BAŞKENT UNIVERSITY
JOURNAL OF EDUCATION

2020, 7(2), 200-211 ISSN 2148-3272

# The Implementation of Six Thinking Hats Technique in Teaching Socio-scientific Issues and the Analysis of its Effect on Certain Variables

# Altı Şapka Düşünme Tekniğinin Sosyobilimsel Konuların Öğretiminde Uygulanması ve Bazı Değişkenler Üzerindeki Etkisinin İncelenmesi

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**Abstract**
It is aimed to develop some skills such as argumentation, reasoning and decision making of students by implementing different methods and techniques while teaching socio-scientific issues (SSIs). In this regard, in the current study, the purpose was to investigate the effect of six thinking hats technique on students' academic achievement, critical thinking and decision-making states while teaching SSIs. In the quasi experimental study in which 121 seventh grade students participated, while the experimental group was taught SSIs through six thinking hats technique, the current in-class applications were carried out in the control group. The achievement test, Critical Thinking Disposition Instrument (CTI) and Adolescent Decision-Making Questionnaire (ADMQ) were administered in both groups as pre-test and post-test. According to MANOVA findings, it is seen that there are significant differences between the experimental group and the control group in terms of one of the variables of the study, which is the post-test scores in the academic achievement test; however, there is no statistically meaningful difference between CTI and ADMQ post-test scores of the experimental group and the control group. Several recommendations were made after the findings of the study were evaluated in the light of the related literature.

*Keywords: Socio-scientific issues, six thinking hat technique, critical thinking skills, decision-making skills, chemical industry.*

**Öz**
Sosyobilimsel konuların öğretiminde farklı yöntem ve teknikler uygulanarak öğrencilerde argümantasyon, muhakeme ve karar verme gibi bazı becerilerin geliştirilmesi hedeflenmektedir. Bu bağlamda, mevcut çalışmada da sosyobilimsel konuların öğretiminde altı şapka düşünme tekniğinin, öğrencilerin akademik başarılarına, eleştirel düşünme ve karar verme durumlarına etkisinin araştırılması amaçlanmıştır. 121 yedinci sınıf öğrencisinin katıldığı yarı deneysel çalışmada deney grubuna sosyobilimsel konular altı şapka düşünme tekniği ile öğretilirken kontrol grubunda mevcut sınıf içi uygulamalara devam edilmiştir. Başarı testi, Eleştirel Düşünme Eğilimi ve Karar Verme Ölçekleri her iki gruba ön-test ve son-test olarak uygulanmıştır. Elde edilen verilerin analizi bağımsız örneklemler için t-testi ve MANOVA ile yapılmıştır. Çalışma bulgularına göre deney grubu ile kontrol grubu arasında ele alınan değişkenlerden akademik başarı son test puanları açısından anlamlı farklılığın olduğu ancak Eleştirel Düşünme ve Karar Verme Ölçekleri son test puanları açısından deney ve kontrol grupları arasında istatistiksel olarak anlamlı bir farklılığın olmadığı görülmüştür. Çalışmanın bulguları ilgili alan yazın ışığında değerlendirilerek çeşitli önerilerde bulunulmuştur.

*Anahtar Kelimeler: Sosyobilimsel konular, altı şapka düşünme tekniği, eleştirel düşünme, karar verme, kimya endüstrisi*.



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## 1. Introduction

Science education enables to discover the environment one lives in, to use scientific process skills, to reach the acquired information and find appropriate solutions when faced with a problem. In this respect, raising scientifically literate individuals is among the main goals of science education. With scientific literacy, it is aimed that students will be productive individuals who have scientific knowledge and skills, can make decisions individually and can participate in discussions about science, technology and society (Erdoğan & Köseoğlu, 2012). It is considered important that students learn by establishing a link between science and technology and society (Sadler & Zeidler, 2005). In line with this, science-technology-society (STS) education is included in not just Turkish curriculum and course books, but in the ones in other countries as well. Following STS approach, some researchers supported the integration of environment factor in terms of moral and social responsibilities (Zeidler, Sadler, Simmons & Howes, 2005) by mentioning the need for the adoption of science-technology-society and environment approach (Hodson, 1994). This understanding has also been adopted by Turkish education system and a section titled Science-Technology-Society and Environment (STSE) was allocated in the science curricula. STSE, which was included in the 2013 Turkish curriculum, made emphases on some important issues as well as SSIs.

Given within the scope of raising scientifically literate individuals, the teaching of SSI and these issues are very important in order for individuals to be able to express their opinions comfortably and support them, and to make evaluations within the framework of moral and ethical dimension, individual experiences and the nature of science.

SSIs are defined as issues which can be approached from different perspectives and need to be contemplated on. They include scientific claims, political, personal and ethical questions. They are issues which contain social dilemmas that are difficult to reach quick conclusions about, which usually have a moral dimension, and which might have serious effects on the individual's life (Lee, Abd-El-Khalick & Choi, 2006). According to Sadler and Zeidler (2005), SSIs raise dilemmas which involve issues of biotechnology, environmental problems and genetics. SSI is a broad term which also covers students' emotional and moral development, and the relationship between science, technology and society, which are also related to the ethical dimension of science. (Zeidler, Sadler, Simmons & Howes, 2005). SSI and the teaching of SSIs, which started to have their place in curricula in time, are as important in decision making and implementation stages as the teaching of traditional topics in terms of developing reasoning skills when these issues bear a resemblance to the issues that students might come across in their daily lives (Sadler, Barab & Scott, 2007). Some research studies have shown that science teaching based on SSI might be effective in helping students gain critical thinking, inquiring, decision making, analytical thinking, ethical and moral reasoning, and argumentation skills (Sadler & Zeidler, 2005). Similarly, helping students gain reasoning, scientific thinking and decision-making skills with the help of SSIs is among the objectives of science teaching in the 2017 updated Turkish curriculum (MoE, 2017).

When the studies conducted in the field of science education were analyzed, it was seen that such issues as stem cell, genetic engineering, genetically modified organisms, global warming, greenhouse effect, recycling, balanced diet, mines and their environmental effects, nuclear energy, animal rights, seal hunting, the particulate nature of the matter are examined as socio-scientific issues (Nichols & Zeidler, 2009; Soysal, 2012). In these studies, SSIs are examined especially together with factors such as individuals' perception level of self-efficacy, epistemic beliefs, critical, scientific and analytical thinking skills, mental modelling, argument developing and reasoning skills (Yang & Anderson, 2003; Topçu, 2008; İşeri, 2012; Yenilmez Türkoğlu & Öztürk, 2019). For example, in the study conducted by Çavuş (2013) on perspectives, it was stated that the students with different epistemological beliefs about nuclear energy thought that nuclear energy stations have a negative effect on the environment and human health, and the students with developed epistemological beliefs have a developed level of SSI sensitivity as well. In the study carried out by İşeri (2012) on pre-service science teachers' opinions on the risks and benefits of nuclear energy, it was claimed that nuclear energy was considered highly risky due to its possible negative effects on living things and especially human beings. In another study by Gedik (2018), which is on the argumentation skills of $8^{th}$ graders and their opinions on global warming, female students when compared with male students, and the students who live in villages when compared with the ones living in city centers had more information about global warming. In another recent study, Yenilmez Türkoğlu and Öztürk (2019) analyzed several SSI related mind models of pre-service science teachers and found that they had alternative concepts about SSIs. In addition to the studies given as examples above, some researchers analyzed the effect of different methods and techniques in teaching SSIs and evaluated this effect in terms of some variables. For instance, in their study on sustainable development and environmental education, Gresch, Hasselhorn and Bögeholz (2013) used a computer-based software which includes trainings on decision making strategies. In the findings of the study, it was stated that these trainings were effective while making decisions about SSIs. In their study where they analyzed biology teachers' knowledge and skills about biotechnology by organizing a one-week summer camp, Gray and Bryce (2006) reported that at the end of the camp,

the teachers gained a positive attitude towards teaching the issue but they confronted a dilemma about whether it is possible to find sufficient materials and time to implement the SSI. In another different study, Karabal (2018) aimed to determine the effects of the use of Common Knowledge Construction Model in SSI education on pre-service science teachers 'problem solving and decision-making tendencies. In the findings of the study, it was stated that the pre-service science teachers in the experimental group, where the lessons were conducted through Common Knowledge Construction Model, displayed a statistically meaningful improvement in evaluative, self-confident and organized problem-solving tendencies, when compared with the control group. On the other hand, in the study by Karaca (2018), which analyzed the effect of SSI based science education through constructivist approach on 7th graders scientific thinking skills, their reflective thinking and SSI perspectives, it was stated that the students in the experimental group who received socio-scientific issues based science education through constructivist approach had better content knowledge about the units focused on the study when compared with the students in the control group who received science education based on the already existing program through constructivist approach. Moreover, these students in the experimental group were better at providing reasons/evidence/explanations for their opinions they supported through their socio-scientific thinking and perspectives when compared with their counterparts in the control group. Different from the studies briefly summarized above, in the current study, it is aimed to investigate the effect of six thinking hats technique on SSI education and students' critical thinking and decision-making states.

Six thinking hats technique (STHT) was suggested by Edward De Bono in the 1980s in order to improve thinking. Some of the objectives of this technique are to provide solutions to the problem faced, to improve creative thinking skills, to carry out a healthy decision making process by keeping emotions under control, to express feelings and opinions comfortably and objectively with the help of hats in different colors (Arslan et. al., 2007). In STHT, the hats in different colors (white, red, black, yellow, green and blue) are symbols used in order to differentiate opinions and separate them from each other. The problem or issue that the individual is faced with is analyzed separately according to the thinking manner symbolized by each hat with a different color. The white hat gives information about the issue with an objective point of view, enables the listeners to acquire information and presents research findings. The red hat gives individuals the chance to express their feelings about the issue without any hesitation. The black hat shows the negative sides of the issue and possible risks of the decision to be made, possible danger and weaknesses that might arise with the help of a critical and pessimistic point of view. The yellow hat tries to investigate the positive and beneficial aspects of the issue and to provide logical evidence on these valuable aspects. The green hat puts forward alternative solutions, new ideas and suggestions regarding the issue. Moreover, by spending intensive effort for creativity, innovation and change, the green hat is the one which requires the individual to be mentally active the most. The blue hat analyzes the issue from all perspectives, reaches conclusions, reviews the thinking process by controlling all discussions and summarizes the results (Bono, 2014). There have been some research studies in which all these roles regarding the teaching of science topics were activated. For example, in Arıcı's (2016) study in which six thinking hats technique was implemented in the teaching of Human and Environment unit in an elementary school 7th grade science lesson, it was found that STHT had a positive effect on academic achievement. In another study within the scope of philosophy class, which investigated the effect of STHT based teaching techniques on the students' creativity, critical thinking and academic self-efficacy, Akkılıç (2018) stated that SHTH affected high school students' creative and critical thinking and their academic self-efficacy positively. It is noticeable that not many studies have been conducted on the effect of STHT in terms of different variables and STHT has not been much frequently considered in SSI education in the national literature, especially in recent years. In this regard, the current study has analyzed STHT in teaching the issues of household waste, recycling and chemistry industry, which were identified as SSIs, and has determined its effect on both students' academic achievement, and their critical thinking and decision-making states.

Critical thinking, which is one of the variables of the current study, can be defined as the ability to use information correctly and evaluate discussions (Williams, 2003). Individuals are expected to resort to critical thinking while they are trying to solve the problems they are faced with in all aspects of their lives and to reach the best result about an issue. When the studies in the related literature are analyzed, it is observed that there have been several studies which addressed critical thinking skills as a variable and analyzed its relationship with other variables; however, there have been fewer and a limited number of studies which examined SSI and critical thinking skill together. One example of these limited number of studies is Topçu's (2008) study, in which it was stated that pre-service science teachers' critical thinking manners did not change depending on the content of socio-scientific issues. In their studies, Solbes, Torres and Traver (2018) emphasized that regarding socio-scientific issues as scientific problems has the potential to motivate students to think critically. In the present study, in addition to critical thinking, students' decision-making states were also examined. Decision making is all the mental and kinesthetic efforts as a whole regarding making a choice and preference among different attitudes and situations by

taking all the available opportunities in order to achieve a goal. Individuals' ability to make a decision depends on their personalities and their interactions with the environment. While making a decision, each individual uses different styles and strategies on his/her own way (Payne, Bettman & Johnson, 1993). In their study on the effect of exam anxiety on decision making styles, Bacanlı and Sürücü (2006) stated that among the non-adaptive styles, boys preferred recklessness and avoidance of responsibility more than the girls did. Different from similar studies mentioned above, when the studies on individuals' decision-making states about socio-scientific issues are examined, it is thought that the number is not sufficient especially in the related literature. In addition to these studies, in their studies with Chinese students in a different learning environment, Lee and Grace (2012) emphasized that decision making states about avian flu differed in a different contextual environment. In the study by Gresch, Hasselhorn and Bögeholz (2013), a computer-based learning program was implemented for the development of decision-making strategies for socio-scientific issues about sustainable development and it was stated that this program had a positive effect on the decision-making process. In brief, in the current study, the purpose was to determine the effect of STHT in teaching household waste, recycling and chemistry industry, which are less frequently studied socio-scientific issues, on 7$^{th}$ grade students' academic achievement, and their critical thinking and decision-making states. It is thought that this study will not only contribute to the related literature on SSI but also fill the gap in the literature since it deals with SSI together with the variables of critical thinking and decision making. As it is mentioned above, argumentation-based learning is usually preferred in the teaching of socio-scientific issues, but studies with STHT are limited. In this regard, STHT is preferred in the present study.

## 2. Method

In order to determine the effect of six thinking hats technique on 7$^{th}$ grade students' academic achievement in the issues of household waste, recycling and chemical industry, and their critical thinking and decision-making states, quasi-experimental, which is one of the quantitative research approaches, has been implemented. The experimental and the control groups were formed through random assignment.

While in the experimental group, there was a learning environment in which six thinking hats technique was implemented, in the control group, there was a learning environment in which the already existing science curriculum was implemented. The independent variable of the study was the different learning methods applied in the experimental and the control groups. The dependent variables, on the other hand, were the post-test data on the student academic achievement test on the topics of household waste, recycling and chemical industry, decision making scale and critical thinking tendency scale.

### *2.1 Participants*

The sample of the study consisted of 121 seventh grade students attending an elementary school in central Konya. The students participated in the study were determined through convenience sampling. This method is defined as collecting data from the sample that is easy for the researcher to reach (Büyüköztürk, 2010). In the experimental group, there were 32 female and 34 male students, and in the control group, there were 26 female and 29 male students.

### *2.2 Measures*

Within the scope of the study, Academic Achievement Test, Critical Disposition Instrument and Adolescent Decision-Making Questionnaire were used.

*Academic Achievement Test.* The Academic Achievement Test (AAT) was administered to 7$^{th}$ grade elementary school students who participated in the study in order to determine their academic achievement in the topics of household waste, recycling and chemical industry. The students in both the experimental and control groups answered the questions in ATT before and after the experimental application. ATT was prepared by the researcher in line with the outcomes of the topics of household waste, recycling and chemistry industry in 'The Structure and the Characteristics of the Matter' unit in elementary school science lesson by making use of several sources. In the pilot study, 24 multiple choice questions were prepared and after it was reviewed and analyzed, it was decided that the final version of the test should include 22 multiple choice questions.

As part of the validity studies on AAT, each question was categorized according to Bloom taxonomy with a table of specifications which included the outcomes and the questions. In this way, it was aimed to gather data regarding content validity. The multiple-choice questions prepared for the study were given to two science teachers apart from

the implementers of the study to be evaluated and expert opinions were obtained. In order to make item and internal validity analyses of ATT, a pilot study was conducted with a group of 54 seventh grade students. The analysis of the data gathered through this application was conducted by ITEMAN software and as a result of the item analysis, it was seen that the item discrimination index of most of the questions was 0.5 and over. Only one of the questions had an item discrimination index of 0.3-0.4. However, it was realized that the item discrimination indexes of item 2 and item 22 were outside the range mentioned above and it was decided that these items should be removed from AAT. When the items in AAT were analyzed in terms of their item difficulty indexes, it was decided that twelve items had medium level difficulty, and that eleven items were easy, and one item was difficult. As a result, after the 24-item in pre-application, two items were removed from the test and item analyses were repeated. In this case, item discrimination index was found to be 0.628 and total difficulty value was found to be 0.482. As part of the reliability studies on AAT, Cronbach alpha coefficient was found to be .86.

*Decision Making Scale.* In order to determine the decision making states of the elementary students who participated in the study, 30-item 'Decision Making Scale' (DMS), which was developed by Mann, Harmoni and Power (1989) to determine self-respect and coping styles in decision making and was adapted to Turkish by Çolakkadıoğlu (2003), was implemented before and after the experimental application.

In the light of the data gathered through the pre-application, and as part of confirmatory factor analyses, fit indexes such as $x^2$/df, GFI (Goodness of Fit Index), CFI (Comparative Fit Index), NFI (Normed Fit Index), RMR (Root Mean Square Residuals) and RMSEA (Root Mean Square Error of Approximation) were examined for the fit of the model. The $x^2$/df value was calculated as 1.41 and since it was under 3, it was considered as a situation signaling a good fit. The RMSEA value was found to be 0.088. It is seen that this value is considered an acceptable value in the related literature (Vieira, 2011). Moreover, in general, good fit indexes such as GFI=.88; CFI=.83; NNFI=.85 were obtained (Brown, 2006). For the current study, as part of reliability analyses, Cronbach alpha coefficient was found to be .85.

*Critical Thinking Tendency Scale.* In order to determine the participant students' critical thinking tendencies, 'UF/EMI Critical Thinking Disposition Instrument,' which was created as the outcome of Delphi project conducted by American Philosophy Association in 1990 and was translated to Turkish by Ertaş (2012), was used. The scale was formulated as 5-item Likert type and it consisted of 25 items. In the validity studies conducted within the scope of the current study, $x^2$/df was found to be 1.81. Moreover, RMSEA value was 0.078. The other good fit indexes were as follows: GFI=.87; CFI=.76; NNFI=.73. As a result of the reliability analyses, Cronbach alpha coefficient obtained from the whole scale was found to be .90.

### *2.3 Procedure*

Quasi-experimental design was used in the current study in which 121 seventh grade students attending an elementary school in central Konya during 2017-2018 education year participated. During the six-week application, six thinking hats technique was applied to the experimental group; on the other hand, in the control group, the flow of the already existing curriculum went on. However, before starting the steps of the application, the teachers in the experimental and the control groups were informed in detail about the applications in the study and conducting the lesson plans. In this way, it was thought that the applications would be completed in line with the purpose of the study.

Before the application in the experimental group, the students were provided with a detailed explanation on what kind of a technique STHT is with the help of various visuals and on how the topics in the lesson will be instructed in line with this technique. Six thinking hats technique had been used while teaching another topic before the teaching of the topics which were focused on within the scope of this study, i.e. household waste, recycling and chemistry industry, and during the application, it was tried to take some precautions against the possibility of internal validity being affected by the perception of a new teaching method and technique. During the applications, some reminders and evaluations about the meaning of each hat were made. Six thinking hats technique was implemented under the guidance of the course teachers in accordance with the outcomes of the topics of household waste, recycling and chemistry industry. The students were encouraged to be active during the whole lesson and to express their opinions in accordance with the duties they had in six thinking hats technique. For each topic focused on, the hat with the color which matched the students' opinion was given to the students and the students with the same color hat were asked to share their opinions. The course of the lesson conducted in the current study was explained below in order to set an example.

Within the framework of the chemistry industry related outcomes of 'The student realizes the contributions of the businesses in their immediate environment in the field of chemistry industry to society and the country's economy' and 'The student researches and presents the works of official/private institutions and non-governmental organizations which contribute to the development of our country's chemistry industry,' the course teacher asked the students what the word 'chemistry' means and what it connotes in order to draw their attention. The students were asked to share their knowledge in classroom environment and depending on the answers they gave to their teacher's questions, they were asked to represent hats with various colors, i.e. white, black, yellow, red, green and blue. The student wearing the white hat told his/her friends what 'chemistry' means, what 'chemistry industry' means, which institutions related with chemistry industry exist in our country and which occupations use the products of chemistry industry. The one with the black hat informed his/her friends about the harms given by chemistry industry to the environment and the living things, the negative effect of the products produced by chemistry industry on the health of human beings, the negative effect of using hair dyes on the hair, the harm to the ecosystem in the soil caused by the use of pesticides and the greenhouse effect caused by the perfumes by providing several examples. The student with the yellow hat, in opposition to the student with the black hat, mentioned how chemistry industry makes people's lives easier, its benefits for the living things, the fact that people prefer hair dyes, and the fact that pesticides allow fast production and financial gain. In this way, the student explained why chemistry industry is indispensable to our lives and added a new dimension to the discussion by mentioning its contribution to the country's economy. The student wearing the red hat stated that she/he liked dying her/his hair in different colors, and that she/he liked the products produced via chemistry industry a lot, but she/he feels frightened about the future when she/he remembers the possible dangers these products pose. The one with the green hat told her/his friends that it is possible to produce a self-cleaning carpet with the help of chemistry industry, and in this way, a great need will be satisfied, and mothers' lives will be easier. The student with the blue hat, on the other hand, redirected the questions she/he has received to her/his friends and summarized the speeches of the other five students with different colors of hats.

The procedure of the lesson given above continued for six weeks in the experimental group. However, in the control group, the teaching of the outcomes regarding the topics of household waste, recycling and chemistry industry was conducted through the teaching methods and the techniques that the course teacher used in the previous lessons. This application is different from the one in the experimental group because the teacher was more active, the book was more frequently used, and the topics were taught through lecturing and question and answer technique.

## 3. Data Analysis

In order to find answers to the research questions of the study, independent samples t-test and multivariate analysis of variance (MANOVA) were used.

## 4. Results

The statistical analyses of the pre-test and post-rest data for AAT, ADMQ and CTI which were implemented within the scope of the study are given under the titles descriptive and inferential statistics.

### *4.1 Findings of the Descriptive Statistics*

The measures of central tendency and dispersion were determined for the pre-AAT and post-AAT scores of the $7^{th}$ grade elementary students who participated in the study (Table 1), their pre-ADMQ and post-ADMQ scores (Table 2), and their pre-CTI and post-CTI scores (Table 3).

Table 1
*Descriptive statistics for the AATscores*

| AAT | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Pre-test | Post test | Pre-test | Post-test |
| N | 66 | 66 | 55 | 55 |
| mean | 14.69 | 18.50 | 15.78 | 16.78 |
| median | 15.00 | 19.00 | 16.00 | 17.00 |
| Mod | 19.00 | 20.00 | 15.00 | 17.00 |
| Standart dev. | 4.18 | 2.75 | 3.89 | 4.31 |
| skewness | -.44 | -.77 | -.98 | -.38 |
| kurtosis | -.78 | -.03 | 1.03 | 1.60 |

According to Table 4.1, it was observed that there was a difference of 3.81 points between the experimental group pre-test (14.69) and post-test (18.50) average data. It was calculated that the average increase in the control group's pre-AAT and post-AAT data was 1.00. It was found that there was an increase in the averages in both groups, but this increase was more obvious in the experimental group. Moreover, when median and mode values as measures of central tendency regarding both the experimental and the control groups' pre-test and post-test data were analyzed, it was thought that these values were close to each other and the data gathered belonged to normal distribution. In this regard, when skewness and kurtosis values were also examined, it was found that all values were between -2 and +2 (Gravetter & Wallnau, 2014), which was considered an important finding for normal distribution.

Within the scope of the study, ADMQ was also implemented in order to determine the decision-making states of the elementary students who participated in the study, and the findings of the data gathered regarding the descriptive statistics are given in Table 2.

Table 2
*Descriptive statistics for the ADMQ scores*

| DMQ | Experimental group | | Control group | |
|---|---|---|---|---|
| | Pre-test | Post-test | Pre-test | Post-test |
| N | 66 | 66 | 55 | 55 |
| mean | 35.72 | 38.36 | 36.94 | 37.67 |
| median | 34.00 | 35.50 | 35.00 | 37.00 |
| mod | 27.00 | 27.00 | 34.00 | 34.00 |
| standard dev. | 10.96 | 12.23 | 9.45 | 9.70 |
| skewness | 1.06 | 1.29 | 1.04 | 1.62 |
| kurtosis | 1.66 | 1.96 | 1.76 | 2.17 |

According to Table 2, the difference in the averages of the ADMQ pre-test and post-test data in the experimental group was higher than the ones in the control group. Moreover, when the values examined in order to collect evidence for normal distribution were considered, it can be said that the skewness and kurtosis values of the experimental and the control groups were between the range which is considered as normal distribution, and the mean, median and mode values of the pre-ADMQ and post-ADMQ data in the control group were close to each other.

The last scale which was used within the scope of the study in order to determine the students' critical thinking tendencies was CTI. The values concerning the experimental and the control groups are given in Table 3.

Table 3
*Descriptive statistics for the CTI*

| CTI | Experimental group | | Control group | |
|---|---|---|---|---|
| | Pre-test | Post- test | Pre-test | Post-test |
| N | 66 | 66 | 55 | 55 |
| mean | 95.82 | 99.25 | 96.05 | 100.00 |
| median | 96.50 | 98.50 | 97.00 | 102.00 |
| mod | 106.00 | 97.00 | 94.00 | 101.00 |
| standard deviation | 16.72 | 17.35 | 17.79 | 14.01 |
| skewness | -.463 | -1.27 | -1.45 | -.554 |
| kurtosis | -.394 | .1.90 | 2.05 | .282 |

According to CTI data of the experimental and control groups, it was seen that a difference between pre-CTI and post-CTI in both groups arose, but this difference was similar in both groups.

When the analyses of the normal distribution of CTI were examined, the mean, median and mode values of post-CTI values of the experimental group and pre-CTI and post-CTI values of the control group were close to each other, and the skewness and kurtosis values were between -2 and +2 (Gravetter & Wallnau, 2014).

*4.2 Findings of the Inferential Statistics*

In order to understand whether the experimental and the control groups were different in terms of AAT, ADMQ and CTI data before the application, independent samples t-test was conducted, and in order to understand whether these groups were different in terms of dependent variables after the application, multivariate analysis of variance (MANOVA) was implemented.

*4.3 The Analysis of the Assumptions*

It is necessary to check some certain assumptions such as normal distribution, the equality of group variances and the independence of the data before the statistical analyses. Firstly, the findings obtained regarding the normal distribution of AAT, ADMQ and CTI data were explained in detail above under the title of 'Findings of the Descriptive Statistics.' It was assumed that the data regarding each of the three dependent variables had a normal distribution. In order to check the assumption regarding the homogeneity of group variances, Levene equality of error variances test was carried out and the findings are given in Table 4.

Table 4
*Levene's test for AAT, ADMQ ve CTI scores*

| Tests | Levene tests | |
|---|---|---|
| | F | p (Sig.) |
| pre-AAT | 1.41 | .237 |
| pre-ADMQ | .392 | .533 |
| pre-CTI | .578 | .449 |
| post-AAT | .010 | .899 |
| post-ADMQ | 3.61 | .06 |
| post-CTI | 1.11 | .294 |

It was seen that the group variances of AAT, ADMQ and CTI pre-test and post-test values were homogeneous ($p>.05$) in the study (Table 4). It was observed that the situation was not against the assumption of the equality of group variances. In addition to the assumptions regarding the normal distribution of the data and the equality of the group variances, the sample number required especially for the multivariate analysis of variance and other assumptions such as the equality of covariance matrices for all groups were also checked.

It was thought that the sample size of the current study met the requirement that the sample size in studies with multiple variables should be preferably 10 times or more of the number of variables (Büyüköztürk, 2010). For another assumption, the equality of variance-covariance matrices for all groups, the findings from the Box's M test were taken into consideration. In this analysis, the fact that Box's M test was not statistically meaningful ($p>.05$)

was interpreted as that the related premise was met. However, in this study, the significance value of Box's M test was found to be .003 and it was seen that the assumption regarding the homogeneity of the covariance matrices could not be met. In this case, based on the evaluations in the related literature, it was understood that the number of the participants might affect the significance of Box's M test (Tabachnick & Fidell, 2007). In the light of the information acquired, it was decided that if the ratio of the greatest sample size to the smallest one was 1.5 or less, the fact that the significance value of Box's M test was meaningful was not considered a serious violation (Stevens, 2002). This ratio was 1.2 in the current study and it was thought that it is appropriate to conduct MANOVA. However, it was decided that Pillai's Trace value be used instead of Wilks' Lambda value while evaluating the findings of MANOVA (Tabachnick & Fidell, 1996).

*4.4 The Results of the Analysis*

In order to see whether the experimental and the control groups were different in terms of pre-AAT, pre-ADMQ and pre-CTI values before the experimental application, independent samples t-test was conducted. It was seen that the experimental and the control groups were not different in terms of pre-AAT, pre-ADMQ and pre-CTI scores before the application, and they are similar to each other in terms of their pre-test score averages (Table 5).

Table 5
*Independent t-test results regarding pre-AAT, pre-ADMQ and pre-CTI scores of experimental and control groups*

| Test | Varyans | df | Sig. (2-tailed) |
|---|---|---|---|
| pre-AAT | Equal | 119 | .146 |
| | Not equal | 117.53 | .143 |
| pre-ADMQ | Equal | 119 | .519 |
| | Not equal | 118.84 | .513 |
| pre-CTI | Equal | 119 | .940 |
| | Not equal | 112.25 | .941 |

In order to see whether the experimental and the control groups were different in terms of post-AAT, post-ADMQ and post-CTI values, MANOVA was conducted. The dependent variables of the study were post-AAT, post-ADMQ and post-CTI scores, and the independent variables were the different teaching methods and strategies implemented in the two groups. The findings obtained after the analyses are given in Table 6.

Table 6
*MANOVA Results*

| Effect | Pillai'sTrace | F | Hyp. df | Error df. | p (sig.) |
|---|---|---|---|---|---|
| Group | .075 | 3.172 | 3.00 | 117.00 | .027 |

As it is mentioned in Table 6, when all the three variables of the study were evaluated together (combined dependent variable), a statistically meaningful difference between the experimental and the control groups was observed (Pillai's Trace = .075 F (3, 117) = 3.172, p = .027). It was seen that the independent variable of the study had an effect on at least one of the three variables. In order to identify the dependent variable which caused this significant difference between the experimental and the control groups, the Test of Between-Subjects Effects was conducted, and the results are given below (Table 7).

Table 7
*ANOVA Results*

| Source | Dependent variables | df | Mean squares | F | Sig. |
|---|---|---|---|---|---|
| Group | post-AAT | 1 | 88.564 | 7.027 | .009 |
| | post-DMQ | 1 | 14.321 | .115 | .735 |
| | post-CTI | 1 | 87.319 | .344 | .558 |

It was seen that the difference between the experimental and the control groups was caused by the post-AAT dependent variable (F (1, 119) =7.027, p= .009) and in terms of post-ADMQ ((F (1, 119) =.115, p= .735) and post-CTI (F (1, 119) =.344, p= .558), no significant difference was observed.

## 5. Discussion and Conclusion

In the study, the effect of six thinking hats technique on 7th grade elementary students' academic achievement in the topics of household waste, recycling and chemistry industry, their decision-making states and their critical thinking tendencies was investigated. The effect of six thinking hats technique implemented in the experimental group and the effect of the already existing curriculum carried out in the control group on the students' academic achievements in the topics of household waste, recycling and chemistry industry were compared and it was found that the average increase was in favor of the experimental group. Findings similar to the ones obtained in the current study exist in the related literature (Uçar, 2019; Arıcı, 2016; Kaya, 2013; Ayaz Can, 2005). For example, in the study by Arıcı (2016), it was stated that six thinking hats technique made a positive contribution to 7th grade students' academic achievement in science lesson. Likewise, in the study by Uçar (2019), which was carried out with 5th grade students, it was claimed that implementing six thinking hats and jigsaw techniques coordinately had a positive effect on the students' learning in the World of Living Things unit. Just as seen in the current study, using six thinking hats technique in different lessons had a positive effect on students' academic achievements in the topics in which the application took place. In this regard, it is thought that six thinking hats technique can be used in the teaching of the topics which educators and course teacher consider appropriate.

Within the scope of the present study, in addition to the effect of six thinking hats technique on the students' academic achievement, its effect on the students' decision-making states and critical thinking tendencies was also investigated. According to the findings of the study, no significant difference was observed in the post-ADMQ and post-CTI averages of the experimental and the control groups. This situation is different from the ones in some of the studies in the related literature. For instance, Akkılıç (2018) revealed the positive effect of activities based on six thinking hats technique on high school students' creativity, critical thinking and academic self-efficacy. Similarly, Kenny (2003) stated that six thinking hats technique might positively affect critical thinking and the ability to find solutions to the patients' problems in nursing. Different from the limited number of studies mentioned above, in the study by Çakmak (2015), which examined the effect of example cases and six thinking hats activities on the critical thinking abilities of the pre-service science teachers, the methods implemented did not cause a significant difference in the participants' critical thinking abilities. Furthermore, it is known that the effect of six thinking hats technique on critical thinking and decision-making abilities is not frequently investigated in the related literature. Therefore, making a comprehensive evaluation and making a comparison with the existing research studies were not possible much while interpreting the findings obtained in the current study. During the experimental application, it was observed that the students were pleased with the implementation of six thinking hats techniques. The fact that this procedure was not too long, that the application was limited to the topics of household waste, recycling and chemistry industry in order for the students to form different and new perspectives, and that unfortunately, the technique was not carried out for a whole education year or during the whole semester might have resulted in such kind of a finding.

Various suggestions on some important points for the future studies to be conducted in the light of the findings obtained through the study are listed. Firstly, it was found that six thinking hats technique was effective in science courses of 7th grade elementary students. In this regard, science teachers can implement six thinking hats technique in the topics covered in the curriculum if they think it is appropriate to do that. Implementing this technique might be beneficial not only in science courses, but also in other courses such as social sciences and Turkish. The effects of these applications, which aim to increase students' academic achievement, on some other characteristics such as self-efficacy, motivation and perceptions of learning might also be investigated. Moreover, by using other teaching methods and techniques which are compatible with six thinking hats technique, investigations on critical thinking tendency and critical thinking states, in which no significant difference was observed in the current study, can also be conducted. It is also important to implement the methods and techniques chosen for the study in different grade levels in order to make comparisons.

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