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A Cross Sectional Survey about Students' Agreement Rates on Non-Scientific Ideas concerning the Concept of Magnet

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ABSTRACT
The present study aims to find out the agreement rates of students on non-scientific ideas concerning the concept of magnet with a cross sectional survey. A total of 436 students studying in the final years of elementary (n=113), middle (n=110), high school (n=105) and university (n=108) participated in the study. Data were collected with the help of a concept test. Quantitative methods were utilized in data analyses. According to the results, students were found to agree with non-scientific ideas in different percentages in each educational level. Most of those non-scientific ideas were prevalent misconceptions in the literature. The least percentages of agreements were detected among university students. Besides, five different mental models were presented to explain the cognitive structures of the students related to their agreements. Several recommendations were provided to consider in future studies at the end of the study.

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Introduction

In Turkey, it is seen that concepts are given to the students with a spiral curriculum regarding science teaching program (MEB, 2018a). Spiral curriculum means that concepts are addressed in a basic way in elementary levels and details are added to the instruction in the subsequent grades. The subject, magnetism is also addressed in a spiral way in different grades of elementary and high school regarding the teaching programs. Magnets, the sources of magnetic field, magnetic field lines, right hand rule, magnetic flux, magnetic force, induction and inductance might be asserted among the concepts which make up the subject of magnetism. This paper considers the concept of magnet. At this respect, the units, subjects and concepts which take place in elementary science (MEB, 2018a) and physics teaching programs (MEB, 2018b) related to magnetism are displayed in Table 1.

As can be seen in Table 1, teaching of the subjects related to magnetism starts with magnets in the elementary level. The subject is attractive for young children (Kalogiannakis, Nirgianaki & Papadakis, 2018). This introduction in elementary level provides students the basis for their further learning in high school. Students expand their knowledge on this subject in case they take university education in related departments. Thus, they might realize that our modern ideas about magnetism did not come from a linear progression but it was a result of huge work based on observing, experimenting, modeling, explaining and reworking on the phenomena (Binnie, 2001).

Table 1

The Distribution of the Subjects and Concepts related to Magnetism in Elementary Science and Physics Teaching Programs

Grade	Unit	Subject	Subject/Concepts
4	The effects of force	Force exerted by magnets	• Magnets • The poles of magnets • The fields of use of magnets
	The properties of matter	Properties qualifying matter	• Attraction of magnets
10	Electricity and magnetism	Magnet and magnetic field	• Magnetic fields produced by magnets • The variables that affect magnetic field • Magnetic field lines • Attraction of magnets
		Current and magnetic field	• The magnetic field produced by a straight wire carrying an electric current • Right hand rule • Electromagnets • Magnetic field of the World and its consequences • The use of compass
11	Electricity and magnetism	Magnetism and electromagnetic induction	• The magnitude of magnetic field around a straight wire carrying an electric current and in the central axis of a loop and coil. The variables which affect the magnitude of those magnetic fields. • Right hand rule • Magnetic force exerted by a straight wire carrying an electric current and a rectangular frame in a magnetic field • The movement of charged particles in magnetic field • Magnetic flux • The induced current • The self-induced current • Electromotive force (electric generator, dynamo)

The discovery of the first magnet was known to be made by the Greek in the western Anatolia around the rocks called “magnesia” and the word; “magnet” was known to stem from this fact (Heyl, 1941; Serway & Beichner, 2002). Additionally, it was reported legendarily that this discovery was made by a Greek shepherd who realized that the iron tips of his shoes were attracted by the rocks. When the situation is considered from the Ancient ages to the present day, it is seen that magnets are utilized in various fields of daily life; from high-speed trains to magnetic resonance (MR) devices, generators and earphones. As well as the mentioned items, magnets are among the materials which are used in scientific research. So, the concept of magnet constitutes an indispensable part of daily life and scientific field. Also, the subjects of electricity and magnetism are closely related to each other (Scaife & Heckler, 2011). Due to those reasons, teaching of magnets is believed to have an important place in science and physics education.

One of the biggest challenges of learning physics is learning concepts (Koponen & Huttunen, 2013). Kınık Topalsan and Bayram (2019) stated that students often have difficulty in understanding the higher levels when they do not make sense of a basic concept in physics. Also, it is seen that children generally gain conceptions which contradict with scientific facts as a result of their experiences to make discoveries around them (Smolleck & Hershberger, 2011). Students are expected to learn scientific conceptions. However, students' conceptions might be different from the scientific conceptions. The term, misconceptions will be used to indicate such conceptions of the students in this study. Misconceptions can be defined as conceptions that are wrong from the scientific point of view (Kokkonen, 2017). They cause problems for students and often lead to misunderstanding and misconstruction (Kaniawati et al., 2019). However, all of students' non-scientific concepts might not refer a misconception. Although misconceptions and erroneous responses are confused with each other from time to time, instant cases such as inattention, hurrying might cause an erroneous response (Çavuş Erdem & Gürbüz, 2017). On the other hand, misconceptions show a continuous structure. They are difficult to eliminate or they might reappear despite using various strategies (Özgür, 2013).

Magnetism is perceived as one of the most difficult, abstract and irrelevant subjects among the physics course subjects (Çoramık, 2012; Güler & Şahin, 2017). The reason of the fact that magnets cannot be fully understood especially by younger children might be due to the invisibility of the causal elements whereas their actions are observable (Preston, 2016). At this point, mental models play a significant role while students make inquiries about scientific phenomena and try to comprehend them (Yuksel, 2011).

The development of correct mental models about the basic concepts about magnetism is significant for the students to understand the concepts such as right-hand rule, magnetic force, magnetic flux and electric current in high school and university level (Özdemir & Çoramık, 2018). However, misconceptions stemming from elementary levels make student learning harder at this respect and those misconceptions tend to appear in the subsequent grades. Deeply rooted opinions of students provide barriers for their learning (Yuksel, 2011). Such kind of opinions might continue in the entire academic life of a student if they are not dealt with in the earlier grades (Çepni & Keleş, 2006).

The analysis of the literature reveals a number of non-scientific ideas concerning the concept of magnet (Bar, Zinn & Rubin, 1997; Burgoon, Heddle & Duron, 2011; Gülçiçek, 2004; Hickey & Schibeci, 1999; Lemmer, Kriek & Erasmus, 2018; Smolleck & Hershberger, 2011; Tanel & Erol, 2005). Several studies focused on students' opinions about the interaction between a magnet and a material. The study of Smolleck and Hershberger (2011) revealed that children aged 3-8 carried the misconception that magnets attracted all materials. In addition, they believed that magnets attracted all metals (Smolleck & Hershberger, 2011). The same misconception was also prevalent among elementary students (Karabacak, 2014), high school students (Gülçiçek, 2004; Lemmer et al., 2018), university students (Hickey & Schibeci, 1999; Ince & Yilmaz, 2012) and teachers (Burgoon et al., 2011; Hickey & Schibeci, 1999) as well. Also, Güneş (2017) explained the reasons of the misconceptions in the form of "magnets only pull" and "magnets push non-metals" among students in his book. The misconception, "magnets only pull" was also determined among high school students by Lemmer et al. (2018).

It is also seen that the conception of the poles of a magnet constitutes a problem for Turkish students because the poles of a magnet are shown with letters, "N" and "S" which are different from the initial names of the poles in Turkish language. The study of Karabacak (2014) indicated that middle school students had problems related to the naming of the poles of a magnet. The students were determined to name the poles of a magnet as K-M, +/- and in several other ways. Likewise; Gülçiçek (2004) determined that high school students believed that there were single poles on magnets. In addition, the same misconception was addressed in the study of Güneş (2017). The literature also revealed that students carried misconceptions related to the interaction between the poles of magnets. The misconceptions, "opposite poles of magnets push each other" and "the same poles of magnets attract each other" were determined in Karabacak's (2014) study which is conducted with middle school students.

The abovementioned literature addresses the conceptions concerning the interaction between a magnet and a material as well as the poles of a magnet. Another characteristic of magnets is related to their natural/artificial structure. This characteristic is explained in the learning objectives in elementary (MEB, 2018a) and high school program (MEB, 2018b). In her study, Karabacak (2014) determined the misconception as "a material could not gain magnetic characteristic later" among middle school students.

Students also possess misconceptions related to the comprehension of cutting magnets. For example, middle school (Karabacak, 2014) and high school students (Lemmer et al., 2018) were found to believe that a magnet lost its magnetic property if it was divided into smaller parts. In addition, they were determined to think that a magnet lost its poles if it was divided into smaller parts (Güneş, 2017; Lemmer et al., 2018). Furthermore, high school students were found to assert that if a magnet was separated in its center, new magnets had one pole (Çoramık, 2012).

The literature also points out misconceptions of the students on the comprehension of the effect of the magnetic force produced by magnets. "Bigger magnets are stronger than smaller magnets" is a popular misconception among all grade level students (Gülçiçek, 2004; Lemmer et al., 2018; Smolleck & Hershberger, 2011; Tanel & Erol, 2005) as well as the teachers (Burgoon et al., 2011). The opinion, "a magnet has to touch a material in order to attract it" was detected among students aged 9-18 (Bar et al., 1997) in addition to the university students and teachers (Hickey & Schibeci, 1999). Similarly, high school students believed that magnetism did not go through the objects (Lemmer et al., 2018). The studies also revealed misconceptions about the distance that magnets can attract materials in all grade level students (Bar et al., 1997; Bar & Zinn, 1998; Hickey & Schibeci, 1999) and teachers (Hickey & Schibeci, 1999).

As can be seen, there are misconceptions about magnetism issue both in students in different grade levels and in teachers. When the research is analyzed, it is realized that non-scientific ideas about magnetism were generally detected with the help of the studies focusing on students at a definite age (Christidou, Kazela, Kakana & Valakosta, 2009; Çolak, 2014; Çoramık, 2012; Gülçiçek, 2004; Ince & Yilmaz, 2012; Karabacak, 2014; Kartal Taşoğlu & Bakaç, 2014; Okulu & Oğuz Ünver, 2018; Yuksel, 2011). Few studies deal with children aged 3-8 (Smolleck & Hershberger, 2011) and 9-18 (Bar et al., 1997). However, conceptions show a dynamically emergent structure and they might change with time (Lemmer et al., 2018). So, their structure with respect to grade level might provide insights for the educators. For example, the idea that "magnets could attract all metals" was identified among preschoolers and elementary graders (Smolleck & Hershberger, 2011), middle graders (Yuksel, 2011), university students (Ince & Yilmaz, 2012) as well as science teachers (Burgoon et al., 2011). So, it might be required to investigate the conceptions of the students with a cross sectional survey.

The Aim and Significance of the Study

Depending on the reasons mentioned above, this study targets to investigate different grade level students' agreement rate on non-scientific ideas concerning the concept of magnet. Thus, it is aimed to determine the mental models of the students to explain their responses.

Magnetism is one of the physics topics which has a wide range of content and it involves different sub-topics such as the production of magnetic field, magnetic induction and electromagnetic radiation (Guisasola, Almudi, & Zubimendi, 2004). This situation is thought to make it difficult to conduct a cross-sectional survey on magnetism. In the literature, there are limited number of studies dealing with magnetism considering students' ideas from elementary level to university level. Therefore, the study is believed to carry significance in terms of carrying a cross-sectional approach. Also, the study tries to investigate whether students' agreements on non-scientific ideas change in time by determining their tendencies. Thus, it is intended to make contribution to the research concerning misconceptions about magnetism with a different perspective. Therefore, the study is expected to provide beneficial results in terms of developing activities and materials to improve students' conceptual understandings.

The research questions are as follows:

1) What are the agreement rates of elementary school, middle school, high school and university students on non-scientific opinions concerning the concept of magnet?

2) Is there a significant relationship between the educational level and non-scientific opinions of the students concerning the concept of magnet?

Methods

Research Design

The study was conducted with a cross-sectional survey model which was one of the general survey models. Cross-sectional surveys are utilized when the study sample is larger and involves groups with different characteristics (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz & Demirel, 2010). In such cases, this model allows the researchers to measure the variables at a single time and to determine whether the variables show differentiation with respect to other variables. In the present study, the size of the sample is large enough to include students in different educational levels. In the study, addressed non-scientific ideas were measured through a concept test at a single time with the application of it to each student group. Afterwards, it was tried to figure out whether agreements on each non-scientific idea showed a statistically significant differentiation with respect to educational level.

The Study Group

A total of 436 students from four different educational levels (elementary school, middle school, high school and university) were included in the study. All of the students were studying their final year at the governmental schools in the west part of Turkey in the fall term of the 2019-2020 academic year. One-hundred and thirteen (25.9%) of the participants were fourth graders, 110 (25.2%) of them were eight graders, and 105 (24.1%) of them were twelfth graders. Besides, 108 (24.8%) of them were fourth year science teaching and fifth year physics teaching students.

The study group was formed via stratified sampling model. This approach intends to make descriptions and comparisons when the study group involves definite sub-groups (Büyüköztürk et al., 2010). As mentioned above, the present study group includes students attending their final years in different educational levels. The reason of the participation of final year students in the study was to determine the reflection of their educational status on their responses. Thus, it was tried to figure out the appearance of their non-scientific ideas.

Data Collection Tool

Data were collected with the help of a concept test. The data collection tool was developed by the researchers as a result of the analysis of the literature (Bar et al., 1997; Bar & Zinn, 1998; Barrow, 2000; Burgoon et al., 2011; Çoramık, 2012; Gülçiçek, 2004; Güneş, 2017; Hickey & Schibeci, 1999; Ince & Yilmaz, 2012; Karabacak, 2014; Okulu & Oğuz Ünver, 2018; Preston, 2016; Smolleck & Hershberger, 2011; Tanel & Erol, 2005). Firstly, a pilot test was developed. The test involved statements which indicated misconceptions identified in the literature. Also, several statements which reflected non-scientific concepts based on the learning objectives related to magnetism were included in test (MEB, 2018a; 2018b). The students were asked whether they agreed or disagreed with each statement in the test. Thus, it was intended to provide the distribution of their non-scientific ideas for each educational level.

The literature includes several surveys which examine the misconceptions of students on different subjects by utilizing agreement-disagreement items (Özgür, 2013; Sak, 2011). After developing the items, the test was presented to three field experts' opinion in order to check its content validity. Next, it was applied to 35 students from each educational level in a pilot application. Thus, the final version of the test which consisted of 19 items was obtained. Table 2 shows the details of the concept test.

Table 2

The Items in the Concept Test

Themes	Item No.	Conceptions
Interaction between a magnet and a material	1	Magnets attract all materials.
	12	Magnets attract all metals.
	16	Magnets only pull.
	17	Magnets push non-metals.
Magnetic materials	2	All magnets are natural.
	7	A material cannot gain magnetic characteristic later.
	8	All magnets are artificial.
Poles of magnets	3	N is the south pole of a magnet.
	4	There are magnets with single pole.
	9	S is the north pole of a magnet.
Interaction between poles of magnets	5	Opposite poles of magnets push each other.
	11	The same poles of magnets attract each other.
Cutting magnets	6	A magnet loses its magnetic property if it is divided into smaller parts.
	10	A magnet loses its poles if it is divided into smaller parts.
	13	If a magnet is separated in its center, new magnets have one pole.
The effect of magnetic force produced by a magnet	14	Magnets can attract materials at all distances.
	15	Bigger magnets are stronger than smaller magnets.
	18	A magnet has to touch a material in order to attract it.
	19	There has to be no material between a magnet and an object in order for a magnet to attract the object.

Table 2 introduces the items in the concept test structured under proper themes as shown by Lemmer et al. (2018). Most of the items (items 1, 4, 5, 6, 7, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19) indicate popular misconceptions from the literature. Also, four items (items 2, 3, 8 and 9) were based on the learning objectives in science and physics program. The concept test is presented in the Appendix.

Data Analysis

Data analysis was conducted with the help of quantitative approaches. Firstly, the responses of the participants were examined. The responses which indicated agreement for each item were scored with "0". Such responses asserted non-scientific concepts of the students. On the other hand, the disagreements were scored with "1". Those responses indicated scientific concepts. The scores of the participants were transferred to computer and analyzed by using IBM SPSS 21. The Cronbach's Alpha coefficient was calculated to be 0.714. This value indicated the reliability of data analysis since it was higher than 0.70 (Çepni, 2018).

After conducting reliability analysis, the frequency and percentage distributions were provided for the responses to each item in the test. Also, Chi Square tests were performed to compare their responses with respect to educational levels. Chi Square tests are one of non-parametric tests which make comparisons among the groups when the dependent variable is in nominal scale (McHugh, 2013). As in the present study (when the number of cells is more than 2x2), it is important to consider that no cells (0%) should have expected count less than 5 while using this test (Chan, 2003). Thus, the validity of data analysis was provided by considering this rule for each item. However, the first item in the test was observed not to fit this rule. At this point, it is specified to use Fisher's Exact test (Chan, 2003). So, p value determined for Fisher's Exact test was considered as a result of the analysis of the first item. On the other hand, p values determined for Pearson's Chi Square test were presented as a result of the analysis of the other items in the test. The p values which indicated a significant differentiation with respect to educational level were marked with * in the findings.

In the final stage of data analysis, mental models of the students were presented. In this process, the distribution of non-scientific conceptions of the students for each item was examined in a detailed way. The items which displayed a similar tendency were collected together. As a result, the students' responses were found to demonstrate in five different tendencies and they were presented with five different models. While developing the models, the average of the percentages of students' agreements was calculated for the items in the model at each educational level. Thus, the tendencies of their non-scientific conceptions were depicted in line graphs to demonstrate the transition from one educational level to another.

Findings

Table 3 introduces the frequency and percentages of agreements (A) and disagreements (DA) of the participants for each item in the test in addition to Chi Square test results.

Table 3

The Results of the Analysis of the Concept Test

Item No	n (%)								χ^2	p
	Elementary S.		Middle S.		High S.		University			
	DA	A	DA	A	DA	A	DA	A		
1	111 (98.2)	2 (1.8)	106 (96.4)	4 (3.6)	104 (99.0)	1 (1.0)	107 (99.1)	1 (0.9)	2.934[a]	.474
2	106 (93.8)	7 (6.2)	94 (85.5)	16 (14.5)	100 (95.2)	5 (4.8)	107 (99.1)	1 (0.9)	17.384[b]	.001*
3	58 (51.3)	55 (48.7)	57 (51.8)	53 (48.2)	55 (52.4)	50 (47.6)	91 (84.3)	17 (15.7)	35.588[b]	.0001*
4	68 (60.2)	45 (39.8)	54 (49.1)	56 (50.9)	75 (71.4)	30 (28.6)	87 (80.6)	21 (19.4)	26.833[b]	.0001*
5	88 (77.9)	25 (22.1)	81 (73.6)	29 (26.4)	86 (81.9)	19 (18.1)	107 (99.1)	1 (0.9)	28.840[b]	.0001*
6	104 (92.0)	9 (8.0)	101 (91.8)	9 (8.2)	97 (92.4)	8 (7.6)	102 (94.4)	6 (5.6)	0.697[b]	.874
7	51 (45.1)	62 (54.9)	55 (50.0)	55 (50.0)	64 (61.0)	41 (39.0)	95 (88.0)	13 (12.0)	50.447[b]	.0001*
8	95 (84.1)	18 (15.9)	85 (77.3)	25 (22.7)	87 (82.9)	18 (17.1)	107 (99.1)	1 (0.9)	23.180[b]	.0001*
9	56 (49.6)	57 (50.4)	43 (39.1)	67 (60.9)	52 (49.5)	53 (50.5)	94 (87.0)	14 (13.0)	58.727[b]	.0001*
10	97 (85.8)	16 (14.2)	90 (81.8)	20 (18.2)	88 (83.8)	17 (16.2)	104 (96.3)	4 (3.7)	11.884[b]	.008*
11	92 (81.4)	21 (18.6)	76 (69.1)	34 (30.9)	88 (83.8)	17 (16.2)	106 (98.1)	2 (1.9)	32.938[b]	.0001*
12	62 (54.9)	51 (45.1)	60 (54.5)	50 (45.5)	57 (54.3)	48 (45.7)	78 (72.2)	30 (27.8)	10.465[b]	.015*
13	64 (56.6)	49 (43.4)	71 (64.5)	39 (35.5)	75 (71.4)	30 (28.6)	101 (93.5)	7 (6.5)	40.406[b]	.0001*
14	95 (84.1)	18 (15.9)	102 (92.7)	8 (7.3)	98 (93.3)	7 (6.7)	107 (99.1)	1 (0.9)	17.714[b]	.001*
15	16 (14.2)	97 (85.8)	38 (34.5)	72 (65.5)	36 (34.3)	69 (65.7)	54 (50.0)	54 (50.0)	32.442[b]	.0001*
16	88 (77.9)	25 (22.1)	87 (79.1)	23 (20.9)	91 (86.7)	14 (13.3)	106 (98.1)	2 (1.9)	22.750[b]	.0001*

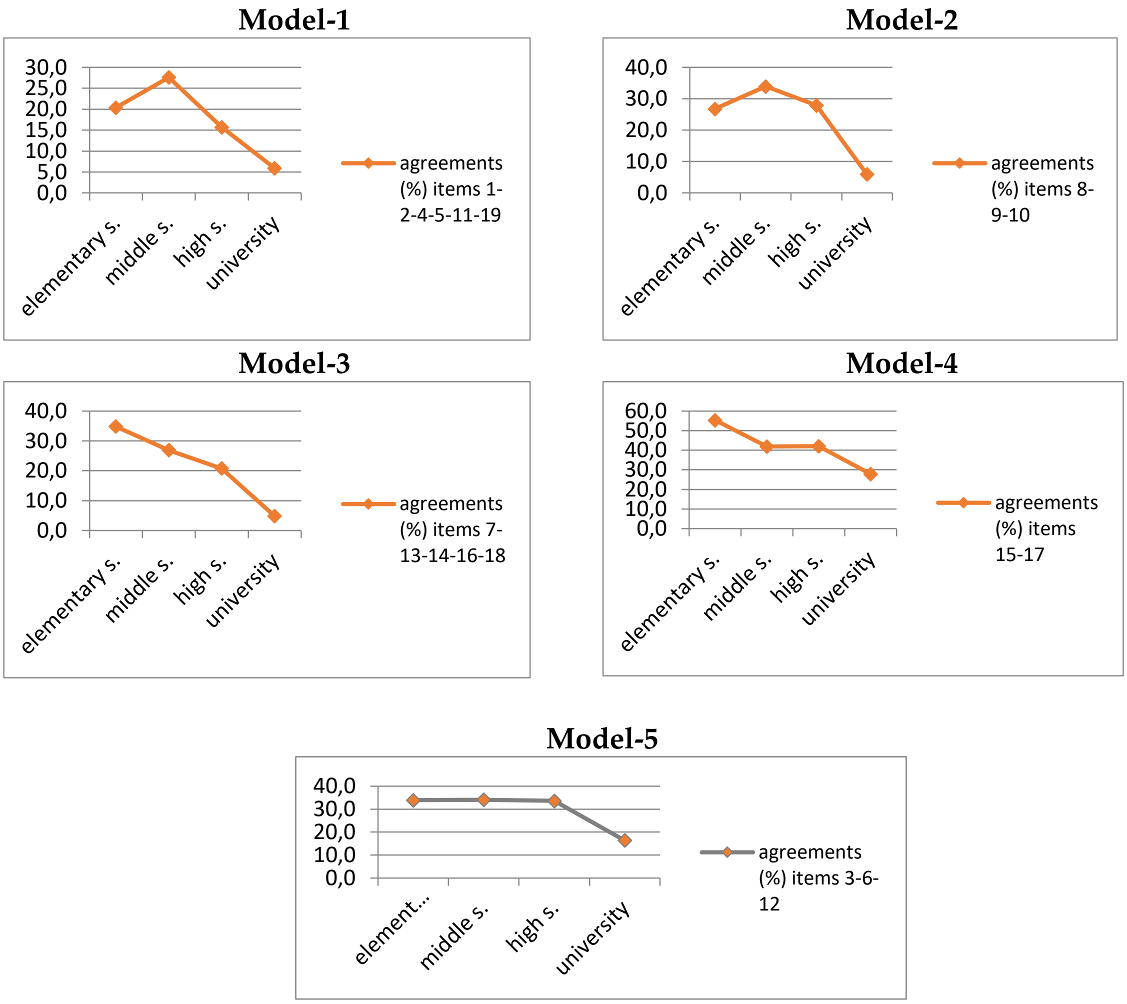
17	85 (75.2)	28 (24.8)	90 (81.8)	20 (18.2)	86 (81.9)	19 (18.1)	102 (94.4)	6 (5.6)	15.232 [b]	.002*
18	48 (42.5)	65 (57.5)	87 (79.1)	23 (20.9)	88 (83.8)	17 (16.2)	105 (97.2)	3 (2.8)	98.106 [b]	.0001*
19	75 (66.4)	38 (33.6)	67 (60.9)	43 (39.1)	78 (74.3)	27 (25.7)	95 (88.0)	13 (12.0)	22.519 [b]	.0001*

*Note. a 4 cells (50.0%) have expected count less than 5.; b 0 cells (0%) have expected count less than 5.; * Differentiation is significant at p=.05.*

According to Table 3, Chi Square test analysis indicates statistically significant results for all the items except the first and sixth items in the test. In another words, there is a significant relationship between students' responses and their educational level for most of the items in the test. Also, Table 3 implies the tendencies of students' conceptual structure from item to item. As a result of the analyses, five models were constructed to explain the mental structure of the students concerning their responses. Figure 1 depicts those models.

Figure 1

Mental Models of The Students According to The Trends of Their Responses



Model 1 explains students' mental structures related to their agreements for the items 1, 2, 4, 5, 11 and 19. According to this model, students' agreements make an increase while passing from elementary to middle school. On the other hand, they show a decrease while passing from middle to high school. In high school level, the proportion of their agreements is seen to stay below the elementary level. Similarly, they show a decrease while passing from high school to university.

Model 2 considers the tendency of their agreements for the items 8, 9 and 10. In this model, agreements of the students also make an increase from elementary to middle school. Afterwards, they show a decrease while passing from middle to high school level. The proportion of their agreements in high school level stays close to the elementary level. In the university level, they decrease again and get the lowest percentage.

Model 3 considers the distribution of students' agreements concerning the items 7, 13, 14, 16 and 18. This model explains that students' agreements show a decreasing trend with increasing educational level.

Model 4 displays the tendency for the items 15 and 17. In this model, students' agreements display a decrease while passing from elementary to middle school and they take the same value in high school as in the middle school level. Afterwards, students' agreements show a decrease as they pass from high school to university and take their lowest value.

The final model, model 5 considers the items 3, 6 and 12. According to this model, students' agreements stay in the same value during elementary, middle and high school years. However, there is a decrease in students' such ideas with their transition to the university.

Discussion and Conclusions

The general results obtained from the study showed that the students from all educational levels agreed with non-scientific ideas concerning the concept of magnet. Most of those non-scientific ideas were prevalent misconceptions in line with the studies concluding misconceptions determined at different grade levels (Ince & Yilmaz, 2012; Lemmer et al., 2018; Okulu & Oğuz Ünver, 2018; Preston, 2016; Yuksel, 2011). Also, there was a significant relationship between students' responses and their grade levels for all the items except the first and sixth item. This finding highlighted the importance of concept teaching concerning the subject of magnetism.

When the responses of the students were examined, it was seen that students' agreements on non-scientific ideas took their least value in the university level. This finding showed parallelism with the research which reported more correct responses from teacher candidates as a result of the given instruction (Ince & Yilmaz, 2012; Okulu & Oğuz Ünver, 2018). Teacher candidates become experts in their field with the help of the university education. So, the reflection of this situation on their academic performance might produce such a positive consequence.

The results also indicated that students showed much more agreements on several conceptions. Items 3 and 9 were among five items which reached the highest percentages among university students. Those items considered the use of letters, N and S to indicate the poles of a magnet. Despite the fact that children could recognize the existence of two poles of a magnet from an early age (Kalogiannakis et al., 2018), the university students seemed to fail at this respect. Their failure to determine the meanings of N and S correctly might stem from the fact that it required memorization rather than inquiry. In his study, Çoramık (2012) also determined that university failed to know the meanings of N and S. Likewise; Tanrıverdi (2001) showed the existence of this conception among high school students.

The item which was determined to reach the highest agreement among all educational levels was item 15. It described a misconception about the relationship between the size of a magnet and its magnetic field strength. This view was also common among high school students (Lemmer et al., 2018) as well as the elementary school teachers (Burgoon et al., 2011). In the present study, it might be indicated that elementary level students had a belief as "the bigger, the stronger". Similarly, in another study, preschoolers believed that there were "imaginary elements" which were responsible for the attraction of the magnets (Kalogiannakis et al., 2018). In addition, absence of those concepts in middle school science program (MEB, 2018a) and no conduction of experiments in high school level to remove this concept might be stated as the causes of this response in such a high percentage. Besides, this response was common among the university students (50%). Presentation of theoretical knowledge during the courses without relevant applications in laboratory practices might explain this situation. This result was supported by the study findings of Yener, Köklü, Yamaç and Yalçın (2020). The researchers reported that the subjects held in the laboratories were mostly about electricity and heat-temperature in the scope of physics. On the other hand, magnetism was not determined to be a subject addressed in the laboratory at this respect. So, conduction of experiments and proper learning activities with different size magnets at all grade levels to observe magnetic field's strength is expected to be beneficial at this respect.

Items 4 and 13 were related to each other and they were also found to be among the items which got relatively a high percentage of agreements from the participants. Item 13 described the existence of single pole magnets. The decreasing trend of this concept with increasing educational level was an expected result. Explanations at this respect are given almost at all educational levels and the poles of a magnet are demonstrated with figures in textbooks (Barrow, 2000). When the results obtained from item 4 were considered, it was realized that a relatively high percentage of agreements were obtained from university students (19.4%). This is also in line with the literature (Okulu & Oğuz Ünver, 2018). The researchers underlined the conduction of proper learning activities during courses and utilization of scientific inquiry for the elimination of those misconceptions.

In item 12, it was stated that all metals were attracted by the magnets. The research showed that teacher candidates (Ince & Yilmaz, 2012) and teachers (Burgoon et al., 2011; Hekkenberg, Lemmer, & Dekkers, 2015) also believed that all metals were attracted by the magnets as well as the students (Lemmer et al., 2018; Yuksel, 2011). The present study indicated about half of the elementary, middle and high school students agreed on this misconception in addition to nearly one quarter of the university students. The reason of obtaining this misconception in such a high percentage among the students might be due to the insufficiency of the students related to the properties of the metals. It might be stated that high school chemistry program has a superficial approach concerning magnetic properties of the metals (MEB, 2018c). Besides, overgeneralization of elementary and middle school students might be effective at this point. They might attribute the characteristics of iron to all metals. The literature showed that students aged 3-8 indicated metals such as silver (Smolleck & Hershberger, 2011), copper and gold (Christidou et al., 2009) could be attracted by magnets. Classroom activities where students deal with different kind of metals' interaction with a magnet are expected to be useful.

Another result of the study was the introduction of mental models of the participants related to their responses. From those models, model 3 depicted that students' agreements had a decreasing trend with increasing education level. This was an expected outcome which might mean that students' conceptual structures developed as a result of education that they received. Model 4 also included a decreasing trend however students' agreements were steady at middle and high school levels. Besides, such conceptions of them were also seen to stay steady in elementary, middle and high school levels in model 5. Those outcomes supported the fact that misconceptions had a resistance towards change despite the changing educational level (Özgür, 2013). However, it can be concluded that university education is effective in terms of breaking this resistance as can be understood from declining percentages in the study.

Model 5 which considered three items depicted that students' agreements stayed in the same percentages in elementary, middle and high school level. In this model, a significant differentiation was determined in the distributions of students' responses for two items (items 3 and 12). On the other hand, no significant relationship was determined between students' responses and their educational level for the item 6. Item 6 yielded percentages of responses which were close to each other at all levels. This might stem from the fact that almost all textbooks visualize the separation of a magnet at its center into two parts to produce two new magnets (Barrow, 2000). On the other hand, the significant differentiation for the items 3 and 12 might be due to the sharp decline in the agreements of the students in university level due to the objective in their subject matter knowledge as mentioned in the earlier researches (Ince & Yilmaz, 2012; Okulu & Oğuz Ünver, 2018).

The first two models in the study depicted an increase in students' agreements when passing from elementary to middle school. This finding was obtained from almost half of the items. It is thought that science teaching program is effectual at this point. Students learn magnetism in the fourth grade of elementary level. On the other hand, it was remarkable that this subject did not take place in the program of middle school (MEB, 2018a). So, this situation might cause this negative reflection as on the study findings.

According to the study, it is clear that all models display a common decline in students' agreements with their transition to the high school except model 4 and 5. This was an expected outcome as it showed parallelism with their cognitive development. However, when the percentages of their agreements in high school level were compared to the elementary level, two cases were seen to emerge: (i) A lower percentage of misconceptions (Models 1, 3 and 4). (ii) Almost the same percentage of misconceptions as in the elementary school (Models 2 and 5). The first outcome was expected and parallel to students' cognitive development. The second outcome also supported the resistant characteristic of misconceptions (Özgür, 2013).

Items 5 and 11 in model 1 considered the interaction between the poles of magnets. Gathering both items under the same model can be an indication of students' association of the concepts of magnets' pull and push generally as a single case in their minds. It was determined that appropriate activities were conducted for teaching magnetism to the students at elementary level (Karadaş, Yaşar & Kırbaşlar, 2012). In addition, it was reported that the use of science diagrams was beneficial at this point (Preston, 2016). However, the absence of those subjects and activities in the middle school science program (MEB, 2018a) might explain the reason of the increase in their non-scientific responses from elementary to middle school level. In high school level, it could be stated that there was a decline in their agreements as they learnt the subject in the tenth grade. In the university level, such responses were determined to be 1-2% since they experienced the interaction of the poles of magnets with each other in a detailed manner.

Item 19 was another item under model 1 and stated that there had to be no matter between the magnet and the object in order for the magnet to attract that object. Likewise; in another study it was indicated that the percentages of scientific responses of the second- and third-year university students were higher than their non-scientific responses at this respect (Güler & Şahin, 2017). This finding is in line with the present study. However, the percentage of non-scientific responses in Güler and Şahin's (2017) study were determined to be higher than the non-scientific responses in the present study. This outcome also supported the decreasing trend of the misconceptions with increasing grade level.

Items 14 and 18 in model 3 referred to the distance required for a magnet to be attractive on the objects. The collection of both items under the same model might be due to the fact that they were related to each other. In this model, students' agreements demonstrated a decrease as their educational levels increased. In item 16 of model 3, it was stated that magnets only pulled. The research showed similar misconceptions also among high schoolers (Lemmer et al., 2018).

Items 6 and 10 considered the magnetic characteristics of new magnets which were obtained due to cutting a bigger magnet into smaller parts. The findings obtained from those items showed that they took place under separate models. Item 10 was determined to get higher agreements than item 6 in elementary, middle and high school levels. This outcome might stem from the fact that the concept of "magnetism" in item 6 might be easier for the students than the concept of "pole" in item 10. In their studies, Çoramık (2012) and Yuksel (2011) also determined that students could explain the poles of a magnet which was divided into two parts by using different models. The poles of a magnet cannot be observed with naked eye. However, the magnetic characteristics of them can be experienced easily in the form of pull and push when they interacted with proper objects.

Limitations and Recommendations

In this study, the mental structures of the students were determined with the help of various statements with which students were asked to agree or disagree. The students were not asked to explain their reasons for their responses. Also, no interviews were conducted with them due to the relatively large sample size and limited data collection period as it was close to the end of the term. This point might be asserted a limitation of the study. However, the study gave beneficial data with the help of a cross sectional survey which was expected to provide insights for the researchers. In the future studies, this limitation can be eliminated by asking explanations from the students to reduce the risk of chance on their agreements.

In the literature, it is seen that preschoolers' views were also analyzed at this respect. It was not possible to include preschool children in the present study since written responses were collected from the participants. However, conducting interviews with preschoolers as well as collecting drawings concerning the studied concepts might make it possible to make comparisons among different educational levels in a study which involves qualitative approaches also.

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References

Bar, V., & Zinn, B. (1998). Similar frameworks of action-at-a-distance: Early scientists' and pupils' ideas. *Science and Education*, *7*, 471-498.

Bar, V., Zinn, B., & Rubin, E. (1997). Children's ideas about action at a distance. *International Journal of Science Education*, *19*(10), 1137-1157. Doi: 10.1080/0950069970191003

Barrow, L. H. (2000). Do elementary science methods textbooks facilitate the understanding of magnet concepts? *Journal of Science Education and Technology*, *9*(3), 199-205.

Binnie, A. (2001). Using the history of electricity and magnetism to enhance teaching. *Science & Education*, *10*, 379–389.

Burgoon, J. N., Heddle, M. L., & Duran, E. (2011). Re-examining the similarities between teacher and student conceptions about physical science. *Journal of Science Teacher Education*, *22*(2), 101-114. Doi: 10.1007/s10972-010-9196-x

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2010). *Bilimsel araştırma yöntemleri [Scientific research methods]*. Ankara: Pegem Akademi Yayınları.

Chan, Y.H. (2003). Biostatistics 103: Qualitative data – tests of independence. *Singapore Medical Journal*, *44*(10), 498-503.

Christidou, V., Kazela, K., Kakana, D., & Valakosta, M. (2009). Teaching magnetic attraction to preschool children: a comparison of different approaches. *International Journal of Learning*, *16*, 115- 128.

Çavuş Erdem, Z., & Gürbüz, R. (2017). Öğrencilerin hata ve kavram yanılgıları üzerine bir inceleme: Denklem örneği [An analysis on students' mistakes and misconceptions: The case of equations]. *YYÜ Eğitim Fakültesi Dergisi (YYU Journal of Education Faculty)*, *XIV*(I), 640-670.

Çepni, S. (2018). *Araştırma ve proje çalışmalarına giriş [Introduction to research and project studies].* Trabzon: Pegem Akademi Yayınları.

Çepni, S., & Keleş, E. (2006). Turkish students' conceptions about the simple electric circuits. *International Journal of Science and Mathematics Education*, *4*(2), 269–291. https://doi.org/10.1007/s10763-005-9001-z

Çolak, A. (2014). *Ortaöğretim 11. sınıf elektromanyetizma ünitesinde 7e modelinin öğrencilerin kavramsal başarılarına etkisi [The effect of 7e model on 11th grade high school students' conceptual understanding in the unit of electromagnetism)]* [Unpublished doctoral dissertation]. Atatürk University, Erzurum.

Çoramık, M. (2012). *Manyetizma ünitesinin bilgisayar ve deney destekli etkinlikler ile öğretiminin 11. sınıf öğrencilerinin özyeterlilik ve üstbilişlerine, tutumlarına, güdülenmelerine ve kavramsal anlamalarına etkisi [The effect of teachıng magnetism unit with computer aided and experiment-aided activities on 11th grade students' self-efficacy, metacognition, attitude, motivation and conceptual understanding]* [Unpublished master's thesis]. Balıkesir University, Balıkesir.

Guisasola, J., Almudi, J. M., & Zubimendi, J. I. (2004). Difficulties in learning the introductory magnetic field theory in the first years of university. *Wiley Periodicals, Inc. Sci Ed*, *88*, 443– 464.

Gülçiçek, N. (2004). *Kavramsal değişim metinlerinin öğrencilerin manyetizma konusunu anlamalarına ve fizik tutumlarına etkisi [The effect of conceptual change texts on students' understanding on magnetism subject and attitudes towards physics]* [Unpublished master's thesis]. Gazi University, Ankara.

Güler, B., & Şahin, M. (2017). Fen bilgisi öğretmen adaylarının "elektrik ve manyetizma" konusundaki kavramsal anlamalarının incelenmesi [Investigation of science teacher candidates' conceptual understanding on "electricity and magnetism"]. *The Journal of Buca Faculty of Education*, *44*, 179-193.

Güneş, B. (Ed.) (2017). *Doğru bilinen yanlışlardan, yanlış bilinen doğrulara: Fizikte kavram yanılgıları [From correct known incorrects to incorrect known corrects].* Ankara: Palme Yayıncılık.

Hekkenberg, A., Lemmer, M., & Dekkers, P. (2015). An analysis of teachers' concept confusion concerning electric and magnetic fields. *African Journal of Research in Mathematics, Science and Technology Education*, *19*(1), 34-44. Doi: 10.1080/10288457.2015.1004833

Heyl, P. R. (1941). Magnetism and its uses. *Proceedings of the American Philosophical Society*, *84*(2), 339-351. Retrieved December 10, 2020 from http://www.jstor.org/stable/984927.

Hickey, R., & Schibeci, R. A. (1999). The attraction of magnetism. *Physics Education, 34*(6), 383-388.

Ince, E., & Yilmaz, O. (2012). The usage of alternative assessment techniques in determination of misconceptions about electromagnetic field-magnetism contents and effects of video-based experiments on pre-services' achievement. *Procedia - Social and Behavioral Sciences, 55*, 206–211.

Kalogiannakis, M., Nirgianaki, G.-M., & Papadakis, S. (2018). Teaching magnetism to preschool children: The effectiveness of picture story reading. *Early Childhood Education Journal, 46*, 535–546. Doi: 10.1007/s10643-017-0884-4

Kaniawati, I., Fratiwi, N. J., Danawan, A., Suyana, I., Samsudin, A., & Suhendi, E. (2019). Analyzing students' misconceptions about Newton's laws through Four-Tier Newtonian Test (FTNT). *Journal of Turkish Science Education, 16*(1), 110-122. Doi: 10.12973/tused.10269a

Karabacak, Ü. (2014). *Özdüzenleme ve ilköğretim ikinci kademe öğrencilerinin fen başarısının incelenmesi [Examination of self-regulation and science achievements of the 2nd levels of primary school students]* [Unpublished master's thesis]. Balıkesir University, Balıkesir.

Karadaş, A., Yaşar, I. Z., & Kırbaşlar, F. G. (2012). 4. ve 5. sınıf fen ve teknoloji kitaplarında "madde ve değişim" öğrenme alanı etkinliklerinin incelenmesi [An examination to activities on learning domain of "matter and change" in the 4th and 5th grade science and technology textbooks]. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, 6*(1), 94-123.

Kartal Taşoğlu, A., & Bakaç, M. (2014). The effect of problem based learning approach on conceptual understanding in teaching of magnetism topics. *Eurasian Journal of Physics & Chemistry Education*, *6*(2), 110-122.

Kınık Topalsan, A., & Bayram, H. (2019). Identifying prospective primary school teachers' ontologically categorized misconceptions on the topic of "force and motion". *Journal of Turkish Science Education, 16*(1), 85-109. Doi: 10.12973/tused.10268a

Kokkonen, T. (2017). *Concepts and concept learning in physics, the systemic view*. Report Series in Physics, HU-P-D256. University of Helsinki, Helsinki, Finland.

Koponen, I. T., & Huttunen, L. (2013). Concept development in learning physics: the case of electric current and voltage revisited. *Science & Education, 22*(9), 2227–2254. Doi: 10.1007/s11191-012-9508-y

Lemmer, M., Kriek, J., & Erasmus, B. (2018). Analysis of students' conceptions of basic magnetism from a complex systems perspective. *Research in Science Education*, https://doi.org/10.1007/s11165-018-9693-z

McHugh, M. L. (2013). The Chi-square test of independence. *Biochemia Medica, 23*(2), 143–149. Doi: 10.11613/BM.2013.018

MEB. (2018a). Fen bilimleri dersi öğretim programı (İlkokul ve ortaokul 3, 4, 5, 6, 7 ve 8. sınıflar) [Science course teaching program (Primary and middle school grades 3, 4, 5, 6, 7 and 8)]. Ankara.

MEB. (2018b). Ortaöğretim fizik dersi öğretim programı (9, 10, 11 ve 12. sınıflar) [Secondary level physics course teaching program (Grades 9, 10, 11 and 12)]. Ankara.

MEB. (2018c). Ortaöğretim kimya dersi öğretim programı (9, 10, 11 ve 12. sınıflar) [Secondary level chemistry course teaching program (Grades 9, 10, 11 and 12)]. Ankara.

Okulu, H. Z., & Oğuz Ünver, A. (2018). The process of facilitating knowledge acquisition and retention: An inquiry into magnetic poles with challenging questions. *International Education Studies, 11*(5), 25-37.

Özdemir, E., & Çoramık, M. (2018). Reasons of student difficulties with right-hand rules in electromagnetism. *Journal of Baltic Science Education*, *17*(2), 320-330.

Özgür, S. (2013). The persistence of misconceptions about the human blood circulatory system among students in different grade levels. *International Journal of Environmental & Science Education, 8* (2), 255-268. Doi: 10.12973/ijese.2013.206a

Preston, C. (2016). Effect of a science diagram on primary students' understanding about magnets. *Research in Science Education*, *46*, 857–877. Doi: 10.1007/s11165-015-9484-8

Sak, U. (2011). Prevalence of misconceptions, dogmas, and popular views about giftedness and intelligence: a case from Turkey, *High Ability Studies, 22*(2), 179-197. Doi: 10.1080/13598139.2011.622942

Scaife, T. M., & Heckler, A. F. (2011). Interference between electric and magnetic concepts in introductory physics. *Physical Review Special Topics - Physics Education Research, 7*, 1-11. Doi: 10.1103/PhysRevSTPER.7.010104

Serway, R. A., & Beichner, R. J. (2002). *Fen ve mühendislik için fizik 1 [Physics for scientists and engineers]* (Trans. Ed. K. Çolakoğlu). Ankara: Palme Yayıncılık.

Smolleck, L., & Hershberger, V. (2011). Playing with science: An investigation of young children's science conceptions and misconceptions. *Current Issues in Education, 14*(1), 1-32.

Tanel, Z., & Erol, M. (2005). *Lisans düzeyindeki öğrencilerin manyetik alan şiddeti, manyetik akı yoğunluğu ve manyetizasyon kavramlarına yönelik yanılgıları [Misconceptions of undergraduate students on the magnitude of magnetic field, magnetic flux density and magnetisation].* Türk Fizik Derneği 23. Uluslararası Fizik Kongresi (September 13-16, 2005). Muğla: Muğla Üniversitesi.

Tanrıverdi, İ. (2001). *Elektrik ve manyetizmada kavram yanılgıları [Misconceptions in electricity and magnetism]* [Unpublished master's thesis]. Süleyman Demirel University, Isparta.

Yener, D., Köklü, N., Yamaç, R. Z., & Yalçın, S. (2020). Analysis of the studies done on laboratories in Turkey. *Journal of Turkish Science Education, 17*(2), 162-179. Doi: 10.36681/tused.2020.19

Yuksel, T. (2011). *Turkish eighth grade students' mental model representations about the nature of magnets and magnetic interactions* [Unpublished master's thesis]. Purdue University, USA.

Appendix
The Concept Test

Items	Conceptions	Agree	Disagree
1	Magnets attract all materials.		
2	All magnets are natural.		
3	N is the south pole of a magnet.		
4	There are magnets with single pole.		
5	Opposite poles of magnets push each other.		
6	A magnet loses its magnetic property if it is divided into smaller parts.		
7	A material cannot gain magnetic characteristic later.		
8	All magnets are artificial.		
9	S is the north pole of a magnet.		
10	A magnet loses its poles if it is divided into smaller parts.		
11	The same poles of magnets attract each other.		
12	Magnets attract all metals.		
13	If a magnet is separated in its center, new magnets have one pole.		
14	Magnets can attract materials at all distances.		
15	Bigger magnets are stronger than smaller magnets.		
16	Magnets only pull.		
17	Magnets push non-metals.		
18	A magnet has to touch a material in order to attract it.		
19	There has to be no material between a magnet and an object in order for a magnet to attract the object.		