondary school participated in the study. In deciding on the participants to be involved in the study, convenience sampling and maximum variation sampling that are the purposeful sampling methods were used. The secondary school where the participants were educated was determined by using the convenience sampling method. In the selection of the participants from the school, maximum variation sampling was used to allow the students from each class level to participate in the study. 16.3% (*n*=17) fifth grade, 14.4% (*n*=15) sixth grade, 25% (*n*=26) seventh grade, 44.2% (*n*=46) eighth grade students were included in the sample. 49% (*n*=51) of students were girls and 51% (*n*=53) of the students were boys.

Table 1

Descriptive Statistics of Participant Students

	Girls		Boys		Total	
	n	%	*n*	%	*n*	%
Fifth grade	12	23.5	5	9.4	17	16.3
Sixth grade	6	11.8	9	17.0	15	14.4
Seventh grade	10	19.6	16	30.2	26	25.0
Eighth grade	23	45.1	23	43.4	46	44.2
Total	51	49.0	53	51.0		

Data Collection Tool

The data of the study were obtained with the use of mind maps, highlighted in the literature as a tool for qualitative data collection (Tattersall, Watts, & Vernon,

2007). First of all, students were informed about the implementation of mind mapping technique in the data collection process. Examples of mind maps were given to students about different science topics and then mind maps were made with the students. In this way, students used the information they learned in relation to the rules of mind maps. Then, in accordance with the purpose of the research, students were asked to create mind maps related to science. Students draw their own mind maps incorporating the words, images, shapes, and pictures that the concept of science evoked in their minds during a course. In the scoring of the mind maps, the scoring criteria developed by Evrekli, İnel, and Balim (2010) were used. Each student's mind map was scored by two experts based on the evaluation criteria shown in Table 2.

Table 2

Assessment Criteria for Mind Maps (Evrekli, İnel, & Balım, 2010)

Scoring Criteria	Point
1st level concept links	2 point for each if valid
2nd level concept links	4 point for each if valid
3rd level concept links	6 point for each if valid
4th level concept links	8 point for each if valid
Cross links	10 point for each if valid
Examples	1 point for each if valid
Relationships	3 point if valid
Picture, Image and Figure	3 point if valid
Invalid component	0 point

Data Analysis

In this study, the Kolmogorov-Smirnov normal distribution test was applied to the data to decide the statistical analysis test to be used to analyze the quantitative data obtained from the scoring of the mind maps. Since the significance value of a normal distribution test is less than 0.05, and the number of students in the class is less than 30, it was decided that the data did not show normal distribution, and non-parametric tests were used in the data analysis. In general, parametric tests are used when the data are suitable in terms of normal distribution and the variance of the scores of the groups is homogeneous. For non-parametric testing, there is no need for these assumptions (Greasley, 2008). For this reason, in this study, the Mann-Whitney U test was used to compare mind map scores in terms of the gender of the students, and the Kruskall Wallis test was used to compare them in terms of grade levels.

A content analysis method was used for a detailed evaluation of the expressions in the mind maps. Content analysis is the process of coding content by using a category list prepared by the researchers, or by revealing categories after each data source has been read (Dawson, 2007). In this research, the mind maps that students prepared were examined by two experts, and the categories were formed by taking into consideration the statements of the students in the mind maps. It was determined which sub-themes could be included under each category. The experts individually analyzed the mind

maps based on these categories. Quantitative data were obtained by calculating the frequency of repetition of expressions encountered in the students' mind maps. In the literature, it is seen that there is a similar data analysis process in studies where mind maps are used as a qualitative data collection tool (Beckett, 2010; Inel-Ekici, 2015; Karataş, 2010; Tattersall, Watts, & Vernon, 2007). Then, the percentage of convergence was calculated to ensure reliability among the experts. The percentage of convergence among experts was found to be 73.5%.

Results

To solve the first research question, "How do middle school students' mind map scores related to science differ in terms of their gender and grade levels?", the students' scores from the mind maps were compared by using non-parametric statistical tests in terms of their gender and grade levels. Table 3 shows the statistical data obtained as a result of comparing the mind map scores of middle school students in terms of their gender.

Table 3

Comparison of Mind Map Scores of Middle School Students in terms of Gender (Mann-Whitney U Test Results)

Gender	*N*	Mean Rank	Sum of Ranks	*U*	*p*
Girl	51	57.39	2927.00	1102.000	.103
Boy	53	47.79	2533.00		

*$p > .05$

As a result of the data analysis, it was observed that the scores obtained from the mind maps prepared by middle school students in relation to science did not significantly differ in terms of their gender. The mean score of the girls was 57.39 while the mean score of the boys was 47.79. This result shows that boys and girls remember a similar number of concepts, expressions, relationships, and visual elements in relation to science through mental association. Table 3 shows the statistical data obtained as a result of comparing the mind map scores of middle school students in terms of their grade level.

Table 4

Comparison of Mind Map Scores of Middle School Students in terms of Grade Level (Kruskall Wallis Test Results)

Grade Level	*n*	Mean Rank	X^2	*df*	*p*	Differences
5	17	27.12	16.544	3	.001	5-6, 5-7, 5-8
6	15	48.10				
7	26	56.85				
8	46	60.86				

*$p < .05$

In the results arising from the data analysis, it was observed that the scores obtained from the mind maps about science differed significantly in terms of grade level. The results of the Mann Whitney U tests showed that the fifth and sixth grades, the fifth and seventh grades, and the fifth and eighth grades showed a significant difference in terms of mind map scores. The mean score of the fifth grade students was 27.12, the mean score of the sixth grade students was 48.10, the mean score of the seventh grade students was 56.85 and the mean score of the eighth grade students was 60.86. This results show that the students' mind maps scores in the fifth grade were significantly lower than those in the sixth, seventh and eighth grades. In other words, fifth grade students have presented fewer concepts, expressions, relationships, and visual elements in relation to science through mental association than other students.

In this section, to solve the second and third research question, "How are middle school students' mental models about science?", "How do middle school students' mental models differ in terms of their gender?", the themes obtained as a result of an examination of students' mind maps about science, and the frequency and percentage of the expressions encountered in these themes, were included. With regard to classifying similar characteristics with regard to expressions in the students' mind maps, 9 main themes - "Science and Technology", "Descriptive and Theoretical Processes", "Disciplines and Topics", "Scientific Studies", "The Earth and The Universe", "Science and Education", "Science and Communication", "Science, Art and Sport" and "Other Expressions" - were identified. Table 5 shows the frequency of the related themes in the mind maps of the middle school students.

Table 5

Themes Including Students' Visual and Verbal Expressions about the Concept of "Science" in Their Mind Maps

Themes	Boys		Girls		Total	
	f	%	*f*	%	*f*	%
Science and Technology	101	22	104	20	205	21
Descriptive and Theoretical Processes	67	15	104	20	171	18
Science Disciplines and Subjects	60	13	82	17	142	15
Scientific Studies	67	15	50	10	117	12
The Earth and The Universe	46	10	41	9	87	9
Science and Education	33	7	51	10	84	9
Science and Communication	9	2	21	4	30	3
Science, Art and Sport	16	4	11	2	27	3
Other Expressions	58	12	43	8	101	10
Total	457	47	507	53	964	100

As a result of the analysis, it can be said that the students mostly associate science and technology with each other in mind maps, were involved in the descriptive and theoretical processes of science, were devoted to science branches and subjects, and

presented examples and expressions related to scientific studies. It is observed that the frequency of some expressions is different when the mind map content is compared to the gender of the students. While girls emphasized the descriptive and theoretical processes of science at a frequency of 20% (*f*=104), boys emphasized this aspect at a frequency of 15% (*f*=67). Similarly, the frequency of expressions related to science disciplines and topics was 17% (*f*=82) in girls and 13% (*f*=60) in boys. On the other hand, boys presented scientific studies in their mind maps at a frequency of 15% (*f*=67), whereas girls emphasized scientific studies at a frequency of 10% (*f*=50) in their mind maps. These results show that the mind maps of girl students include more expressions about the descriptive and theoretical processes of science, science disciplines and subjects than was the case with boys students' mind maps, whereas boy students presented more examples of scientific studies in their mind maps than did girl students. When other themes are examined, it can be seen that the expression of the students in the mind maps is similar.

Table 6

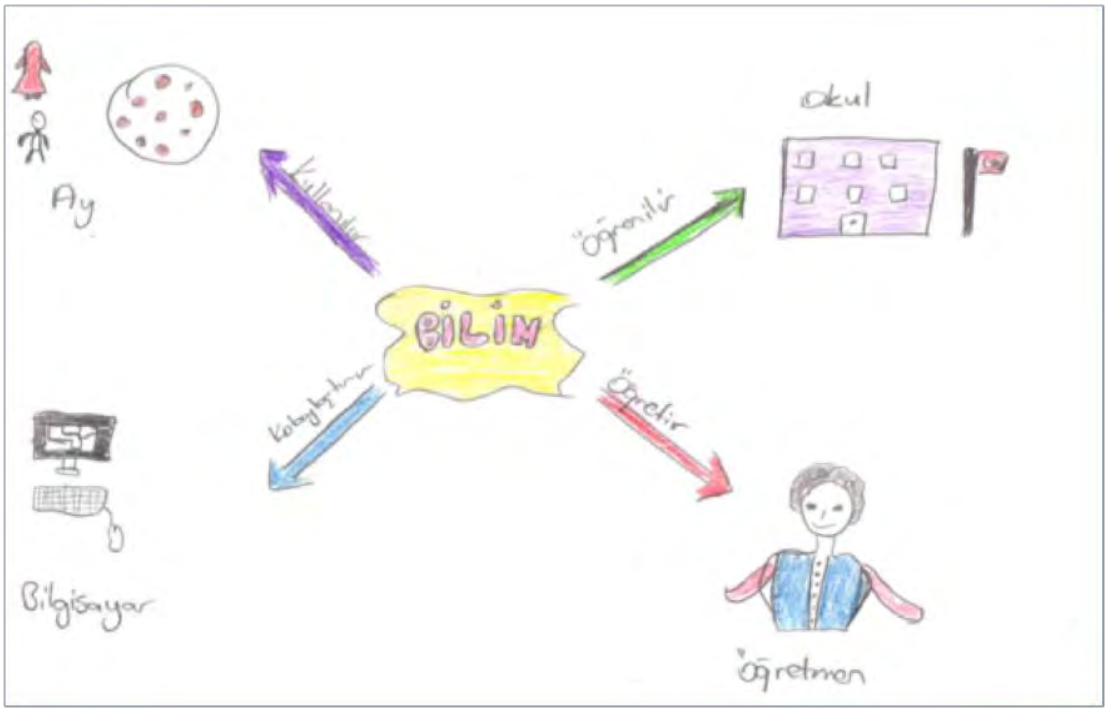
Frequency and Percentage Values of Students' Visual and Verbal Expressions in Mind Maps Related to the "Science and Technology" Theme

Science and Technology	Boys		Girls		Total	
	f	%	*f*	%	*f*	%
Technology	20	20	22	21	42	20
Technological Tools	72	71	74	71	146	71
Tablet/Phone	25	35	20	27	45	31
Computer	14	19	20	27	34	23
White goods (refrigerator, TV, broom etc.)	7	10	16	22	23	16
Transportation vehicles	7	10	3	4	10	7
Software (Windows, Facebook, Internet, Google)	1	1	7	9	8	5
Rocket	5	7	3	4	8	5
Robot	2	3	4	5	6	4
Machinery / Industry	5	7	1	2	6	4
Weapon	4	5	-	-	4	3
Satellite	2	3	-	-	2	2
Convenience / More time	3	3	5	5	8	4
Future Technologies	4	4	2	2	6	3
Time machine	2	50	1	50	3	50
Flying car	2	50	1	50	3	50
Technology and design	2	2	1	1	3	2
Total	101	49	104	51	205	100

With regard to the theme of Science and Technology, mostly students directly associated with science and technology with each other in their mind maps, and gave

examples of technological tools such as computers, white goods, and transportation vehicles. Some students emphasized that technology facilitated human life, and allowed people a lot of time. They gave examples of technological tools that could be produced in the future, and stated that technology was a result of the design process. The content in the mind maps of the students, in terms of their gender, shows that girl and boy students associate with each other science and technology in similar frequencies. Students' opinions differ in terms of some examples they gave with regard to technological tools. Girls showed examples of software technology at a frequency of 9% (*f*=7), whereas boys provided examples at a frequency of 1% (*f*=1). On the other hand, boys showed machines at a frequency of 7% (*f*=5), weapons at 5% (*f*=4), and satellites at a frequency 3% (*f*=2) as examples of technological tools. In contrast, girls did not include the related technological tools in their mind maps. In addition, girl and boy students often presented examples of their own living spaces in terms of technological tools. As a result, boy and girl students can be said to associate science and technology with one another to a large extent and gave examples of technological tools, but their knowledge about the benefits of technology are limited, and they reveal no negative thoughts about science and technology.

Drawing 1. Mind Map about the Concept of Science of a Boy Student in Eighth Grade (Participant 65)



In the mind map presented above, the student tries to explain the concepts they associate with science in his mind. When the relationships in the student's mind maps are examined, it can be seen that he thinks that science is taught through a teacher at school, that the information produced as a result of scientific development is used in explaining the functioning of the universe, and that technological tools such as computers that are produced as a result of scientific developments make our lives easier.

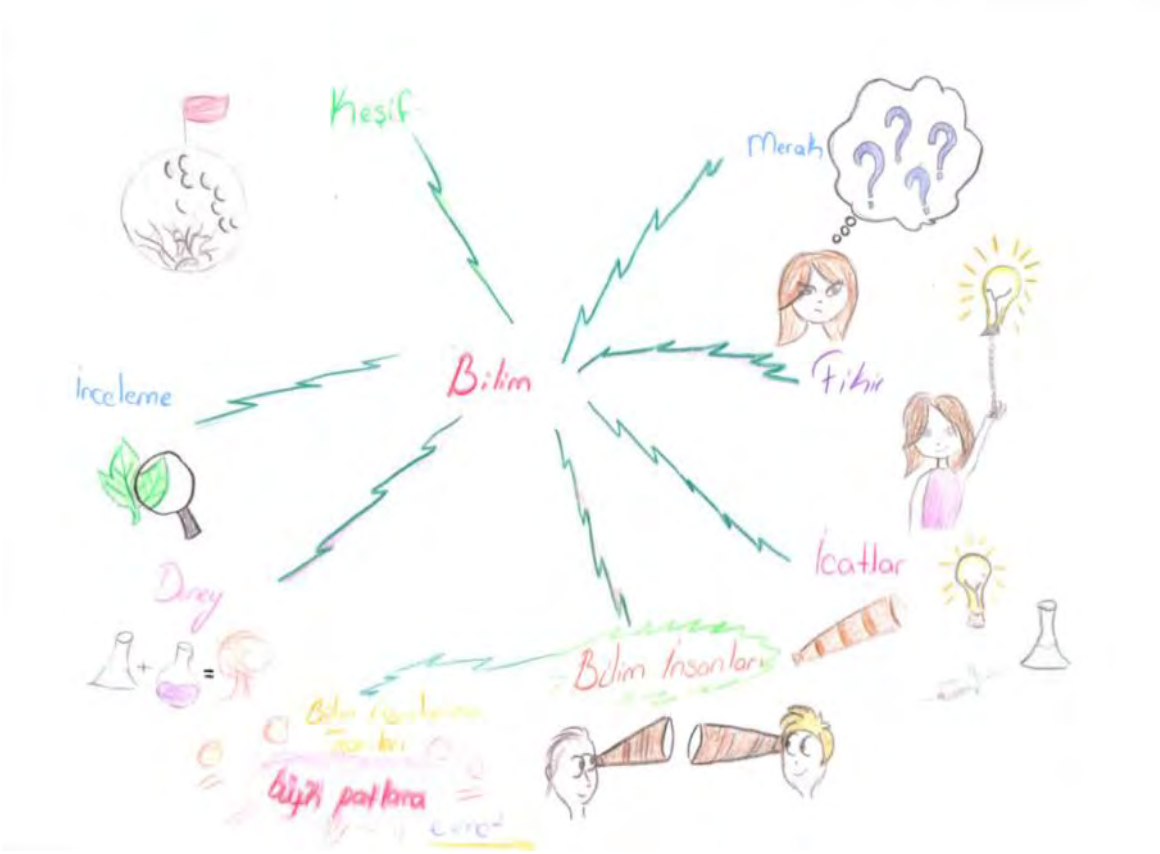
Table 7

Frequency and Percentage Values of Visual and Verbal Expressions in Mind Maps Related to the "Descriptive and Theoretical Processes" Theme of the Students

Descriptive and Theoretical Processes	Boys		Girls		Total	
	f	%	*f*	%	*f*	%
Laboratory / Laboratory equipment	18	27	24	22	42	25
Invention /Discovery/New	17	26	22	21	39	23
Experiment/Project	12	18	21	20	33	18
Research/Study/Learning	6	9	11	11	17	10
The Mind/Brain	4	6	10	10	14	8
Information	5	7	5	5	10	6
Observation	1	1	4	4	5	3
Curiosity/Idea	2	3	3	3	5	3
Dream/Inspiration	1	1	1	1	2	1
Talent/Patience/Love	1	1	2	2	3	2
Theory	0	0	1	1	1	1
Total	67	39	104	61	171	100

Middle school students have also partially emphasized the descriptive and theoretical processes of science in the mind maps they produced. It can be observed that the students indicated the laboratory environment, the tools and materials in the laboratory environment, and concepts such as discovery, invention, observation, experiments and project methods in their mind maps. The results show that students have an idea that scientific knowledge can be produced by experimental methods. In addition, students included mental processes such as mind, curiosity, imagination, talent and ideas in their mind maps. It can be seen that while students include the descriptive processes of science and the features of scientists in their mind maps, they do not make much mention of the theoretical processes of science such as hypothesis formation, theories and laws. In the case of linking the student's mind maps to their gender, it can be said that boy and girl students have similar perceptions about the descriptive and theoretical processes of science. It can be observed that the frequency of girl students' perceptions with regard to this theme was 61% (*f*=104), whereas that of boy students was 39% (*f*=67). This result shows that girls have more information in their minds about the descriptive and theoretical processes of science than boys.

Drawing 2. Mind Map about the Concept of Science of a Girl Student in Seventh Grade (Participant 24)



In the mind map presented above, a girl student includes the descriptive and theoretical processes associated with science. This student emphasizes concepts such as curiosity and ideas by emphasizing the mental processes of science on the mind map, and she states that scientific research start with a research idea. She also notes that scientific knowledge is obtained through experimentation, that investigations are carried out in this process, and that discoveries and inventions are achieved with the results obtained. As a result, this particular student tries to emphasize the process of scientific research with her visual and verbal expressions in the mind map.

Table 8

Frequency and Percentage Values of Visual and Verbal Expressions in Mind Maps Related to the "Science Disciplines and Subjects" Theme of the Students

Science Disciplines and Subjects	Boys		Girls		Total	
	f	%	*f*	%	*f*	%
Science Disciplines	29	48	31	38	60	42
Natural Sciences	13	45	14	45	27	45
Medical	6	21	9	29	15	25
Social Sciences (History, Literature, Philosophy)	5	17	5	16	10	17
Math	5	17	3	10	8	13

Science Subjects	31	52	51	62	82	58
Electricity/Energy	10	32	6	12	16	19
Living things	2	6	13	25	15	18
Atom/atomic model/heat	7	24	7	14	14	17
Cloning/DNA/cell/genetic structure	6	19	3	6	9	11
Minerals/Water/Nutrients	-	-	8	16	8	10
Gravity/lifting force/light	2	6	5	10	7	9
Geographical discoveries/Seasons	1	3	4	8	5	6
Formulas	3	10	2	4	5	6
History of creatures/big bang	-	-	3	5	3	4
Total	60	42	82	58	142	100

Table 8 shows that middle school students noted science disciplines at a frequency of 42% (*f*=60) and science subjects at a frequency of 58% (*f*=82) in their mind maps. The students gave more examples of natural sciences in terms of the branches of science than other disciplines. The students noted the existence of social sciences such as history, literature, and philosophy at a frequency of 17% (*f*=10) in their mind maps. This result shows that students consider natural sciences to be the main branches of science. In relation to the subjects of science, the students gave examples of the subjects of natural sciences to include such aspects as electricity, living things, atoms, cloning, nutrients, and gravity. At a frequency of 6% (*f*=5), some students emphasized geographical discoveries and seasons. In addition, it can be said that the students do not associate social science subjects with science in their minds. When the content of the students' mind maps is compared in terms of gender, it can be said that boys and girls have a similar mental model about the branches and subjects of science.

Drawing 3. Mind Map about the Concept of Science of a Girl Student in Seventh grade (Participant 27)

In the mind map presented above, a girl student included the disciplines and subjects of science. When the mind map is examined, it can be seen that the student relates science and natural sciences such as cells, but also as a branch of social science she includes archaeology in her mind map, and also relates science and art to each other. This result shows that this particular student considers science not only as a positivistic subject, but also as a social science and art.

Table 9

Frequency and Percentage Values of Visual and Verbal Expressions in Mind Maps Related to the "Scientific Studies" Theme of the Students

Scientific Studies	Boys		Girls		Total	
	f	%	*f*	%	*f*	%
Scientist (science man)	20	30	14	28	34	29
Scientist (science woman)	3	4	6	12	9	8
Researchers	-	-	2	4	2	2
Examples of Scientists	21	31	11	22	32	27
Einstein	4	19	3	27	7	23
Edison	3	14	2	18	5	16
Atatürk	3	14	3	27	6	19
Graham	2	10	1	10	3	9
Philosophers (Democritus and Socrates)	3	14	-	-	3	9
Cahit Arf/Ali Kuşçu/Farabi	3	14	-	-	3	9
Henry Moseley/Newton	-	-	2	18	2	6
Marie Cruie	2	10	-	-	2	6
Mark Zuckerberg	1	5	-	-	1	3
Important Inventions	23	35	17	34	40	34
Bulb	10	43	14	82	24	60
Car	8	35	1	6	9	22
Wheel	5	22	1	6	6	15
Printing	-	-	1	6	1	3
Total	67	57	50	43	117	100

The students identified people who do scientific research on their mind maps and gave examples to some important scientific discoveries. While the students were identifying people who did scientific research, they used expressions on their mind maps such as science man with a frequency of 29% (*f*=34), science woman with a frequency of 8% (*f*=9) and researchers with a frequency of 2% (*f*=2). When the examples they give of scientists are examined, it can be seen that they included such scientists as Einstein, Graham-Bell, Newton, Edison, who are particularly noted for research in the natural sciences. The students included Mustafa Kemal Atatürk at a frequency of 19% (*f*=6) in their mind maps. As important discoveries affecting the

history of mankind, the students offered examples of the light bulb, the car, the wheel and printing. When the content in the mind maps is compared in terms of gender, it is observed that some boy students mentioned some important philosophers as scientists, whereas girl students did not include philosophers. Some boy students showed Marie Curie as a female scientist. It is observed that the students do not give place in their mind maps to scientists who have done research in recent years. Only one boy student showed Mark Zuckerberg as a scientist. Some of the boy students placed Cahit Arf and Ali Kuşçu as Turkish scientists on their mind maps. As a result, it can be observed that students emphasized science man more than scientists in their mind maps, and give examples of male scientists who had mostly worked in the field of Natural Sciences in the past.

Drawing 4. Mind Map about the Concept of Science of a Boy Student in Seventh Grade (Participant 81)

In the mind map presented above, a boy student associated science with technology and discoveries, but also emphasized the relationship between science and history. On his mind map, this student also showed Ali Kuşçu as a scientist by emphasizing his research with regard to space. In addition, the student gave the Nobel Prize on the mind map, unlike his friends.

Table 10

Frequency and Percentage Values of Visual and Verbal Expressions in Mind Maps Related to the "The Earth and The Universe" Theme of the Students

The Earth and The Universe	Boys		Girls		Total	
	f	%	*f*	%	*f*	%
World	9	20	11	27	20	23
Space	11	23	7	17	18	21
Moon/Star	9	20	5	12	14	16
Sun	5	11	8	20	13	15
Planets	5	11	5	12	10	11
Telescope	4	9	2	5	6	7
Astronaut	3	6	3	7	6	7
Total	46	53	41	47	87	100

It was noted that students relate science and the universe in their mind maps and use various expressions and visuals related to it. Students related the concepts of earth, space, moon, stars, sun, and planets with science on their mind maps. The students exemplified the telescope as an observation tool and exemplified astronauts as the people making research about space. It can be said that the students have a similar mental model about the relationship between science and the universe, when the content in the students' mind maps is compared to their gender.

Table 11

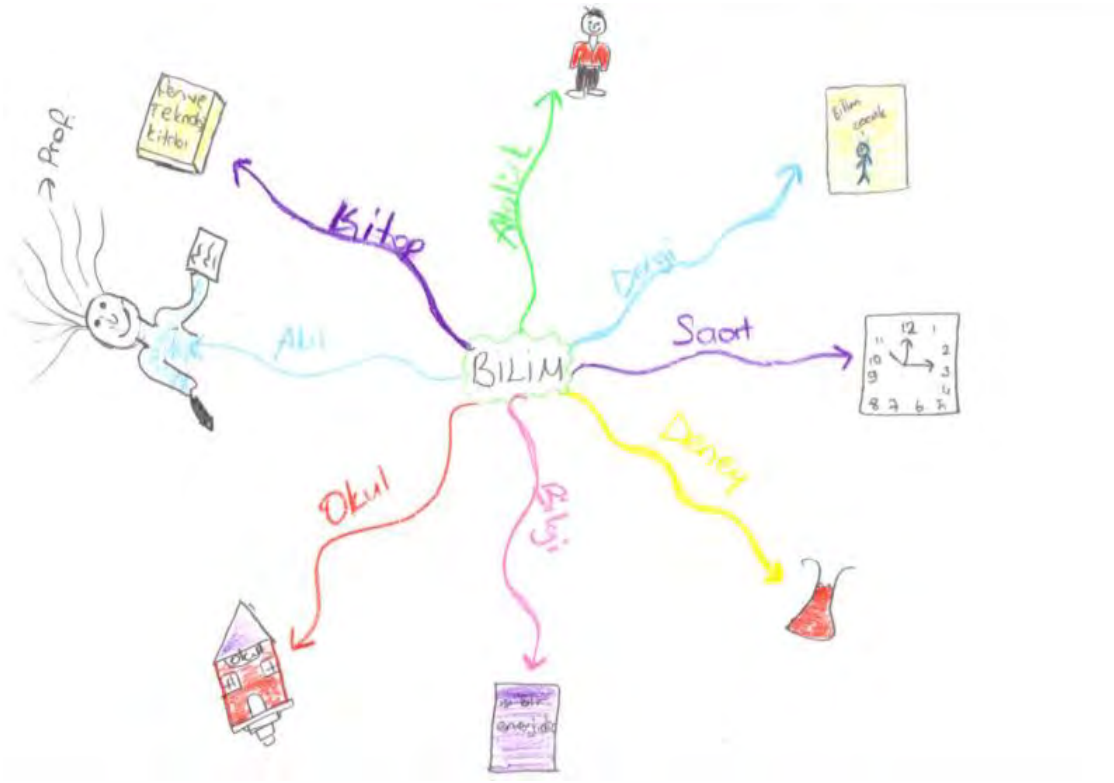
Frequency and Percentage Values of Visual and Verbal Expressions in Mind Maps Related to the "Science and Education" Theme of the Students

Science and Education	Boys		Girls		Total	
	f	%	*f*	%	*f*	%
Book/Encyclopedia	13	39	19	37	32	38
School/Madrasah/Class	4	12	11	22	15	18
Course	3	10	8	16	11	13
Science-Children's magazine	5	15	5	9	10	12
Teacher	5	15	4	8	9	11
Education	2	6	3	6	5	6
Student	1	3	1	2	2	2
Total	33	39	51	61	84	100

As a result of the analyses, it was noted that the students emphasized the concepts of courses, schools, students and teachers in their mind maps when linking education and science. This result shows that students are of the opinion that science can be taught through education. An important point in the research is that students

included the "Science and Children" magazine at a frequency of 12% (*f*=10) in their mind maps. When the mind map content of the students was compared to their gender, it was observed that the girls linked science and education at a frequency of 61% (*f*=51) while boys linked science and education at a frequency of 39% (*f*=33). This result shows that girl students have more awareness of the role of education in scientific development than boy students.

Drawing 5. Mind Map about the Concept of Science of a Girl Student in Eight Grades (Participant 16)



In the mind map presented above, the student relates the concept of science to the concepts of school, information, and books that are related to education. In addition, it is observed that the student includes the magazine "Science and Children" that presents the concepts related to science with visual elements in a fun way. This result shows that this particular student has benefited from school, books and this magazine in learning about the concepts of science.

Table 12

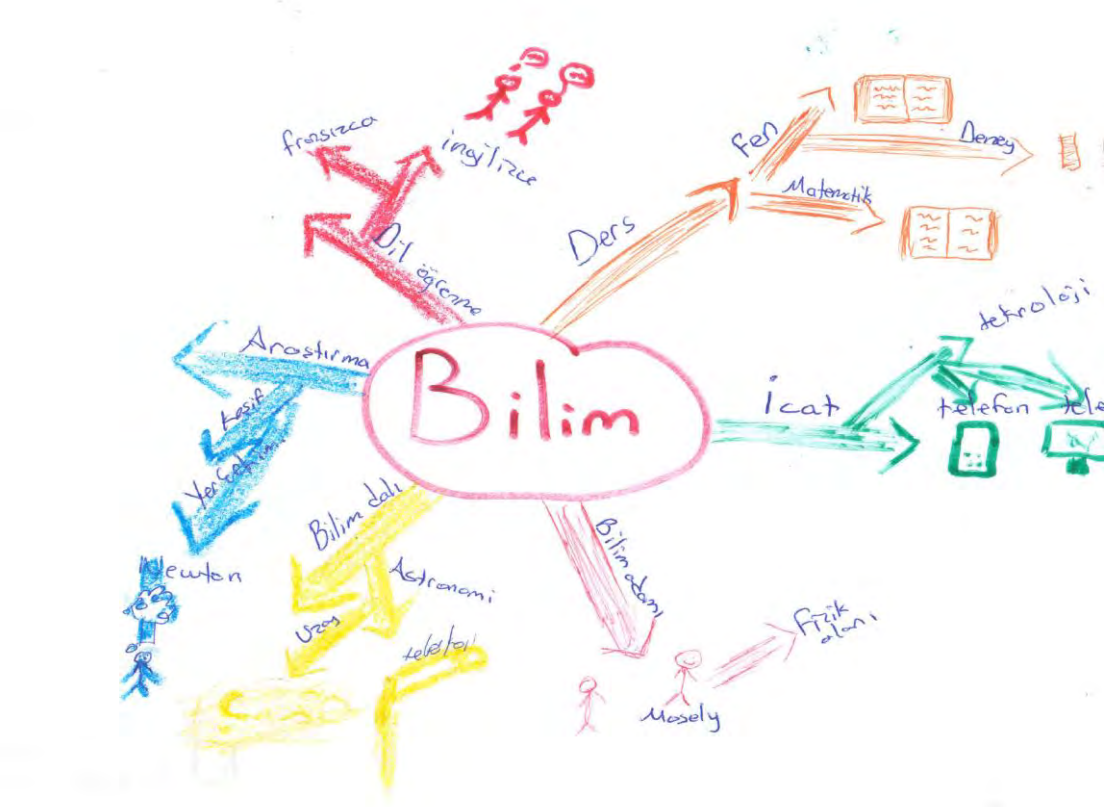
Frequency and Percentage Values of Visual and Verbal Expressions in Mind Maps Related to the "Science and Communication" Theme of the Students

Science and Communication	Boys		Girls		Total	
	f	%	*f*	%	*f*	%
Magazine	6	67	6	29	12	40
News	1	11	3	14	4	13
Foreign Language (English/French)	-	-	3	14	3	10

Dialog	-	-	3	14	3	10
Documentary	-	-	1	5	1	3
Newspaper	-	-	1	5	1	3
Human	2	22	4	19	6	20
Total	9	30	21	70	30	100

It was determined that the students make visual and verbal statements about the importance of communication in the announcement of scientific developments in their mind maps. The students mostly stressed that scientific developments were transferred to society through magazines and news channels. When the content in the students' mind maps were compared in terms of their gender, it is observed that both girl and boy students have established a similar relationship between science and communication; however, the frequency of the expression in the relevant theme on the part of girl students was 70% (*f*=21) while that of boy students was 30% (*f*=9). In addition, only girl students emphasized foreign language knowledge, which is an important element in communication, on their mind maps at a frequency of 14% (*f*=3).

Drawing 6. Mind Map about the Concept of Science of a Girl Student in Eight Grades (Participant 2)



In the mind map presented above, a student associated science and Natural Sciences and mathematics courses, emphasizing that scientific developments led to inventions, and shows technological tools as examples of these inventions. The student emphasized branches of science such as astronomy, and stated that discoveries emerged

as a result of research. The student gave examples of scientists such as Newton and Moseley. In the mind map, the student emphasized the importance of communication in scientific research, and indicated that learning English and French is related to science.

Table 13

Frequency and Percentage Values of Visual and Verbal Expressions in Mind Maps Related to the "Science, Art and Sport" Theme of the Students

Science, Art and Sport	Boys		Girls		Total	
	f	%	*f*	%	*f*	%
Art	5	31	5	46	10	37
Picture	5	31	3	27	8	30
Music	4	25	1	9	5	19
Cartoon /cinema	-	-	2	18	2	7
Sport	2	13	-	-	2	7
Total	16	59	11	41	27	100

It was determined that the students presented visual and verbal expressions related to science, art and sports in their mind maps. The students associated science with art, and gave examples in the fields of painting, music and cinema related to art branches at a frequency of 37% (*f*=10). When the content in the mind maps of the students was compared in terms of gender, it was observed that boys and girls similarly associated science and art, but only some boy students associated science and sport with each other.

Table 14

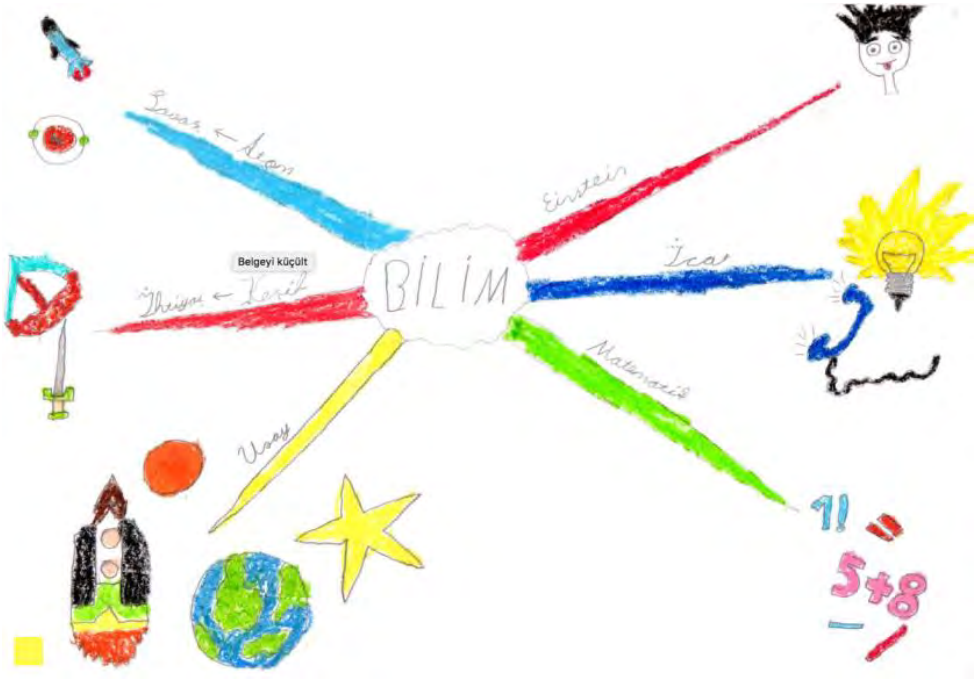
Frequency and Percentage Values of Visual and Verbal Expressions in Mind Maps Related to the "Other Expressions" Theme of the Students

Other Expressions	Boys		Girls		Total	
	f	%	*f*	%	*f*	%
Science and Gender	40	69	41	96	81	80
Male figure / garbage man	36	90	31	76	67	83
Female Figure	4	10	10	24	14	17
War	4	7	-	-	4	4
Modernization And Development	7	12	1	2	8	8
Countries	6	10	-	-	6	6
Supports and rewards (TUBITAK, NOBEL)	1	2	1	2	2	2
Total	58	57	43	43	101	100

As a result of the analysis of students' mind maps, some expressions could not be evaluated under a common theme and "other expressions" are as shown in Table 10.

Students often draw human figures on mind maps. It is observed that 83% (*f*=67) of these drawings were male and 17% (*f*=14) were female. This rate was 76% (*f*=31) in the case of girl students and 90% (*f*=36) in the case of boy students. As a result, students often associate science with males. In the mind maps, boy students, unlike girl students, associated science with war, and evaluated it as an important condition of modernization and development. They gave examples of countries that were influential in scientific development. Only a few students showed examples of the TUBITAK and NOBEL prizes in their mind maps as a reward for scientific progress.

Drawing 7. Mind Map about the Concept of Science of a Boy Student in Seventh Grades (Participant 90)



In the mind map presented above, the student associated science with mathematics and space concepts, presented Einstein as an example of a scientist, stressed that scientific discoveries emerged as a result of needs, and stated that the atomic bomb, one of the scientific discoveries, is used in wars. This result shows that the student has a mental model about the results of scientific development, and that he associates it with science and war.

Discussion and Conclusion

In this study, middle school students' views and perceptions about science were determined by using mind maps in an attempt to describe their mental models about science. As a result of the study, firstly it was observed that the scores obtained from the mind maps prepared by students about science differed significantly according to grade level, and that the related difference was due to the perceptions of fifth grade students. It was concluded that there was no significant difference between the scores of the sixth, seventh and eighth grade students in terms of their mind maps. Demir & Akarsu (2013) also determined that sixth and seventh grade students' views of the nature of science are similar. On the other hand, it was determined that the mind maps scores of fifth grade

students were significantly lower than those of sixth, seventh and eighth grade students. In other words, fifth grade students remembered fewer concepts, expressions, relationships, and visual elements about science through their mental association compared with the other students. This result may be due to the fact that fifth grade students are less likely to encounter science-related concepts and have difficulty structuring their knowledge in their minds. In addition, the fifth grade students may have difficulty understanding the abstract concepts of science because they are still in the process of abstract conceptualization. In the various studies into this topic, it is often emphasized that science should be taught to students at an early age (Kaya, Afacan, Polat, & Urtekin, 2013). For this reason, it is thought that more scientific activities should take place as part of the fifth grade curriculum to provide for students with the opportunity to create and develop mental models related to science.

In this study, the students' mind map scores did not differ significantly in terms of their gender. This result shows that the concepts, expressions, relationships, and visual elements relating to science that boys and girls remember through mental association are at a similar level. In the literature, in some studies on the nature of science there is no difference between boy and girl students. In this study, the content of visual and verbal expressions with regard to the mind maps of boys and girls was also examined, and a comparison made. It can be said that what the students associate most with regard to science and technology in mind maps, includes the descriptive and theoretical processes of science, the separation of science into branches and subjects, and presenting examples and expressions of scientific studies. Girls gave more space on their mind maps to the descriptive and theoretical processes, branches and subjects of science. In contrast, boy students presented more examples of scientific studies in their mind maps than did girl students.

The students in this study identified people who do scientific research on their mind maps and gave examples of some important scientific discoveries. It is observed that the students provided examples of scientists such as Einstein, Graham-Bell, Newton and Edison, who were active in the natural sciences. Only Marie Curie was shown as an example of a female scientist. Some boy students mentioned important philosophers as scientists. On the other hand, in terms of important discoveries affecting the history of mankind, the students showed examples such as the light bulb, the car, the wheel and printing. As a result, it was observed that the students emphasized more male scientists in their mind maps rather than scientists in general, and gave examples of male scientists working in the field of natural sciences in the past. In another study, it was found that the scientists in the minds of pre-service teachers were mostly scientists who undertook research on the natural sciences (Çermik, 2013). In general, the results of the research show that students described men working in a laboratory environment and dealing with natural sciences as being the typical scientist. For example, in another piece of research it was determined that gifted students' images of scientists were that of men who wore glasses, lab coats, worked with test tubes in the laboratory, who used books and technological tools, and were working alone (Camcı-Erdoğan, 2013). Eyceyurt-Türk & Tüzün (2017) also stated that ninth grade students have the perception that science is done in a laboratory. This result can usually be due to the fact that people think that science is directly related to the natural sciences. Esgin & Arslan (2011) emphasized that in their study supporting this view, social sciences are generally seen as

areas that are not taken seriously, and do not produce concrete results, that universities are understood only as places where white-coated scientists do scientific research in laboratories, and that science policies are limited to the natural sciences. In addition, it is observed that the students in our study do not include to scientists who are undertaking recent research in their mind maps. Only one boy student showed Mark Zuckerberg as a scientist. Some of the boy students also emphasized Turkish scientists, Cahit Arf and Ali Kuşçu, on their mind maps. It can be said that students do not have enough knowledge about scientific studies carried out today and about Turkish scientists. This result may stem from the fact that teachers do not provide sufficient examples of scientific developments and do not use historical approach to teach the nature of science. In particular, the belief that science and science features are subjects that should be taught only in science classes may have caused students to encounter only examples in these areas (Altındağ, Tunç-Şahin, & Saka, 2012).

Middle school students also partially emphasized the descriptive and theoretical processes of science in their mind maps. In the study, it was observed that the students stated only the experimental method as a means of data collection. It can be said that boys and girls have similar perceptions about the descriptive and theoretical processes of science. This result shows that students think that scientific knowledge can only be obtained by experimental methods. This may be due to the fact that students think that science should be based on observation and experimentation (Ayvacı & Şenel-Çoruhlu, 2012). Fernandes, Rodrigues, and Ferreria (2018) found that children's conceptualization of the nature of science is based on experimental and technical tools. The results of the studies in the literature show that students usually have this common belief. In research carried out with high school and middle school students, it was determined that the students mostly highlighted experimental–observation–research steps regarding the scientific process, and that they have an understanding of scientific knowledge that is experimental (Eyceyurt-Türk & Tüzün, 2017; Muşlu & Macaroğlu-Akgül, 2006). In another study conducted with pre-service teachers, it was concluded that all the participants emphasized that science is based on experimentation (Abd-El-Khalick, Bell, & Lederman, 1998). Similarly, in our study, students have only included Natural Sciences in relation to the subjects and branches of science. Some students emphasized geographical discoveries and seasons. Apart from these, it can be said that the students do not relate the subjects of social sciences to science. It was observed that boys and girls have a similar mental model regarding the branches and subjects of science. At the same time, Muşlu and Macaroglu-Akgül (2006) determined that secondary school students define science as being natural sciences, and Inel-Ekici (2015) determined that pre-service teachers highlighted natural sciences such as physics and chemistry in their mind maps about science. The results are thought to be derived from the perception of science on the part of society. In order to solve this problem, it is recommended that the subjects related to science, and the characteristics of science should be included not only in the content of natural science lessons but also in social sciences, mathematics, and so on.

As a result of the analysis of the data in this study, it was determined that students frequently emphasize the relationship between science and technology in their mind maps. In addition, girl and boy students presented examples from their own homes. This result shows that students associate science with their daily lives. It can be

said that students' thoughts are product-oriented, and that they emphasize technological tools produced as a result of inventions discovered by scientists through experimental methods in their mind maps. In another piece of research, pre-service teachers similarly associated science and technology in mind maps they drew, and emphasized the scientific process skills such as observation, research and experimentation (Inel-Ekici, 2015). In a study by Fernandes, Rodrigues, and Ferreria (2018), they concluded that the students perceived technology as a part of their lives, and defined it as a tool that involves the application of science. Therefore, it can be said that students consider technology as an integral part of science, and consider it as a tangible application of science in their daily lives. The examples given by the students with regard to technological tools in mind maps are limited. As a result of scientific developments, they stated that technological tools such as the telephone, robots, computers and television have been produced. Aydın (2011) stated that middle school students mostly saw technology as being advanced technologies, and that they always viewed electronic tools in daily life as technology. In addition to the technologies used in daily life such as the telephone, computers and televisions, students gave a limited number of examples of tools that can be produced as a result of recent developments in technology.

One of the remarkable results of this research is the relationship between education and science in the mind maps of a small number of students. Some students particularly emphasized the learning-teaching process while making this association. In the research, some students featured the magazine "Science and Children" in their mind maps. It can be said that boys and girls have a similar mental model about the relationship between education and science. It was determined that the students presented visual and verbal expressions about the importance of communications in the announcement of scientific developments in their mind maps. The students emphasized that society was made aware of scientific developments through magazines and news channels. It was determined that boys and girls have similar views on science and communication, but only girls emphasized foreign language knowledge as an important element in communication in their mind maps. In this study the students who associated science and art gave examples from the fields of painting, music and cinema as related to the branches of art. In addition, in their mind maps, boy students linked science to war, as opposed to girl students, and evaluated science as an important condition of modernization and development. They gave examples of countries that are influential in scientific development. Only a few students presented the TUBITAK and Nobel Prizes in their mind maps as rewards for scientific progress.

As a result, in this study, students' views with regard to science were determined by using free association through a drawing technique in the form of mind maps. Based on the statements of the students, mental models related to science were determined. The most important limitation of the study is that the students do not explain what they want to describe in their drawings. In general, it can be said that the students' mental models of science are based on the natural sciences; they think that scientific knowledge can only be produced through experimental methods, and that there is a strong relationship between science and technology. In the research to be done in the future, it is recommended that the reasons why students offered these views should be examined in detail, and it should be discussed ways in which it is possible to improve and enrich these views.

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