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Exploring the Disciplined Mind in Middle School Science Course *

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Abstract

The purpose of this study was to investigate to what extent middle school students exhibit the disciplined mind traits at science courses and gaining insights about the quality and the quantity of the classroom practices related to the disciplined mind. To this end, the study employed the disciplined mind scale (α=0,89) and the rubric for disciplined mind performance tasks (G=0,85), the teaching and learning environment assessment scale (α=0,93), and classroom observation notes. This study was carried out with 31 sixth-graders and 30 eighth-graders in a school located in the central districts of Ankara of Turkey. Results indicated that there was not any significant difference between sixth and eighth-graders in terms of exhibiting the disciplined mind traits and science courses they took in terms of cultivating a disciplined mind. Additionally, the qualitative data revealed that students' disciplined mind traits they showed were inadequate, and the classroom practices to promote the students' disciplined mind development were insufficient. This study will contribute to future research in terms of deep understanding of the disciplined mind theory and its practice.

Keywords: five minds, disciplined mind, science course, middle school

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Introduction

It is important to set up meaningful ties between pieces of knowledge, suggest original products, and act by considering universal values while adapting to the changing world instead of improving oneself only in one field. Thus, it is important to help individuals gain the skills related to five minds. Howard Gardner, who has been researching psychology for years, describes these five minds as follows (Gardner, 2006): Firstly, the disciplined mind masters the ways of thinking within one or more disciplines. It is aware of the necessity to keep working to improve its skills. Secondly, the synthesizing mind integrates ideas from different sources into a meaningful whole for them by using objective criteria. Thirdly, the creative mind keeps up with the changes, produces new ideas, poses further questions, and develops new thinking ways. Next, the respectful mind has an awareness of and appreciation for differences among individuals and groups and seeks to understand and cooperate with others. Lastly, the ethical mind thinks over society's needs and demands and serves the purposes beyond personal interests. Among these minds, it is crucial to develop a disciplined mind because it reinforces the growth of synthesizing and creative minds. The disciplined mind gains importance in the early years of primary education and develops exactly at puberty (Can Aran & Senemoğlu, 2014a; Gardner, 2006). Individuals should gain this domain of mind to become persons who contribute to the development of their country. The disciplined mind has two aspects, which are called cognitive and affective aspects. In the cognitive aspect, having a way of thinking is unique to the discipline.

In contrast, in the affective aspect, it forms the habits that enable an individual to progress continually to become professional at this discipline (Can Aran & Senemoğlu, 2014a). Although it is important to raise individuals with a disciplined mind, there is no thorough research on the disciplined mind features in the literature except that researchers of this paper did before. So, the researchers were required to group those features. Before researchers group the elements as themes, they observed middle school classrooms for a long time because Gardner (2006) gave examples from higher education. Gardner (2006) put forward the disciplined mind features and the heuristic themes by Can Aran and Senemoğlu (2014a), which are supported by related literature, are shown in Table 1.

Table 1. *A Representation of the Disciplined Mind Traits According to The Themes Put Forward by The Researchers*

	The Disciplined Mind Traits	Themes
1	- Forming a deep and informed opinion on the current affairs of the day, year, or centuries such as comments, new scientific inventions and technological improvements, and new environmental laws. - Learning in a meaningful context, not in bulk. - An understanding of the World.	Making Connections to the Real Life Experiences (Bruner, 2009; Dewey, 2010; Glasersfeld,1981)
2-	- Understanding and interpreting the texts rather than reciting them Making connections between information. - Getting to the heart of the topic. - Viewing information as a tool for more meaningful learning rather than learning it to pass the test. - Reaching a new and deeper understanding, acquiring new skills. - Explaining unfamiliar information within an already known concept or theory.	Learning in deep (Biggs J.B., 1987; Cherif et al.,2010; Entwistle,2000; Entwistle,2009; Light & Micari, 2013)
3-	- Mastering more than one discipline: Mastering ways of thinking peculiar to one discipline (history, mathematics, science, etc.) or more than one discipline (fields of science such as physics and psychology) (because it is not likely to master any subject with the perspective of only one discipline). Distinguishing each perspective unique to the disciplines while mastering more than one discipline and using them when appropriate. - Synthesizing information with an interdisciplinary perspective; using it in unfamiliar methods. - Taking responsibilities and duties to deserve to be a member of an occupational group and behaving accordingly (for, an individual is disciplined as long as he gets into the habits which enable him to master a skill, a job, or information). - Abandoning erroneous and unproductive ways of thinking and showing disciplined ways of thinking and behaving as a sign of professionalism.	Making interdisciplinary connections (Bybee, Powell & Trowbridge, 2008; Venville and Dawson, 2004)

Table 1 continued

	The Disciplined Mind Traits	Themes
4	- Reflecting on the world in a certain way (for instance, a scientist observes the world, put forward temporary classifications, concepts, and theories, carry out experiments to test his temporary theories, and revise his theories in the light of the findings. Then, they observe more, reorganize classifications, and get new information to conduct experiments). - Realizing that it is difficult to uncover the reasons of the incidents. - Distinguishing between a relationship (A and B change together) and causation (A leads to B). - Being objective, thinking like a scientist, avoiding simple and one-sided explanation. - Admitting that the only source of information is not the past, that information is not absolute, and that scientific methods and theories can change in time. Realizing that a new finding can disprove a scientific fact. - Knowing how to get to reliable sources	Thinking like a scientist (Abruscato , 2000; Bybee , Powell & Trowbridge , 2008; Bybee , 2006; Chiappetta & Koballa, 2006; Zimmerman , 2007)
5	- Enjoying the learning process about the world and turning it into a passion. - Dedicating oneself to his job, improving oneself continually, and keeping lifelong learning: Understanding that he should continue learning for his lifetime considering new data, information, and methods and adding further information to his already known information by researching a scientific subject. - Improving oneself continually to make a skill perfect. Studying in the discipline to improve his knowledge and skills (Exercising regularly or performing scientific experiments). - Wishing to get more information, learn more deeply, and show information to oneself and others when grasping a concept very well.	Being motivated to lead a disciplined life (Chiappetta & Koballa, 2006; Deboer, 2006; Enwistle, 2009) Being motivated to lead a disciplined life(Chiappetta & Koballa, 2006; Deboer, 2006; Enwistle, 2009

As Table 1 is examined, it can be seen that there are five different themes. While the first four of these themes are more related to the cognitive aspect of the disciplined mind, the last theme is closer to the affective aspect (Can Aran & Senemoğlu, 2014a). On examining the cognitive and affective aspects of a disciplined mind, it is found that individuals having

this mind type are those who have higher-order thinking and who have internal motivation. It is believed that developing this type of mind, especially in the field of science, will contribute to raising individuals who will bring their country to a further point in science and technology (Jorgenson, Cleveland & Vanosdall, 2004; Lewis & Kelly, 1987) because science is a course which reinforces students' sense of research and curiosity (Lewis & Kelly, 1987) and contributes to the development of scientific process skills such as making the observation, classification, recording data, forming hypotheses, using the data and creating models, changing variables and controlling them and doing experiments (Çepni, 2011; Jorgenson et al., 2004; MEB, 2018). Thus, it was examined at what level middle school students exhibit the disciplined mind features in a science course. It is thought that determining the features of students' disciplined minds will enable us to take earlier steps to develop this type of mind. Due to the lack of studies directly related to middle school students' disciplined mind level in a science course, the results of the studies in the literature conducted at the middle school level concerning the sub-dimensions of a disciplined mind are believed to contribute to the aim of defining the existing situation with the disciplined mind. When explanations such as "thinking like a scientist," one of the sub-dimensions of a disciplined mind, are examined, it is noteworthy that this dimension included the skills that are based on the science field, such as scientific process skills. Within this scope, research about middle school students' scientific process skills provided insight into the current situation related to the development of a disciplined mind. Research shows that scientific process skill levels of 6th and 7th graders are equal (Böyük, Tanık & Saraçoğlu, 2011), while 8th graders' level is higher than 7th graders' (Böyük et al., 2011; Meriç & Karatay, 2014). Different from these findings, a study investigating the scientific process skills of the 5th, 6th, 7th, and 8th graders showed that the 6th graders were better at scientific process skills than the students of other grade levels and the 5th and 8th graders, however, did well at the half of the scientific process skills specified (Bostan Sarioğlan, Gedik & Can, 2016). Another study demonstrated that the 7th and 8th graders had average level success in using scientific process skills. In addition to that, the study also found that the students were less good at higher-order scientific process skills (determining and controlling variables, forming hypotheses and testing them, interpreting the data, making operational definitions, organizing and performing an experiment, and creating a model) than at basic scientific process skills (making an observation, comparing-classifying, communicating scientifically, measuring, making estimations and inferences) (Meriç & Karatay, 2014). In support of these findings, Bostan et al. (2016) also concluded that middle school students frequently use

basic scientific process skills, making observations, and making estimations. Likely, another study results demonstrated that high achievers in 8th grades achieve the objectives of developed countries in the lower mental process more than the objectives of them in the higher cognitive process. Accordingly, it was found that students attained target behaviors at the knowledge level by 84.5% at the application level by 61.1%, and at the analysis level by 41.1% (Işık, 2014).

Also, it is important to reveal the affective aspect of the disciplined mind and its cognitive aspect. Motivation to learn is one of the sub-dimensions of the disciplined mind mentioned in Table 1, and it constitutes the affective aspect of the disciplined mind. Some of the research on middle school students' motivation demonstrates no statistically significant differences between students' motivation according to grade levels (Azizoğlu & Çetin, 2009; Uzun & Keleş, 2010). On the other hand, some research concludes that students' motivation to learn decreases as their grade level increases (Aydın, 2007; Deniş Çeliker, Tokcan & Korkubilmez, 2015; Güngören, 2009; Güvercin, 2008; İnel Ekici, Kaya & Mutlu, 2014; Karakaya, Avgın & Yılmaz, 2018; Seçkin Kapucu, 2018; Yavuz Göçer, Sungur & Tekkaya, 2011; Yenice, Saydam & Telli, 2012; Yıldırım & Kansız, 2018).

In addition to determining students' disciplined mind level, this study aims to reveal to what extent middle school science course cultivates the development of a disciplined mind because the teaching-learning environment is the key factor in developing a disciplined mind. Previous researches reported some problems in science education. Balbağ, Leblebicier, Karaer, Sarıkahya & Erkan (2016), analyzing the studies conducted in the period between 2010 and 2015, found that the major problem in science education was related to teachers and physical and environmental conditions. Science teachers included in the study conducted by Uluçınar, Cansaran, and Karaca (2004), also reported the impossibility of using labs in the real sense and effectively teaching their lessons due to factors such as inadequate lab conditions and crowded classrooms. In the study performed by Karaman and Karaman (2016), teachers also mentioned overcrowded classrooms and inadequate resources in labs as the most important obstacles to student-centered curriculum activities. We believe that considering the findings of previous studies in science education and the findings of this study will contribute to the improvement of science education. Therefore, this study aims to investigate the disciplined mind traits in the middle school science course. The research questions are formulated as follows: (i) To what extent do sixth and eighth graders exhibit the disciplined mind traits at science courses? (ii) To what extent

do the classroom practices in sixth and eighth grade support the development of a disciplined mind?

Method

In this research, a descriptive method was used to determine to what extent the disciplined mind traits are seen at the beginning and at the end of the middle school and to what extent the middle school science course cultivates a disciplined mind. Data was collected through qualitative and quantitative methods.

Participants

The study was carried out with 31 sixth-graders and 30 eighth-graders in a school located in the central districts of the capital city of Turkey in the 2014-2015 academic years. The research was conducted with middle school students because Gardner (2006) stated that the disciplined mind develops exactly at puberty. The study group was determined through criterion sampling (Gall, Walter & Gall, 1996). In order to identify and understand information-rich cases, the research was carried out in a school categorized as highly successful in terms of academic success in the national high school entrance exam. The research findings about five minds (e.g., Altındağ, 2015; Can Aran &Senemoğlu, 2014a) support the claim that students in highly successful schools supply more data to find out the development of a disciplined mind.

Data Collection Process[3]

The research data were collected with a disciplined mind scale (DMS), the disciplined mind performance task and rubric, the teaching and learning environment assessment scale (TLES), and observations. The development processes of data collection tools were explained in detail below.

Disciplined mind scale (DMS)

A disciplined mind scale developed by Can Aran and Senemoğlu (2014a) in a five-point Likert-type was used to find out to what extent middle school students show the disciplined mind traits in science and technology class. The five-point Likert-type scale has five

[3] The data of the research were collected in the 2014-2015 academic year. The data collection process took place with the voluntary participation of the school administration, teachers and students. Identity information of the participants has been kept completely confidential. No sound or video was recorded during the classroom observations. The data collected from the participants with data collection tools were used only for scientific research purposes.

degrees: “Always,” “Usually,” “Sometimes,” “Rarely,” and “Never.” For the content validity of the scale, related literature was examined, and disciplined mind criteria were determined. The table of specifications included these criteria, and items prepared according to these criteria are presented to expert opinion. Four science education experts, three curriculum development experts, and one assessment and evaluation expert were consulted on the trial form. Among the scale items, the experts marked the items that they thought best reflected the criteria or proposed various corrections to make the items better reflect the criteria. According to experts' opinions, some items were removed from the scale, some were corrected, and thus a trial form included 64 items was formed. Also, five secondary school students read the trial form aloud to determine whether the scale was suitable for the purpose, and the concepts that were not understood by students were simplified in a way that the students could understand. The experiment form was applied to 613 middle school students. The scale's construct validity was tested by using exploratory factor analysis using data obtained from the pilot study. Kaiser-Meyer-Olkin (KMO) test was used to test whether the study group's size was sufficient for factor analysis, and the KMO value was calculated as 0.95. In the Bartlett sphericity test, the chi-square value was found to be significant (X^2 (2016) =14162.186 $p<0.01$). Among the items which measured the same feature and collected in one dimension, 22 items with factor load value above 0.45 and item-total correlation above 0.30 were selected. The one factor explained 40.92% of the total variance of the scale. These data show that all items of the scale are collected in one dimension, and each item measures the property that the entire test measures (Can Aran& Senemoğlu, 2014a). That Cronbach’s α of test reliability was 0.89. For the 22 item-scale, the highest point that one could get out of all the items was calculated 110, the lowest 22.

Teaching and learning environment assessment scale (TLES)

A teaching and learning environment assessment scale in a five-point Likert-type developed by Can Aran and Senemoğlu (2014a) was used to determine the extent to which the middle school science course cultivates the disciplined mind. The five-point Likert-type scale has five degrees: “Always,” “Usually,” “Sometimes,” “Rarely,” and “Never.” For the scale's content validity, related literature was examined, and criteria for cultivating disciplined mind characteristics were determined. The table of specifications included these criteria, and items prepared according to these criteria are presented to expert opinion. Four curriculum development experts and one assessment and evaluation expert were consulted on the trial form. According to opinions of experts; some items were corrected and thus a trial form

included 56 items was formed. Also, three secondary school students read the trial form aloud in order to determine whether the scale was suitable for the purpose, and the concepts that were not understood by students were simplified in a way that the students could understand. The trial form was applied to 492 middle school students. The construct validity of the scale was tested by using exploratory factor analysis using data obtained from the pilot study. Kaiser-Meyer-Olkin (KMO) test was used to test whether the study group's size was sufficient for factor analysis, and the KMO value was calculated as 0.96. In the Bartlett sphericity test, the chi-square value was found to be significant ($X2(1540) = 11831.923$, $p<0.01$). Among the items which measured the same feature and collected in one dimension, 28 items with factor load value and item-total correlation above 0.30 were selected. The one factor explained 41.3% of the total variance of the scale. These data show that all items of the scale are collected in one dimension, and each item measures the property that the entire test measures (Can Aran & Senemoğlu, 2014a). That Cronbach's α of test reliability was 0.93. For 28 item-scale, the highest point that one could get out of all the items was calculated 140, the lowest 28.

Performance task and grading form (Rubric)

A performance task was prepared to discover whether middle school students show disciplined mind traits. While this performance task was being developed, a testing tool named "University Learning Assessment" designed by Chun (2008) and called Collegiate Learning Assessment in The Classroom (CLA), was based on. According to CLA, students should be assigned roles in order that they can feel themselves in the given scenario. Similarly, students were asked to write an essay using four different reports on Turkey's investment, whether the investment should be about searching space or producing energy in this performance task. It is also given an assignment to students that they think as they are members of parliament responsible for the budget. In this context, the first report was about the necessity of research about space; the second one was on the countries' spending more money for research about space such as Germany, U.S and their budget for research for space; the third was about why we need energy; and the fourth was about the amount of water, wind and sun energy produced by countries and there was also a map showing the distribution of sun energy by regions.

Moreover, a performance grading form was generated to evaluate data and determine the students' disciplined mind levels. The criteria used to assess students' performance are

as follows: (1) using the reports effectively, (2) analyzing the reports objectively, (3) establishing a cause-and-effect relationship in column writing properly, (4) combining the parts or information as a whole to create a new structure, (5) corroborating his ideas with various examples and references. All of these criteria are related to four sub-dimensions of a disciplined mind. These are making connections to the real-life, learning in deep, making interdisciplinary connections, and thinking like a scientist. The help of this performance task could not measure the affective aspect of a disciplined mind related to motivation. To have a general idea about students' disciplined mind level, all these criteria were evaluated holistically, and total score were calculated with grading form developed by Can Aran and Senemoğlu (2014a). The grading form consists of five categories and four achievement degrees: 0, 1, 2, 3. In the grading form, the highest point one could get from each item was calculated as 3, the lowest 0., while the highest score that one could get out of all the items was 15, the lowest 0. G coefficient of rubric calculated over five categories and four achievement degrees was 0.85.

Observation form

In order to get a deeper understanding of the research questions, observations were conducted in sixth and eighth-grade classrooms through unstructured observation forms. Observation data were collected from the sixth-grade classroom for 6 class hours (40 minutes) and eighth-grade classroom for nine class-hours in each class, 15 class-hours in total. Classroom observations were done for one class hour, with one-minute intervals in every 12 minutes. Less hour observation was done in the sixth-grade classroom than eight grade classrooms because the sixth-grade students' teacher was newly assigned. With the help of an unstructured observation form, teachers and students' behaviors were recorded. The researcher sought to make non-participant observations as much as possible. The classes were observed together with another observer throughout the research to ensure that observations were made properly. Two observers wrote down notes together, compared their observation notes, and missing points in notes were completed.

Data Analysis

In this research, data was collected through quantitative and qualitative methods. The quantitative and qualitative data set were analyzed in detail. The processes of data analysis were explained in detail below.

Quantitative data analysis

Whether or not the scores had normal distribution was tested in the Shapiro-Wilk method prior to analyzing the data to decide on a method for data analysis. The findings are shown in Table 2 below.

Table 2. *Shapiro-Wilk analysis results*

		Shapiro-Wilk		
	Scores	Statistics	df	Sig.
6th grade	Disciplined mind scale	0.963	31	0.360
	Teaching- learning environment assessment scale	0.926	31	0.035*
	Rubric	0.976	31	0.706
8th grade	Discipline mind scale	0.959	30	0.286
	Teaching- learning environment assessment scale	0.952	30	0.187
	Rubric	0.945	30	0.127

*p>.05

As it is clear from Table 2, scores obtained from the teaching-learning environment assessment scale differ significantly from the normal distribution. In contrast, scores obtained from the other measurement tools do not differ considerably from a normal distribution. Therefore, Mann Whitney U-test was used for independent groups in comparing the scores coming from the teaching-learning environment assessment scale for the 6th and 8th graders. Mann Whitney U-test was used for separate groups in comparing the scores obtained from the rubric because the scores were on the ranking scale. In contrast, the scores obtained from the rubrics used in assessing the performance task met the assumption of normal distribution. T-test was used for independent groups in calculating the scores obtained from a disciplined mind scale.

Qualitative data analysis

The qualitative data set of research consists of observation notes. The deductive approach was preferred in analyzing data sets because there is a literature on the disciplined mind traits. Disciplined mind themes determined (see table 1) by Can Aran and Senemoğlu

(2014a) were used in the deductive approach. The researchers carefully read the observation notes by moving back and forth across the documents and analyzed these texts either line-by-line or word by word deductively in search of codes. Then it was counted in how many lessons students show the indicators of a disciplined mind in the teaching-learning environment. These decisions about coding in each category were presented in numbers. In addition, four experts (Three of them study about both science education and curriculum and instruction, one of the studies about both science education and measurement and evaluation) read the five pages of raw data (Miles & Huberman, 1994) and matched the themes with the data in the observation forms. Then, by discussing the matches' inconsistent points, experts came to a common conclusion regarding the deciphered text-theme match.

Findings

In this part, findings on sub-problems of the research were given together to ensure meaningful coherence. Results were presented into four headings: Disciplined Mind Scale (DMS), Performance Task, Teaching and Learning Environment Assessment Scale (TLES), and Observation.

Findings from Disciplined Mind Scale

In this research, the level of disciplined mind traits of sixth and eighth grades was determined via DMS, and it is uncovered whether there was a significant difference between sixth and eighth-graders in terms of showing the disciplined mind traits. T-test results of the level at which sixth and eighth graders show the disciplined mind traits are presented in Table 3. Also, Levene's statistic on the homogeneity of variance was estimated to 0.492, which means variances are homogenous ($p>0.05$).

Table 3. *T-test results of the level at which sixth and eighth graders show the disciplined mind traits*

Grades	n	$\bar{X}$	S	df	t	p
Sixth	31	87.26	13.69	59	0.49	0.96
Eighth	30	87.10	11.35			

As can be seen in Table 3, there is no significant difference between sixth and eighth-graders in terms of showing the disciplined mind traits ($t(59) =0.49$, $p>0.05$). This finding indicates that students' disciplined mind level in both grades is seen as similar to each other.

When the mean of the groups' scale scores is analyzed, it is seen that the majority of the students in both groups show disciplined mind features most of the time.

Findings from Performance Task and Rubric

In addition to DMS, a performance task and rubric were used to determine the level at which sixth and eighth graders show the disciplined mind traits. Descriptive statistics for the level at which the sixth and eighth graders exhibit the disciplined mind traits are presented in Table 4.

Table 4. *Descriptive Statistics for the level at which sixth and eighth graders exhibit the disciplined mind traits according to results getting by rubric*

Grades	n	$\bar{X}$	ss
Sixth	31	5.52	1.050
Eighth	30	6.53	0.868

Table 4 shows that the mean of the groups' rubric scores are close to each other and low score getting from the rubric. So it is clear that the disciplined mind level of middle school students is low. Conducted to learn if there was a remarkable difference between rubric scores of sixth and eighth-graders in science class, Mann- Whitney U-Test was done. The results are shown in Table 5.

Table 5. *U- Test results of the rubric according to the groups*

Grades	n	Mean Rank	Sum of Ranks	U	p
Sixth	31	28.87	895	399	0.337
Eighth	30	33.20	996		

In examining Table 5, it was found that there wasn’t a significant difference between the sixth and eighth-graders. According to the rubric results, it is possible to say that sixth and eighth graders exhibit similar disciplined mind traits.

Findings from Students' Observations

In order to portray the disciplined mind traits of sixth and eighth graders in detail, classroom observations were done. This is important to diagnose the undeveloped disciplined mind traits. Table 6 shows the incidences of the disciplined mind behaviors of sixth and eighth-graders during observations.

Table 6. *Observation Results for Students' Frequency of Displaying Disciplined Mind Traits*

		Making connections between what is learned and real life		Seeking to learn discipline-related information in deep		Making interdisciplinary connections		Thinking like a scientist		Motivated to learn discipline	
Grades	N	f	%	f	%	f	%	f	%	f	%
Sixth	6	2	33.3	5	83.3	0	0	0	0	2	33.3
Eighth	9	3	33.3	6	66.6	1	11.1	0	0	2	22.2

According to Table 6, students generally display less disciplined mind traits in both grade levels. It is remarkable that learning knowledge deeply and being motivated to learn a discipline are seen more frequently in the 6th grade than in 8th grade. This can be considered indicative that students' efforts and desire to learn a discipline diminishes as grade levels increase. Remarkable behaviors students display concerning the indicators of disciplined mind are shown in Table 7.

Table 7. *Examples for Remarkable Behaviors Students Display with Disciplined Mind*

Disciplined Mind Traits	Sixth Grade	Eighth Grade
Making connections between what is learned and real life	Concerning balanced force, a student says 'one person pulls from here, and another person pulls from the other side. Thus it is unbalanced 'while talking about tug of war game. Another student says, 'if it is balanced, the rope does not move. If it is unbalanced, the rope moves in this and that direction.'	When the teacher says 'a ship of tons of weight floats but a stone sinks,' a student says 'there is the ship's air. The air reduces density.'

Table 7 *continued*

Disciplined Mind Traits	Sixth Grade	Eighth Grade
Seeking to learn discipline-related information in deep	While talking about earwax, the teacher says 'it looks dirty but it has an important function.' Then a student asks 'why do we clean our ears?'	About the buoyancy force, a student asks 'if substances with equal density remain in the middle in a liquid, doesn't the water above apply force downwards?'
Making interdisciplinary connections	No observations were made about this criterion in the sixth grade.	While a student asks 'where did Toricelli find the glass rod?' another student asks 'when were glass factories founded?' one of the students set up associations with industrial revolution- the domain of history- and responds by saying' glass factories were founded with industrial revolution'
Thinking like a scientist	No observations were made about this criterion in the sixth grade.	No observations were made about this criterion in the eighth grade.
Motivated to learn discipline	When students make statements about health such as 'jugglers push things into one of their ears and pull them out of the other ear, they do not feel pain, they do not have nerves in their body', a student adds 'I know this. I have seen it on Discovery channel. A man did not feel the heat' and thus emphasize that he/she watches science channels to learn about a discipline.	A student asks the teacher about scientific experiments about buoyancy force he saw on TV: 'there is membrane on the water, isn't there?'

Findings from the Teaching-Learning Environment Scale

In the research, the sixth and eighth-grade science courses cultivate a disciplined mind was determined via TLES. Besides, it is tested whether there is a significant difference between the classroom practices in sixth and eighth-grade science courses in terms of cultivating the disciplined mind. Descriptive statistics for the level at which the sixth and seventh-grade science course cultivates disciplined minds are presented in Table 8.

Table 8. *Descriptive Statistics for the level at which sixth and eighth-grade science course cultivates the disciplined mind*

Grades	n	$\bar{X}$	ss
Sixth	31	109.87	2.939
Eighth	30	104.87	3.110

Table 8 shows that the mean of the scale scores of the sixth and eighth grades are close to each other. The mean of the scale scores also shows that the majority of students in both groups express that practices for cultivating disciplined mind characteristics are often done. Conducted to learn if there was a remarkable difference between TLES scores of sixth and eighth-graders in science class, Mann- Whitney U-Test was done. The results are shown in Table 9.

Tablo 9. *U- Test results of TLES according to the groups*

Grades	n	Mean Rank	Sum of Ranks	U	p
Sixth	31	33.66	1043.5	382.5	0.234
Eighth	30	28.25	847.5		

In examining Table 9, it was found that there wasn't a significant difference between the sixth and eighth grades' teaching-learning environment in terms of cultivating a disciplined mind. This result shows that the level of classroom practices in cultivating a disciplined mind in sixth and eighth grade is similar.

Findings from Observations about Teaching-Learning Environment

In order to portray reality more in this study, a Teaching-learning environment was also observed. In fact, to what extent the sixth and eighth-grade science courses cultivate a disciplined mind was determined. Table 10 shows the incidence of teaching methods and techniques employed in teaching and learning environments. Because the more different instructional methods teachers use, the more the disciplined mind is cultivated (Gardner, 2006).

Table10. *Observation Results about Teaching Methods and Techniques Employed in Teaching and Learning Environments*

		Direct instruction		Question and answer		Discussion		Dramatization		Case study		Homework		Demonstration		Experiment-Lab		Analogy		Using visual symbols such as graphs and Using technology		Peer teaching		Problem solving	
Grades	N	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
Sixth	6	5	83.3	6	100	0	0	0	0	0	0	2	33.3	0	0	0	0	0	0	1	16.6	0	0	0	0	2	33.3
Eighth	9	7	77.7	7	77.7	0	0	0	0	0	0	1	11.1	0	0	0	0	0	0	7	77.7	0	0	0	0	3	33.3

According to Table 10, the same teaching methods and techniques were used in the 6th and 8th grades. Accordingly, direct instruction, question and answer, homework, graphs, visuals, and problem-solving were employed in both grade levels. While direct instruction and questions and answers were employed the most frequently, it was remarkable that teaching through experiments (laboratory technique), which is considered important to use in science courses, was not employed. At the same time, problem-solving was used with both grade levels only in the solution of structured problems. In addition to observation results shown in Table 10, Table 11 shows observation results obtained from the teaching-learning environment about cultivating disciplined mind traits.

Table 11**.** *Observation Results about Cultivating Disciplined Mind Traits in Teaching and Learning Environments*

		Ensuring that connections are made between what is learned and real life		Ensuring that discipline-related knowledge is learnt in depth		Ensuring that interdisciplinary connections are made		Ensuring that students think like a scientist		Motivating students to learn the discipline	
Grades	N	f	%	f	%	f	%	f	%	f	%
Sixth	6	3	50	4	66.6	0	0	1	16.6	2	33.3
Eighth	9	4	44.4	3	33.3	2	22.2	1	11.1	2	22.2

Striking examples of Cultivating Disciplined Mind Traits in Teaching and Learning Environments are shown in Table 12.

Table12. *Remarkable Examples of Cultivating Disciplined Mind Traits in Teaching and Learning Environments*

Cultivating Disciplined Mind Traits	Sixth Grade	Eighth Grade
Ensuring that connections are made between what is learnt and real life	During a conversation about ears, the teacher says, 'invisible things of implant type can be put thanks to medicine-which has been advancing.'	The teacher emphasizes the subject of pressure that diabetes' feet are swollen.
Ensuring that discipline-related knowledge is learnt in depth	In the subject of force, by using a visual, the teacher asks, 'what makes a rocket move upward? Is it a rocket light? If not, how does it move up?' after a student says that force is applied on the rocket, the teacher asks 'ıs rocket applied force? What applies force on it?' and thus makes the students think in-depth about the discipline.	About the subject of pressure, the teacher asks, 'why did Torricelli do his experiment with mercury?

Table 12 continued

Cultivating Disciplined Mind Traits	Sixth Grade	Eighth Grade
Ensuring that interdisciplinary connections are made	No observations were made about this criterion in the sixth grade.	While teaching Torricelli's experiment, the teacher makes the statement 'people had more respect for science in the 1800s. More value was attached to science with the industrial revolution. The royal family gave scientists the opportunity to present their scientific studies' and thus made connections with history.
Ensuring that students think like a scientist	When a student says that jugglers push a substance into one of their ears and pull it out of the other ear, the teacher says, 'is it possible? It is called an illusion'. When the student says, 'the man doesn't feel pain. He doesn't have nerves in his body', the teacher says you should see it with your eye instead of talking about rumors. It can be an illusion'.	The teacher leads students into doing an experiment about pressure by asking them, 'have you ever tried it at home with a knife?'
Motivating students to learn the discipline	While talking about the force applied on the rocket, the teacher says, 'you can take materials to the space from Turkey if you become an astronaut. I hope you will be an astronaut. Then you can go to space.	The teacher asks, 'who will do the experiment about buoyance force?' The students raise their hands. The teacher asks if they are very eager to experiment. And then the teacher says that they need to make a presentation. Then the teacher says, 'I will make arrangements with four people. We will give the key of the laboratory. Tidy up your hair. Be careful. There are examples for experiments on YouTube. You can see them.

Discussion, Conclusion, and Suggestions

The results from the present study showed that there were no differences between the disciplined mind features of the 6th and 8th graders in this sample. More specifically, analysis of DMS, which required students to assess their own performance, indicated that

students' disciplined mind levels at both grades were satisfactory. In contrast, the quantitative data obtained from the rubric graded by the researcher and qualitative data obtained as a result of the researcher's observations found that students exhibit the traits related to the disciplined mind inadequately in most cases. The inconsistency among data obtained from different resources can be that the students, unfortunately, reflect their behaviors related to disciplined minds differently than what their behaviors searched by DMS are. Similar results have been reported by other research. For example, Altındağ (2015) also found some inconsistencies between students' self-assessments and their actual performance in his study, where he examined the relationship between the synthesizing mind behaviors and academic achievement levels of 7th-grade students. In furtherance of the results of international exams like PISA, TIMSS, which measure life skills, show that students performance in science is below average, although they generally report highly positive attitudes towards science (Taş, Arıcı, Özarkan & Özgürlük, 2016; Uzun, Bütüner &Yiğit, 2010). There might be some factors causing this situation. For instance, research points out that students' attitudes and aspirations towards science and mathematics can easily be affected by their social milieu, especially by their parents' and teachers' attitudes toward students as learners of these subject areas (Singh, Granville & Dika, 2002). Considering that the disciplined mind's cognitive domain is related to higher-order thinking, Işık (2014)' results can be regarded as a support to the assertion made by this study that students' actual performance regarding the disciplined mind was below satisfactory. Like this study, she found that 8th-grade students were unable to reach the high-level objectives in science defined in line with Bloom's taxonomy. The findings of this study also support why Turkish students have low scores in international exams like PISA or TIMSS.

Another interesting finding of this study was that the qualitative results showed that students displayed some behaviors like in-depth learning and some motivational behaviors less in the 8th-grade level than the 6th-grade level. This result can be interpreted as an indication of the fact that students' efforts and desire to learn discipline are decreasing in upper grades. Many studies were pointing out that students' motivation towards learning science decreases as their grade level increases are available in the literature (Aydın, 2007; Deniş Çeliker et al., 2015; Güngören, 2009; Güvercin, 2008; İnel Ekici et al., 2014; Karakaya, Avgın & Yılmaz, 2018; Seçkin Kapucu, 2018; Yavuz Göçer et al., 2011; Yenice et al., 2012; Yıldırım & Kansız, 2018).

Also, the result of this study pointed out that there were no significant differences in the teaching-learning processes in the science course between the sixth and eighth-grade levels in terms of cultivating a disciplined mind. In other words, the teaching-learning processes in the 6th and the 8th grades were similar in terms of providing opportunities to develop a disciplined mind. Atilla, Yaşar, Yıldırım, and Sözbilir (2015) asked the middle school students' views on constructivist learning environments containing components such as learning the world, learning science, learning to state thoughts, and learning to learn. Similarly, they concluded that there were no differences between students' views on constructivist learning environments according to grade levels.

Moreover, the results obtained from the teaching-learning environment scale showed that cultivating the traits of a disciplined mind in the teaching-learning environment for 6th and 8th grade were satisfactory. On the other hand, the current qualitative findings also revealed that the middle school science course was inadequate in terms of cultivating a disciplined mind. The reason for the inconsistency of qualitative and quantitative data can be that students feel social pressure on themselves by their teacher, as we mentioned before. The qualitative findings also showed that teachers mostly used direct instruction and questions and answers in teaching middle school science courses. They did not teach their lessons through experiments - which was considered important. Observations also demonstrated that solving unstructured problems- which was to direct students into disciplined thinking- was not preferred. Studies available in the literature are also supportive of this finding. Şimşek, Hırça, and Coşkun (2012) also found that science and technology teachers preferred conventional techniques such as question and answer and direct instruction rather than methods and techniques such as making projects, class trips suggested in the curriculum, and using computers and microscopes, which necessitated students' active participation in the learning process and which helped to develop their scientific research skills. Pınar (2013) also concluded that science and technology teachers taught in traditional methods. Doğru and Aydoğdu (2003) found that the method of direct instruction was often used in science teaching without considering the number of students in the classrooms. In a similar vein, Can Aran and Senemoğlu (2014b) and Güneş, Dilek, Hoplan, and Güneş (2011) also demonstrated that direct instruction and question and answer were used most frequently in science teaching. The teachers included in the study conducted by Can Aran and Senemoğlu (2014b) and Uluçınar, Cansaran, and Karaca (2004) also stated that they could not duly and effectively use laboratories in teaching their lessons. Additionally, the

qualitative findings also demonstrated that the behaviors of ensuring that interdisciplinary connections are made, ensuring to make students think like a scientist, and motivating students to learn the discipline were at the minimum level both in the 6th and the 8th grades. It is important to cultivate interdisciplinary learning, which ensures students to learn knowledge in a meaningful whole, the skill of thinking like a scientist in middle school- where hypothetical thinking skills are developed and also motivating students to learn discipline which is required for turning learnings into performance (Senemoğlu, 2018).

Taking all things into consideration, it is clear that middle school students 'disciplined mind traits are inadequate according to classroom observations where we have a chance to see the reality as starkly as possible. This finding is also supported by the finding that the teaching-learning environments in middle school science courses are inadequate in cultivating a disciplined mind according to classroom observations. Setting out from the findings of this study, educational experiences can be provided to cultivate the disciplined mind in a middle school science course. Studies to be performed in the future can investigate disciplined mind traits for other classes in different types of schools in different countries and at various stages of informal education. Further studies of the issue may involve qualitative research patterns rather than mixed methods research. In addition to all these researches, a curriculum that improves disciplined mind features can be developed and put into effect, observing how it works.

References

Abruscato, J. (2000). *Teaching children science: A discovery approach.* USA: Allyn and Bacon.

Altındağ, M. (2015). *Yedinci sınıf öğrencilerinin matematik ve fen bilimleri derslerinde sentezleyen zihin özelliklerinin incelenmesi* [An investigation of 7 th grade students' synthesizing mind in math & science]. Unpublished doctoral dissertation, Hacettepe University, Ankara, Turkey.

Atilla, M. E., Yaşar, M. D, Yıldırım, M., & Sözbilir, M. (2015). 6, 7 ve 8. sınıf öğrencilerinin fen derslerini yapılandırmacı öğrenme anlayışı açısından algılamaları [6th, 7th and 8th grade students' perceptions in regard to application of constructivist approach in science lessons]. *Milli Eğitim Dergisi*, 45(205), 112-124.

Aydın, B. (2007). *Fen bilgisi dersinde içsel ve dışsal motivasyonun önemi* [Priority of internal and external motivation at science lesson]. Unpublished Master Thesis, Yeditepe Üniversitesi Sosyal Bilimler Enstitüsü, Istanbul, Turkey.

Azizoğlu, N., & Çetin, G. (2009). 6 ve 7. sınıf öğrencilerinin öğrenme stilleri, fen dersine yönelik tutumları ve motivasyonları arasındaki ilişki [Six and seventh grade students' learning styles, attitudes towards science and motivations]. *Kastamonu Eğitim Dergisi*, 17(1), 171-182.

Balbağ, M. Z., Leblebicier, K., Karaer, G., Sarıkahya, E., & Erkan, Ö. (2016). Türkiye'de fen eğitimi ve öğretimi sorunları [Science education and teaching problems in turkey]. *Journal of Research in Education and Teaching*, 5(3).

Biggs, J. B. (1987). *Student Approaches to Learning and Studying*. Hawthorn: Australian Council for Educational Research.

Bostan Sarioğlan, A., Gedik, İ., & Can, Y. (2016). Ortaokul öğrencilerinin bilimsel süreç becerilerinin karşılaştırılması: kuvvet ve hareket ünitesi örneği [Comparison of the scientific process skills of middle school students: force and movement unit example]. *Mersin Üniversitesi Eğitim Fakültesi Dergisi*, 12(2).

Böyük, U., Tanik, N., & Saraçoğlu, S. (2011). İlköğretim ikinci kademe öğrencilerinin bilimsel süreç beceri düzeylerinin çeşitli değişkenler açısından incelenmesi [Analysis of the scientific process skill levels of secondary school students based on different variables]. *Tübav Bilim Dergisi*, 4(1), 20-30.

Bruner, J. (2009). *Eğitim Süreci* (T. Öztürk, Trans.). Ankara: Pegem Yayıncılık.

Bybee, R. W. (2006). Scientific inquiry and science teaching. In L. B. Flick, & N. G. Lederman (Eds.), *Scientific inquiry and nature of science* (pp. 1-14). Netherlands: Springer.

Bybee, R. W., Powell, J. C., & Trowbridge, L. W. (2008). *Teaching Secondary School Science*. New Jersey: Pearson.

Can Aran, Ö. & Senemoğlu, N. (2014a). *An investigation of students' disciplined mind characteristics, and science and technology education* [In Turkish]. Unpublished doctoral dissertation, Hacettepe University, Ankara, Turkey.

Can Aran, Ö. & Senemoğlu, N. (2014b). An investigation of science education in terms of disciplined mind characteristics [In Turkish]. *Hacettepe University Journal of Education,* 29(4), 46-59.

Cherif, A. H., Jedlicka, D., Al-arabi, A., Aron, R., & Verma, S. (2010). Effective understanding of human body organs: A role-playing activity for deep learning. *The American Biology Teacher*, 72 (7).

Chiappetta, E. L., & Koballa, T. R. (2006*). Science Instruction in the Middle and Secondary Schools*. USA: Pearson.

Chun, M. (2008). *[Cla]ssroom academy 101. Introduction to performance tasks*. Newyork: CLA in the Classroom.

Çepni, S. (2011). Bilim, fen, teknoloji kavramlarının eğitim programlarına yansımaları. In A. P. Ayas, S. Çepni, A. R. Akdeniz, H. Özmen, N. Yiğit, H. G. Ayvacı & S. Çepni (Eds.), *Kuramdan uygulamaya fen ve teknoloji öğretimi* (pp. 1-11). Ankara: Pegem Akademi.

Deboer, G. E. (2006). Historical perspectives on inquiry teaching in schools. In L. Flick, & N. G. Lederman (Eds.), *Scientific inquiry and nature of science* (pp.17-35). Netherlands: Springer.

Deniş Çeliker, H., Tokcan, A., & Korkubilmez, S. (2015). Fen öğrenmeye yönelik motivasyon bilimsel yaratıcılığı etkiler mi? [Does motivation toward science learning affect scientific creativity?]. *Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 12 (30), 167-192.

Dewey, J. (2010). *Okul ve Toplum* (H. A. Başman, Trans.). Ankara: Pegem.

Doğru, M., & Aydoğdu, M. (2003). Fen bilgisi öğretiminde kullanılan yöntemlerde karşılaşılan sorunlar ile ilgili öğrenci görüşleri. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, 13(13), 150-158.

Entwistle, N. J. (2000). Promoting deep learning through teaching and assessment: conceptual frameworks and educational contexts. *Proceedings of the Teaching and Learning Research Programme (TLRP) Conference*, Leicester, 9-10 November 2000.

Entwistle, N. (2009). *Teaching for Understanding at University*. Newyork: Palgrave Macmillan.

Gall, M. D., Walter, R. B., & Gall, J. P. (1996). *Educational Research*. USA: Longman Publishers.

Gardner, H. (2006). *Five Minds for The Future*. Boston: Harvard Business School Press.

Glasersfeld, E. (1981). An introduction to radical constructivism. In P. W. (Eds.), *Die Erfundene Wirklichkeit*. Munich: Piper.

Güneş, T., Dilek, N. Ş., Hoplan, M., & Güneş, O. (2011,April). Fen ve teknoloji dersinin öğretmenler tarafından uygulanması üzerine bir araştırma. *Paper presented at the meeting of 2nd International Conference on New Trends in Education and Their Implications*, Antalya-Turkey.

Güngören, Ş. (2009). *The effect of grade level on elementary school students' motivational beliefs in science*. Unpublished master thesis, Middle East Technical University, Ankara, Turkey.

Güvercin, Ö. (2008). *Investigating elementary students' motivation towards science learning: A cross-age study*. Unpublished Master Thesis, Middle East Technical University, Ankara, Turkey.

Işık, Ö. (2014). *The level of attainment in Turkey considering the objectives of science and technology curriculum in the developed countries*. Unpublished doctoral dissertation, Hacettepe University, Ankara, Turkey.

İnel Ekici, D., Kaya,K., & Mutlu,O (2014). Ortaokul öğrencilerinin fen öğrenmeye yönelik motivasyonlarının farklı değişkenlere göre incelenmesi: Uşak ili örneği [Investigating of motivation about science learning of middle school students to different variables: The case of Uşak province]. *Mersin Üniversitesi Eğitim Fakültesi Dergisi*, 10(1),13-26.

Jorgenson, O., Cleveland, J., & Vanosdall, R. (2004). *Doing Good Science in The Middle School*. USA: NSTA Press

Karaman, P. & Karaman, A. (2016). Fen bilimleri öğretmenlerinin yenilenen fen bilimleri öğretim programına yönelik görüşleri [Opinions of science teachers about the revised

science education program]. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi*, 18(1), 243-269.

Karakaya, F., Avgın, S. S. & Yılmaz, M. (2018). Ortaokul öğrencilerinin fen öğrenmeye yönelik motivasyonlarının incelenmesi [Investigation of middle school students' motivation toward science learning]. *Kahramanmaraş Sütçü İmam Üniversitesi Sosyal Bilimler Dergisi*, 15(2), 359-374.

.Lewis, J. L.,& Kelly, P. J. (1987). *Science and Technology Education and Future Human Needs*. Newyork: Published for the ICSU Press by Pergamon Press.

Light, G., & Micari, M. (2013). *Making Scientist: Six principles for effective college teaching*. USA: Harvard University Press.

MEB (2018) *Fen bilimleri dersi öğretim programı (3,4,5,6,7 ve 8. sınıflar).* Retrieved from a website like ttkb.meb.gov.tr.

Meriç, G., & Karatay, R. (2014). Ortaokul 7 ve 8. sınıf öğrencilerinin bilimsel süreç becerilerinin incelenmesi [Analyzing middle school seventh and eight class students science process skills]. *Tarih Okulu Dergisi (TOD)*. 7 (XVIII), 653-669.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis: An expanded sourcebook*. USA: Sage Publication.

Pınar, M. A. (2013). *Fen ve teknoloji öğretmenlerinin yapılandırmacı yaklaşımın sınıf içi uygulamalarına yönelik görüşleri (Diyarbakır ili örneği) [The views of teachers of science and techonology on constructivist approach in classroom studies (A sample of diyarbakir city)*], Unpublished doctoral dissertation, University of Muş Alparslan, Institute of Science, Muş, Turkey.

Seçkin Kapucu, M. (2018). Examination of middle school students' continuing motivation for science learning according to different variables. *Kastamonu Education Journal*, 26(4), 1069.

Senemoğlu, N. (2018). *Gelişim, Öğrenme ve Öğretim*. Ankara: Anı Yayıncılık.

Singh, K., Granville, M.& Dika, S. (2002) Mathematics and science achievement: Effects of motivation, interest, and academic engagement, *The Journal of Educational Research*, 95:6, 323-332, DOI: 10.1080/00220670209596607.

Şimşek, H., Hırça, N., & Coşkun, S. (2012). İlköğretim Fen ve Teknoloji Öğretmenlerinin Öğretim Yöntem ve Tekniklerini Tercih ve Uygulama Düzeyleri: Şanlıurfa İli Örneği [Primary Science and Technology Teachers' Selection of Using Teaching Methods And Techniques And The Levels Of Their Applications]. *Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 9(18).

Taş, U. E., Arıcı, Ö., Özarkan, H. B., & Özgürlük, B. (2016). *PISA 2015 ulusal raporu*. Retrieved from a website like http://odsgm.meb.gov.tr/test/analizler/docs/PISA/PISA2015_Ulusal_Rapor.pdf.

Uluçınar, Ş., Cansaran, A., & Karaca, A. (2004). Fen bilimleri laboratuvar uygulamalarının değerlendirilmesi. *Türk Eğitim Bilimleri Dergisi*, 2(4), 465-475.

Uzun, N., & Keleş, Ö.(2010). Fen öğrenmeye yönelik motivasyonun bazı demografik özelliklere göre değerlendirilmesi [Evaluation of the motivation for science learning according to some demographic characteristics]. *Gazi Eğitim Fakültesi Dergisi*, 30(2), 1-16.

Uzun, S., Bütüner, S. Ö., & Yiğit, N. (2010). 1999-2007 TIMSS Fen Bilimleri ve Matematik Sonuçlarının Karşılaştırılması: Sınavda En başarılı ilk beş ülke- Türkiye örneği. *İlköğretim Online, 9*(3).

Venville, G., & Dawson, V. (2004). Integration of science with other learning areas. In G. Venville, & V. Dawson (Eds.), *The art of teaching science*. Australia: Allen& Unwin.

Yavuz Göçer, F.., Sungur, S., & Tekkaya, C. (2011). İlköğretim öğrencilerinin fen derslerindeki güdüsel özelliklerinin incelenmesi [Investigating elementary school students' motivational traits in science classrooms], *Eğitim ve Bilim*, 36(161).

Yenice, N., Saydam, G., & Telli,S. (2012). İlköğretim öğrencilerinin fen öğrenmeye yönelik motivasyonlarını etkileyen faktörlerin belirlenmesi [Determining factors effecting on primary school students' motivation towards science learning]. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi (KEFAD)*, 13 (2), 231-247.

Yıldırım, H. İ., & Kansız, F. (2018). Ortaokul öğrencilerinin fen öğrenmeye yönelik motivasyonları üzerine bir araştırma [An investigation into the secondary school students' motivation toward science learning]. *Cumhuriyet Uluslararası Eğitim Dergisi*, 7(3), 241-268.

Zimmerman, C. (2007). The development of scientific thinking skills in elementary and middle school. *Developmental Review*, 27, 172-223.