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The Effect of Journal Writing, One of the "Writing to Learn" Activities, on Achievement and Science Attitude in the Fourth Grade Science Course*

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Keywords
Writing to learn, Fourth grade students, Journal writing, Academic achievement, Science attitude.

Abstract
The purpose of this study is to examine the effects of journal writing, which is one of the "writing to learn" activities, on students' academic achievement, learning retention, and attitudes towards science in the elementary school fourth grade science course unit called "Illumination and Sound Technologies". Quasi-experimental research design, one of the quantitative research methods, was used in the study. The population of the study consists of a total of 44 fourth grade students, with 24 students in experimental group and 20 students in control group, studying in a state elementary school located in Yakutiye, Erzurum. After the pre-test was administered to the participants, the students in the experimental group students wrote a journal as a "writing to learn" activity for each section of the unit for five weeks. Science Course Achievement Test (SCAT) and Attitude Scale for Science Course (ASS) were used as a data collection tool. Kolmogorov-Smirnov test of normality, Mann Whitney U, Wilcoxon signed rank test and independent t-test were used for the research data analysis. The pre-test findings of the research revealed that there was no statistically significant difference between the achievement levels of the students in the experimental and control groups. When the experimental and control group students' SCAT post test data values were compared, it was found that there was a statistically significant difference in favour of experimental group writing a journal, which is one of the "writing to learn" activities (WTL). When the experimental and control groups' retention data analysis were examined, it was revealed that there was no statistically significant difference between the groups A statistically significant difference was found between the experimental group's pre-test and post-test scores regarding the attitude scale for science course but it was determined that there was not a significant difference between the control group's pre-test and post-test scores.

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1. Introduction

Writing activities are regarded as an effective way for students to gain, use, and retain knowledge for a long time in their memory (Arı, Demir & Yıldırım, 2016). "Writing to learn" activities, which have been frequently used recently activate students during the learning process and turn teachers into guides and facilitatora (Akçay, Özyurt & Bezir Akçay, 2014; Doğan & İlhan, 2016) and these activities enable students to do research about the topic, reconcile, and reach the highest level by forcing their knowledge level (Akçay & Baltacı, 2017; Günel, 2009; Özturan Sağırlı, 2010; Uzun & Alev, 2013; Yıldız, 2014; Yıldız & Büyükkasap, 2011a; Yıldız & Büyükkasap, 2011b). Writing to learn develops communication skills and thus enables individuals to express themselves and retain their learning. The writing that is discussed is not to copy what the teacher explains in the lesson but is a piece of writing in which an individual organizes what he knows about the topic and writes it using his/her own words (Yıldız, 2014).

Many studies were carried out about the effect of writing on learning, academic achievement, and retention of knowledge. Hand and Prain (2002) stated that non-traditional writing activities were effective in the learning of scientific knowledge. Writing is an activity, which helps students think critically and generate new knowledge (Klein, 1999). Writing activities that are used in determining and eliminating misconceptions (Mason & Boscolo, 2000) can help ideas to develop, to be consistent and solid (Yıldız, 2014).

Prain and Waldrip (2006) in their study, stated that different factors affected students' understanding of different modes and asserted that the students in the experimental group who recognized the relations between the different modes exhibited much better conceptual understanding than the students in the control group.

Reaves, Flowers and Jewell (1993) in their study, stated that "writing to learn" activities had a positive effect on students' learning and attitudes and also promoted their confidence in writing. Tynjälä (1998) maintained that writing activities composed in group discussions during the lessons provided understanding and conceptual change and thus promoted a higher level of learning. Moreover, the students in the experimental group stated that their study and communication skills increased.

Beretier and Scardamalia (1987) proposed two models called "knowledge-telling" and "knowledge-transforming". In the knowledge-telling model, the writer probes knowledge in his memory and creates texts. In this model, the success of an individual depends on the amount of the knowledge stored in his memory. In the knowledge-transforming model, knowledge is shaped with the problem solving process (Beretier & Scardamalia, 1987; Erduran Avcı & Akçay, 2013). In cases of being displeased with the concepts, knowledge is transformed with writing, new content is generated, and the writer develops a new understanding about the topic. In the other studies conducted (by Akyol & Dikici, 2009; Ay, 2018; Baltacı, 2013; Bozat & Yıldız, 2015; Çavuş, 2015; Çömen, 2018; Demirci, 2016; Duymaz, 2011; Eker & Coşkun, 2012; Günel, Hand & Prain, 2007; Günel, Uzoğlu & Büyükkasap, 2009; Koçak, 2013; Öztürk, 2014; Tynjälä, 1998; Yıldız & Büyükkasap, 2011a;

Yıldız & Büyükkasap, 2011b), the aim was to develop the relationship between writing and theoretical learning but it can be stated that there are experimental studies, which concentrate on determining the effects of "writing to learn" activities on learning.

According to Bereiter and Scardamalia (1989), a writing activity forces an individual to express his/her opinions concisely and precisely. Baltacı (2013) carried out a study by using multiple writing activities, which had positive effects on students' academic achievement, on learning the concepts of astronomy, and attitudes towards science course and concluded that writing to learn science method did not cause a significant change in students' science process skills.

Using different ways of learning in elementary schools can enable students to understand, focus on, comprehend, and interpret the subject they have to learn. When the studies carried out about the effectiveness of WTL activities were examined, it was found that they facilitated learning, synthesis, and analysis and developed communication and study skills (Akçay & Baltacı, 2017; Choi, Notebaert, Diaz, & Hand, 2010; Doğan & İlhan, 2016; Günel, 2009; Günel, Kabataş Memiş & Büyükkasap, 2009; Uzun & Alev, 2013).

It was stated in a study (Uzoğlu & Gürbüz, 2013:505-506) that the use of writing activities had four main benefits: 1) They are helpful in eliminating misconceptions, developing communication and study skills. 2) They help individuals gain a quite consistent and well-based knowledge by developing their opinions. 3) They enable to make knowledge permanent and thus promote newly learned concepts to be reinforced. 4) They enable individuals to use and practice their prior knowledge and make the learning of difficult concepts possible.

Journal writing is a written record of a person's feelings, opinions, experiences, and observations (Creative writing now, 2019). Journal writing is an activity, which develops a person's sense of identity, helps a person gain critical thinking skill (Williford, 2019), and generates new ideas (Ho, 2019). Generating new ideas or creative thinking develops a person's feelings of open-mindedness, permanence, positivity, and curiosity (Ho, 2019).

Waywood (1992:35) classified journal writing into three categories including recount, summary, and dialogue. A reflective journal, called "science notebook" by many scientists, was written. The purpose of these journals is to record data, analyse, and synthesise the information in their minds. Journals act like a source, which enables students to review their opinions and the ways they use to reach these opinions. It is stated that reflective journals are particularly effective for shy and introvert students who do not want to join in class-discussions (Goerghides, 2004; Çavuş, 2015:6).

In the study carried out by Özturan Sağırlı (2010), it was stated by the participants that journal activities were effective in the better understanding of some concepts, in detecting unknown sections, and actualizing more permanent learning. It was determined in the same study that writing a journal in the lesson led students to monitor themselves and raised their self-awareness and the reflective course journals enabled students' active participation in the lesson.

Reflective course journals were considered as an effective implementation in terms of students' monitoring their own learning and reflection of opinions in the study carried out by Eker and Coşkun (2012:111). Çardak, (2010) in his study explored the effect of science journal on academic achievement and attitudes towards science and technology and concluded that writing a science journal increased students' academic achievement and had a positive effect on their attitudes towards science.

Çavuş (2015) concluded that science journals had a positive effect on students' academic achievement and metacognitive awareness. Demirci (2016) emphasized that the use of student journals had a positive effect on students' academic achievement and metacognitive awareness.

Kocabaş Yılmaz (2013) explained in his study that research-based learning strategy assisted by electronic journals had a positive effect on students' academic achievement. It was revealed in the same study that there was no statistically significant difference between the subjects' attitudes towards science and technology course and science process skills; however, during the research process, the students stated that electronic journals increased their motivation, that they learned via learning by doing and practising, and e-journals contributed to their science process skills.

Uslu (2009) graded the daily journal writing activity, which lasted nine weeks in science and technology course and mathematics course with a rubric. At the end of the implementation, individual interviews were carried out with volunteer students. It was found that students considered journal writing as a fun activity and their communication with their teacher increased. It was also detected that the students who wrote journals could share their opinions and feelings much better, they could study for the exams easily and in a short time, and their learning became permanent. Tuncel and Ayva (2009) aimed at determining the reflective journals' degree of attaining objectives in social studies course. The researchers stated that reflective journals provided students an opportunity to review their lessons and thus had an effect on their achievement.

Emig (1977) stated that among the basic tools such as speaking, listening, reading and writing, which provide communication between people, writing activity was a strong learning strategy and claimed that writing to learn was a unique way of learning. According to Arı and Yıldırım (2017), writing is one of the most effective ways of gaining and retaining knowledge for a long time in memory. . Apart from the traditional use of writing, in today's education system, it is necessary to use writing in line with innovative methods and environments in which students are active and teachers are facilitators. Yıldız (2016) asserted that activities of "writing to learn" could be used in the third and fourth grade science courses in elementary schools based on the documents analysed in his study.

An attitude, which is often a result of experiences or upbringing refers to an emotional and cognitive tendency of an individual toward a particular object, person, thing, or institution and it has a powerful influence over behaviour. Thus, attitudes have a power to have a positive or negative influence on learning (Özgüven, 2004). One of the important aims of schools in science education is to

develop a positive science attitude. According to De Boo, teachers can develop attitudes such as creativity, open-mindedness, and inventiveness in science education. While developing attitudes, student experiences must stand out and the attitudes must be implemented in parallel with the course content. Student experiences can be developed in class environments consisting of positive attitudes (as cited in Loxley, Dawes, Nicholls & Dore, 2016:67).

The Purpose of the Study

This study aims at examining the effects of journal writing, one of the "writing to learn" activities (WTL), on students' academic achievement, retention of learning, and attitudes towards science in elementary fourth grade science course unit called "Illumination and Sound Technologies".

2. Method

2.1. The Research Design

The study was carried out via quasi-experimental design, one of the quantitative research methods, with the intention of investigating the effects of journal writing, one of the "writing to learn" activities (WTL), on students' academic achievement, retention of learning, and attitudes towards science in elementary fourth grade science course unit called "Illumination and Sound Technologies". Because the groups identified in the research are selected without any pre-selection methods among the classes, the study has a quasi-experimental design (Altunışık, Coşkun, Bayraktaroğlu & Yıldırım, 2010; Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz & Demirel, 2013; Creswell, 2017; Gürbüz & Şahin, 2018; Punch, 2005). The pre-test administered to the groups before the implementation process at the beginning help to determine their similarity levels and the post-tests help to compare implementation results and to determine the effectiveness of intervention (Özmen, 2015).

2.2. The Study Group

The population of the study consisted of a total of 44 fourth grade elementary school students, with 24 students in the experimental group and 20 students in the control groups, studying in a state school located in Yakutiye, Erzurum in the 2018-2019 education year. The experimental group consisted of 10 female and 14 male students while there were 10 female and 10 male students in the control group. SCAT was administered to four classes among the fourth grades, which did not start studying "Illumination and Sound Technologies" unit and out of the two classes whose arithmetic means were close to one another; one of them was selected as an experimental group and the other one was selected as a control group.

2.3. Implementation

1) After the necessary permission was obtained from Erzurum Provincial Directorate of National Education, Yakutiye, attitude scale for science course and SCAT were administered to both experimental and control groups as pre-tests.

2) The instruction for journal writing prepared by the researcher was distributed to the students at the beginning of the study and unclear questions and points were explained.

3) The unit called "Illumination and Sound Technologies" consisted of five sections. The unit was taught by the class teacher by using existing methods based on the curriculum. The experimental group students were asked to write a journal as a WTL activity at the end of each section for five weeks.

4) It was approved that journal writing activity could be performed at home. The journals written by the students were checked and accepted the next day by the researcher.

5) The class teachers in the control group were observed to teach the "Illumination and Sound Technologies" unit by using the existing methods based on the curriculum and at the end of the unit, questions about the unit were answered. (or problems were solved).

6) At the end of the unit, the attitude scale for science course and SCAT were administered to both the experimental and the control groups as a post-test on the same day.

7) SCAT was administered to both the experimental and the control groups at the same time three weeks after the post-test.

2.4. Data Collection Instruments

2.4.1. Academic achievement test

Science Course Achievement Test (SCAT) was developed by examining the course book, the other books written on the topic, item banks, the previous questions asked in the placement tests by considering unit outcomes and doing research on the internet. The item bank was developed by involving questions about each objective in order to provide content validity. The type of questions for the fourth grade elementary school students included true/false, gap filling, and multiple choice. The questions were examined and proof-read by two experienced teachers who taught science in the past and one instructor and then the necessary changes were made considering their suggestions and opinions. The piloting of the test consisting of 45 questions was performed with the 5th graders and the questions' item difficulty and item discrimination were calculated.

Among the SCAT questions that were developed and piloted, the items whose distinctiveness were negative or smaller than 0,20 were excluded or redesigned. The test questions were reviewed by the same team of experts and new items were added to the test. Therefore, a test consisting of 40 questions was developed and piloted by a different group of experts. Split-half reliability, which is frequently used for scale development and adaptation studies is carried out by splitting a set of data into two equal halves and measuring the consistency between two equal

sets. The test's split-half reliability was calculated by using SPSS program and it was found that Spearman-Brown correlation value was .87 and Guttman Split-Half coefficient reached the highest level of .86. These values exhibit that the scale's reliability is higher (Seçer, 2017:214-217). The test items were reduced to 25 questions including 5 true/false, 5 gap filling, and 15 multiple choice questions developed considering each objective of the unit and eventually they were finalized. The unit achievement test was administered to the experimental and control groups as pre-test and post-test and as a retention test three weeks after the pre-test and post-test.

2.4.2. Attitude scale towards science course

The Attitude Scale Towards Science and Technology developed by Kenar and Balcı (2012) in order to determine students' attitudes towards science was updated and transformed into Attitude Scale towards Science Course. The 5 point Likert scale response options for each item include "Strongly Agree", "Agree", "Undecided", "Disagree", and "Strongly Disagree". The positive items begin with "Strongly Agree" and the negative items begin with Strongly Disagree" and they are scored as 5, 4, 3, 2, 1. Five items in the scale involve positive statements (7, 9, 10, 11, 12) and seven of them involve negative statements (1, 2, 3, 4, 5, 6, 8).

The points in the scale are between 1.00 and 5.00, so it is accepted that when the points get closer to 5.00, students' participation levels are high and when the points get closer to 1, their participation level is low. It will be possible to have an ideaabout the students' attitudes towards science with the score that will be obtained by dividing the total item points into the number of statements marked by a student (Çavuş, 2015) . Thus, if an individual gets lower than 2.60 from the science course attitude scale, this will mean that s/hehas a negative attitude and if s/hegets higher than 2.60, this will mean that s/he has a positive attitude.

Kaiser-Meyer-Olkin, (KMO) which gives information about the adequate sample size in exploratory factor analysis varies between 0 and 1. According to Pallant, the KMO value must be at least 0.60 and above. In our study, after the first implementation, it was found that KMO value was .68 and it was at an adequate level. It was found that significance level of Barlett's test was 0.00. The scale's reliability coefficient was α=.73 in the pre-test implementation of the study.

2.5. Data Analysis

In order to perform the data analysis of the research, firstly skewness and kurtosis values of the data distribution and normality values (Kolmogorov-Smirnov) were checked.

Table 1. Skewness and Kurtosis Coefficients and Normality Values for Pre-test, Post-test, Retention Tests, and Attitude Scale Implementations

Dependent variable	n	Ort.	Ss.	Skewness	Kurtosis	Kolmogorov-Smirnov	p
Achievement pre-test	44	63.75	17.24	-.362	-.772	.079	.000
Achievement post-test	44	74.13	18.22	-.629	-.735	.156	.001
Achievement retention test	44	72.95	18.96	-.499	-.417	.101	.200
Attitude pre-test	44	4.01	.642	-.703	-.804	.228	.009
Attitude post-test	44	4.29	.719	-1.176	1.034	.177	.200

When the table about the normality of data was examined, it was found that the Skewness-Kurtosis coefficients of the implementations were between the range of (±1.96) (George & Mallery, 2010). According to Akbulut, when the normality values were n>30, parametric tests were used because retention test data and attitude post-test values exhibited normal distribution with Kolmogorov-Smirnov values (p>.050). Because pre-test achievement post-test achievement, and pre-test attitude data were not distributed normally (p<.050), non-parametric tests were used (Seçer, 2017).

Because the comparison of SCAT pre-test data related to the "Illumination and Sound Technology" could not provide the independent samples t-test assumption of normality, Mann Whitney U test was used. Mann Whitney U test is a non-parametric alternative to the independent t-test and it has two main assumptions. These assumptions are that the scores related to the dependent variable should be at least at the level of the ranking scale and the samples should be independent (Büyüköztürk, 2007:155-158; Seçer, 2017).

Because the comparison of the SCAT post-test values of the experimental and control groups could not provide the post-test assumptions of normality, Mann Whitney U test was used. Calculating the retention test mean scores and standard deviations of the experimental and control groups, independent samples t-test was used to test the significance of the differences between the mean scores of the groups. Independent Samples t-test involves the comparison of the means of two independent groups (Akgül & Tanrıseven, 2019).

Wilcoxon signed rank test, non-parametric test, was used to analyse the pre-test and post-test measurements of the attitudes of experimental and control groups towards science course because the pre-test attitude data could not provide the assumption of normality.

3. Findings

3.1. A comparison of the experimental and control group students' pre-test scores regarding "illumination and sound technologies" unit

Before beginning to teach the subjects related to the elementary school fourth grade unit called "Illumination and Sound Technologies", SCAT was administered as a pre-test and post-test to the experimental and control group students. The analysis of the data obtained at the end of the implementation was performed with Mann Whitney U Test. The results are presented in Table 2.

Table 2. The Results of Mann Whitney U Test regarding Experimental and Control Group Students' "Illumination and Sound Technologies" Unit Pre-test Scores

Pre-test	n	Mean Rank	Sum of Ranks	U	p
Experimental Group	24	24.29	583	.197	.311
Control Group	20	20.35	407		

When the Mann Whitney U test values given in Table 2 are examined, it is observed that the experimental and control groups' mean ranks and sum of ranks are close to one another. When the groups' mean ranks and sum of ranks are close to one another, it reveals that the students' achievement levels are close to one another. When the p value is examined, it can be assumed that there is no significant difference for the experimental and control groups before the implementation and the groups are equal to one another ($U=.197$, $p>.05$).

3.2. A comparison of the experimental and control group students' post-test scores of performing journal writing activity

Table 3. The Results of Mann Whitney U Test Regarding the Experimental and Control Group Students' "Illumination and Sound Technologies" Unit Post-test Scores

Post-test	n	Mean Rank	Sum of Ranks	U	p
Experimental Group	24	27.10	650.50	129.50	.009
Control Group	20	16.98	339.50		

When the results presented in Table 3 are examined, it is found that there is a statistically significant difference in favour of experimental group students ($U=129.50$; $p<.05$). According to the findings obtained, it can be stated that journal writing, which was performed as a WTL activity has positive effects on academic achievement.

3.3. The effect of journal writing as a writing to learn activity on learning retention

Three weeks after the implementation of SCAT as a post-test, it was administered to the experimental and control group students again for the unit "Illumination and Sound Technologies" to measure groups' learning retention. As a result of the implementation, the data obtained from the experimental and control groups were analysed via independent samples t-test. Table 4 presents the t-test results regarding the retention of the unit "Illumination and Sound Technologies".

Table 4. T-test results of the Experimental and Control Group Students Regarding the Retention of the Unit "Illumination and Sound Technologies"

Retention Test	n	$\overline{X}$	Sd.	t	p
Experimental Group	24	77.86	19.38	1.942	.059
Control Group	20	67.06	17.08		

When the independent samples t-test results for the SCAT administered as a retention test in Table 4 are examined, it is revealed that there is difference (10.8) between the mean scores of the experimental (77.86) and control groups (67.06); however, this difference is not statistically significant ($t_{42}=1.942$; $p>.05$). Considering the data obtained, it can be stated that journal writing performed in the experimental group as a WTL activity does not have an effect on retention.

3.4. A comparison of control group students' pre-test and post-test scores for attitudes towards science course

Attitude Scale towards Science Course was administered to the control group for the unit "Illumination and Sound Technologies" in two different times, before teaching the unit and after learning the unit. The data obtained were analysed with Wilcoxon Signed Rank test, which is a non-parametric equivalent to the dependent samples t-test.

Table 5. Wilcoxon Test Results of the Control Group Students' Pre-test and Post-test Scores of Attitude Towards Science Course

Control Group	n	Mean Rank	Sum of Ranks	Z	p
Negative rank	11	9.09	100.0	-.201	.840
Positive rank	8	11.25	90.0		
Equal	1				

Table 5 presents the Wilcoxon Signed Rank test results for the control group regarding the data of the Attitude Scale towards science course. It is revealed that the control group's pre-test and post-test scores' mean ranks are in favour of positive ranks and considering the sum of ranks, they are in favour of negative ranks ($z=-.201$; $p>.05$).

3.5. A comparison of experimental group students' pre-test and post-test scores regarding attitudes towards science course

Table 6. Wilcoxon Test Results of the Experimental Group Students' Pre-test and Post-test Scores of Attitudes Towards Science Course

Experimental Group	n	Mean Rank	Sum of Ranks	Z	p
Negative rank	3	10	30.0	3.291	.001
Positive rank	20	12.30	246.0		
Equal	1				

When Table 6 is examined, it is discovered that the difference between the pre-test and post-test scores of the Attitude Scale towards Science Course, which was administered to the experimental groups five weeks after journal writing as WTL activity was in favour of positive ranks or post-test. It can be stated that journal writing as a WTL activity affected experimental group students' attitudes towards the science course positively ($z=3.291$, $p<.05$).

4. Results and Discussion

When the post-test scores of the experimental group students who performed a journal writing activity for five weeks and the control group students who solved the questions at the end of the unit were compared, it was found that there was statistically significant difference in favour of the experimental group. According to the findings obtained, it was revealed that journal writing, which was performed by the experimental group students as a WTL activity had a positive effect on academic achievement and thus increased academic achievement. There are studies showing similarities to the result obtained. According to the study carried out by Çavuş (2015), journal writing as a WTL activity has positive impacts on students' achievement and metacognitive awareness. Tuncel and Ayva (2009), in their study stated that journal writing activity provided students with an opportunity to review their lessons and thus affected achievement. Kocabaş Yılmaz (2013) concluded that research-based learning strategy supported with electronic journals had positive effects on students' learning science and technology course and achievements. Çardak (2010) stated that journal activity increased academic achievement at the end of the study. Özturan Sağırlı (2010) remarked that students' interest in the course increased and their attention and motivation enhanced. There are other studies in the literature about the positive effects of WTL activities on academic achievement (Akyol & Dikici, 2009; Ay, 2018; Bahadır, 2011; Baltacı, 2013; Bozat & Yıldız, 2015; Çavuş, 2015; Çömen, 2018; Demirci, 2016; Duymaz, 2011; Eker & Coşkun, 2012; Erol, 2010; Günel, Uzoğlu & Büyükkasap, 2009; Koçak, 2013; Öğdük, 2011; Öztürk, 2014; Özyurt, 2011; Tynjälä, 1998; Yıldız & Büyükkasap, 2011a; Yıldız & Büyükkasap, 2011b).

When the independent t-test results for SCAT administered as a retention test were examined, it was revealed that there was a difference between the experimental and control groups, but it was not a statistically significant difference. According to this result, it can be stated that the journal which was performed as a WTL activity had no effects on retention. Bozat and Yıldız (2015) in their study reached similar results. There are studies in literature stating that WTL activities have effects on retention (Doğan & İlhan, 2016; Eker & Coşkun, 2012; Koçak, 2013; Koçak & Seven, 2016; Uslu, 2009).

When the pre-test and post-test mean rank scores and sum of ranks of the Attitude Scale towards Science Course, which was administered to the experimental groups five weeks after journal writing as a WTL activity were examined, it was revealed that there was a significant difference in favour of post-test but the difference was not significant for the control group. Thus, it can be concluded that journal writing as a WTL activity has positive effects on experimental group students' attitudes towards science course. The researchers who reached similar results to the research finding (Baltacı, 2013; Çardak, 2010; Daşdemir, 2017; Reaves, Flowers & Jewell, 1993) determined that using WTL activities had positive effects on students' attitudes. On the other hand, Akyol and Dikici (2009), Erol (2010), Bahadır (2011), and Külekçi (2018) in their studies, concluded that WTL activities did not have an impact on students' attitudes. Kocabaş Yılmaz (2013) emphasized that there were participants suggesting that writing an electronic journal did not

cause a statistically significant difference in students' attitudes towards science but increased their motivation and science process skills.

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