ORIGINAL ARTICLE

# The Effect of Using Critical Reading in 5th Grade Science on Students' Academic Achievement, Science Performance and Creativity

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***Abstract**: Abstract: This study examined the effect of using critical reading in scientific texts on students' academic achievement, science performance level and creativity. The study was conducted with 5th grade students in Ereğli, Zonguldak during the 2017-2018 academic year. The study group consisted of a total of 34 students, 17 in the experimental group and 17 in the control group. Activities based on critical reading were carried out with the experimental group, whereas traditional activities from the 5th grade science curriculum were employed with the control group. The "Multiple Choice Academic Achievement Test", the "Science Performance Level Test" and the "Torrance Test of Creative Thinking" were administered to both groups as a pre-test prior to the study and as a post-test once the study was completed. The data were analyzed with the dependent and independent samples t-Test using the SPSS package program. The study results revealed a significant difference in science performance level and creativity between the experimental and control groups favoring the experimental group. However, there was no significant difference in academic achievement between the experimental and control groups. Critical reading practices can be used in science lessons to improve students' high-level skills, and critical reading activities can be developed alongside scientific texts for multiple grade levels.*

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# Introduction

READING, one of the basic language skills, has an important place in the intellectual life of individuals. Perception, sense-making, acquiring new knowledge and reusing this knowledge in communicative processes are largely based on reading. The act of reading helps individuals improve their vocabulary and increases the complexity of their thought processes. In its simplest form, reading is defined as the ability to extract meaning from a written text (Snow, 2002). Reading, however, is not just a simple act of recognizing words by skimming a text. In fact, reading is a language skill with many components that needs to go through a mental activity process (Katrancı & Kuşdemir, 2016). One of the main objectives of the Ministry of National Education's Turkish Teaching Curriculum (2019) is "to enable students to assess and question what they read with a critical perspective after comprehending what they read". Giving individuals critical thinking beyond reading comprehension, reading enables them to make sense of their environment and produce effective solutions to complex problems. At this juncture, the most important goal of the reading process is the development of critical reading skills (Flynn, 1989). As part of the critical thinking process, the concept of critical reading has been put forward as a model approach, especially in education, to clarify the complex process simply described as "reading". Critical reading does not mean careful and detailed reading (Yu, 2015), rather, critical reading is defined as thinking about a text, pondering over the rights and wrongs of the text, and interpreting the subject in the text (Aşılıoğlu, 2008). Literacy Gains (2009) describes critical reading as an attitude, emotional and intellectual behavior, and mental stance that a reader exhibits while reading a text. According to Paul and Elder (2008), critical reading is the science and art of examining and assessing the text by adopting a view on improving the nature of one's thinking. Critical reading requires a deep and active interaction with the text (Sutherland & Incera, 2021). It also requires readers to use higher-order thinking skills such as analysis and synthesis, problem-solving and metacognitive thinking skills to discuss the meanings extracted from the text with the author and constructs new meanings (Hermida, 2009 as cited in Sutherland & Incera, 2021). The four basic elements of critical reading are; determining the author's point of view, identifying the primary claims and the main idea, finding the supporting details used to strengthen the thoughts, and assessing the supporting details (Maker & Lenier, 1996). Determining the purpose and main idea of the text, analyzing the reliability, comparing the new information with the previous information, comparing the information in the text with other sources, understanding the implicit or unspoken parts of the text, understanding the author's purpose and to whom he/she is addressing, and determining the author's point of view on the subject are among the critical reading skills. In

the literature, being able to distinguish facts and opinions, make predictions based on certain parts of the text, determine the type of text, identify the language characteristics used by the author, assess the text by asking questions, draw conclusions and summarize the text with the reader's own words are also expressed as critical reading skills (Emiroğlu, 2014).

In the present study, critical reading skills were used to understand scientific texts. Effective use of language and literacy skills in science education is quite important (Osborne, 2020) because language and literacy are among the most important tools used in almost every stage of science, from making scientific explanations to promoting innovative products. Almost every aspect of the phenomenon called "information" is language. This means that the key to understanding a subject is to understand its language (Postman & Weingartner, 1971). For many students, the biggest obstacle to learning science, or at the same time the most important achievement, is learning its language. The functionality of science is related to the richness of the terms and concepts used, and generally, all teaching and learning activities take place using the verbal and nonverbal language environment (Wellington & Osborne, 2001). Effective use of language in science is closely associated with the concept of scientific literacy. Norris and Philips (2003) listed some of the components of scientific literacy as distinguishing real scientific information from fake information, understanding science, and scientific applications, understanding what is considered science, using scientific knowledge in problem-solving, comprehending the risks and benefits of science, and thinking critically about science. At this juncture, using critical reading practices is one of the most important ways to improve scientific literacy skills.

In the literature, there are many studies conducted to examine the effectiveness and usefulness of critical reading (Camp & Camp, 2013; Gyuris & Castell, 2013; Akın et al., 2014; Jarman et al., 2012; Özensoy, 2021). McClune and Jarman (2010) drew attention to some points in the critical reading of scientific news and made various recommendations. According to the researchers, the main purpose of media is not to educate, but to achieve economic gain and to entertain and persuade the reader. Thus, critical readers should be careful about what is written in newspapers. Although there are a number of studies within existing educational programs relating to the critical reading of scientific texts, these studies should be discussed with an interdisciplinary approach. In addition, the development of critical reading skills depends on the quality of interdisciplinary studies. In a study conducted with 4th grade students, a direct relationship between teachers' experiences and practices was found. The aforementioned study also determined that students learned to question texts, criticize social justice and injustice and engaged in social actions using critical literacy approaches, and finally, each student was able to learn to read critically (Krug, 2010). A

study conducted by Koray and Çetinkılıç (2020) concluded that the use of critical reading in understanding scientific texts significantly increased the academic performance and problem-solving skills of 7th grade students. Additionally, Ünal (2006) aimed to determine the degree of relationship between 5th grade students' critical reading skill levels, their reading comprehension levels and their attitudes towards reading. According to the results, there was a significant high-level relationship between the critical reading skill levels and the attitudes, and a moderate-level relationship between the critical reading skill levels and the reading comprehension levels. Another study that explored the relationship between critical reading and cognitive learning put forth that the learning of students who have reached university level was limited to the comprehension level of remembering. Meaning, they were able to memorize what they read, but did not have critical reading skills. Furthermore, low-level reading makes it difficult to achieve learning at the applying, analyzing, synthesis, and evaluation levels, which are the upper levels of the cognitive domain (Aşılıoğlu, 2008). A study designed to determine teacher beliefs about critical reading strategies on teaching English in foreign language classrooms revealed that teachers' critical reading strategies played a very important role in students' understanding of reading materials (Kien & Huan, 2017). In another study, it was revealed that the critical reading training program improved teacher candidates' metacognitive reading strategies and media literacy levels (Karabay, 2015).

As can be seen, there is a great deal of research on critical reading in the literature. However, customized educational programs or interdisciplinary practices for different disciplines and subject areas are needed in order to enable individuals to acquire critical reading skills. Specifically, the use of critical reading skills in understanding scientific texts in science courses is also important for the development of scientific literacy. Testing the effectiveness of such practices, which are expected to have certain common points in terms of high-level thinking skills, is only possible with scientific studies. More empirical research on critical reading with an interdisciplinary approach and interpretation of these results can increase the quality and proliferation of such practices. Critical reading skills are mostly used in language education. Thus, it is believed that the present study, which focuses on the use of critical reading skills in the field of science, a different discipline, will contribute to the literature in the field.

The purpose of the present study is to examine the effect of critical reading practices in science on students' academic achievement, science performance level and creativity. In line with this study purpose, the sub-problems of the study are as follows:

1. Is there a significant difference between the academic achievement gain scores of the experimental group in which the critical reading practices

were carried out and the control group in which the methods appropriate to the science curriculum were carried out?

   i. Is there a significant difference between the academic achievement pre-test and post-test scores of the experimental group in which critical reading practices were carried out?
   ii. Is there a significant difference between the academic achievement pre-test and post-test scores of the control group in which methods appropriate to the science curriculum were carried out?

2. Is there a significant difference between the science performance level gain scores of the experimental group in which the critical reading practices were carried out and the control group in which methods appropriate to the science curriculum were carried out?
   i. Is there a significant difference between the science performance level pre-test and post-test scores of the experimental group in which critical reading practices were carried out?
   ii. Is there a significant difference between the science performance level pre-test and post-test scores of the control group in which methods appropriate to the science curriculum were carried out?
3. Is there a significant difference between the creativity gain scores of the experimental group in which the critical reading practices are carried out and the control group in which methods appropriate to the science curriculum were carried out?
   i. Is there a significant difference between the creativity pre-test and post-test scores of the experimental group in which critical reading practices were carried out?
   ii. Is there a significant difference between the creativity pre-test and post-test scores of the control group in which methods appropriate to the science curriculum were carried out?

# Method

The study employed the quasi-experimental method. The experimental method is used to determine the effect of the variables identified by the researcher and to test the cause and effect relationship between the variables.

The four characteristics of experimental research are; the comparison of the groups, manipulation of the independent variable, randomness, and control of extraneous variables (Fraenkel & Wallen, 2006). Comparable procedures are conducted in experimental studies, their effects are examined, and the results allow the researcher to obtain the clearest interpretations (Büyüköztürk, 2014). In this study, the pre-test-post-test control group design was used. In this design, without any selection process, the participants are assigned to two groups, the experimental and the control group. Meas-

**Table 1. Standard Notation of the Study Design.**

| Group | Measurement I | Experimental Design | Measurement II |
|---|---|---|---|
| Ge | $MCAAT_1$<br>$SPLT_1$<br>$FPDT_1$ | Activities about critical reading practices | $MCAAT_2$<br>$SPLT_2$<br>$FPDT_2$ |
| Gc | $MCAAT_1$<br>$SPLT_1$<br>$FPDT_1$ | Activities appropriate to the science curriculum | $MCAAT_2$<br>$SPLT_2$<br>$FPDT_2$ |

*Ge: The experimental group in which critical reading practices were carried out*

*Gc: The control group in which methods appropriate to the science curriculum were used MCAAT: Multiple Choice Academic Achievement Test for the People and Environment Unit*

*SPLT: Science Performance Level Test for the People and Environment Unit*

*TTCT: Torrance Test of Creative Thinking*

urements are done in the groups before and after the experimental application. Before the application, tests are administered to both groups at the same time and measurements related to the dependent variable are taken. The experimental procedure based on the independent variable is carried out in the experimental group, whereas applications appropriate for the curriculum are carried out in the control group. The administered pre-tests are also administered as post-tests and the scores of the two groups are compared using appropriate techniques (Sönmez & Alacapınar, 2011).

In the current study, the independent variable whose effect on the experimental group was examined was determined as critical reading practices. With the control group students, the lessons were conducted using activities deemed appropriate by the Ministry of National Education's 5$^{th}$ Grade Science Curriculum. The standard notation of the study design is presented in **Table 1**.

## *Study Groups*

The study was conducted with 5th grade students in Ereğli, Zonguldak during the 2017-2018 academic years. A total of 34 middle school students were included in the study. Two of the 5th grade classrooms were randomly assigned, one as the experimental group (17 students) and the other as the control group (17 students). It was assumed that there was no interaction between the groups during the study that would affect the experiment. There were six female and 11 male students in the control group, and five female and 12 male students in the experimental group. While activities based on critical reading were carried out in the experimental group, control group students were taught with methods provided by the Ministry of National Education's 5$^{th}$ Grade Science Curriculum. The duration of the periods in the

experimental and control groups and the classroom's environmental conditions were kept equal. Critical reading activities were used by the researcher for the first time. No additional applications or activities were offered to any of the groups.

## *Equivalence of the Groups*

To ensure the equivalence of the groups, the 4th grade average scores of the students in the experimental and control groups and the 5th grade science average scores of the 1st semester were compared using the independent samples t-test. According to the results, both groups were equivalent in terms of the determined variables. In addition, both groups' pre-tests were examined, and according to the independent samples t-test results, the experimental and control groups were found to be equal in terms of their academic achievement, science performance and creativity pre-test scores.

## *Procedures Carried Out*

Multiple Choice Academic Achievement Test (MCAAT), Science Performance Test (SPLT) and Torrence Test of Creative Thinking Test (TTCT) pre-tests were administered to both groups after the equivalence of the groups was determined. The study included the 5th grade science "Biodiversity" and "Relationship between People and Environment" portion of the curriculum. Activities-based critical reading practices were carried out with the students in the experimental group. In the control group, instruction was carried out using methods and techniques provided by the 5th grade science curriculum such as the activities in the textbook and the Education Information Network application, direct instruction, discussion, experimentation, demonstration, question-answer, etc. The study was carried out by the second researcher in the experimental and control groups. At the end of the application, the MCAAT, SPLT and TTCT post-tests were administered to both groups. The study lasted for seven weeks, including the pre-test and post-test administration periods.

## *Procedures Related to the Development of the Critical Reading Practices*

Before developing activities for the experimental group, the literature on critical reading was examined and scientific articles, periodicals, theses, dissertations, and books were investigated. Opinions were exchanged with two experts who had previously conducted scientific research on critical reading, about the critical reading objectives, activity worksheets, and certain situa-

tions that may be encountered during the implementation phase. The scientific texts covering the subjects of the 5th grade "People and Environment" unit were selected by examining the texts written in the last 20 years using the e-archive of TÜBİTAK (Scientific and Technological Research Institution of Turkey) Publications Science Children's Journal. Among these texts, five scientific texts named "Moas", "Our Unique Orchids", "They Are in Danger", "Living Beings Tell Us If There Is Pollution in Nature" and "Climate Change", which best covered the 5th grade science People and Environment unit learning objectives and were appropriate for the 5th graders in terms of critical reading practice and students' language skills, were selected. The texts were on the relationship between people and the environment, environmental pollution, the factors causing environmental problems, extinct and endangered living organisms, and the reasons behind this. The opinions of two science teachers were taken to ensure the content of the selected texts adequately addressed unit learning objectives and whether it was appropriate for the students' ages. Furthermore, the selected texts were examined by two Turkish language teachers and were found appropriate for the application of critical reading and the students' grade level. A total of five activities consisting of five parts and 12-16 questions related to the reading texts were developed. Activity questions were formed by taking into account the predetermined critical learning objectives. Sections from the selected texts were quoted and questions open to discussion were added. While developing the activity worksheets, attention-grabbing and text-related visuals suitable to the 5th grade level were used. The questions in the activity worksheets were examined by two field experts and found appropriate to critical reading objectives and students' language levels. Lasting five periods, each activity consisted of five parts and was carried out as follows:

*Part 1*: Part 1 included the title of the text to be read and three questions to be answered by making inferences from the title. The activity worksheet called "Inference from The Title', Part 1, was distributed to the students. First, students were asked to examine the group of words in the title and to guess what the text would be about and for what purpose the author wrote the text. After presenting some visual elements related to the text, students were asked to establish a relationship between these elements and the text. Then, the students were divided into groups and they shared and discussed the inferences they made about the title with each other.

*Part 2*: The activity worksheet including the entire text was distributed to the students. They were asked to read the text, and it was recommended to write down the words they did not know and the text keywords in the notes section next to the text while they read. They were also asked to underline the parts of the text that they found important and interesting. Then, they were divided into groups and they tried to understand the text better by discussing it with each other.

*Parts 3 and 4*: At the beginning of the lesson, students were asked to look at the parts they noted and underlined to express their opinions about the text. Later, an activity worksheet consisting of 7-8 questions on average, which included the critical reading objectives and the learning objectives of the "People and Environment" unit "Human and Environment", was distributed to the students. After each question was answered, the students were given the opportunity to express their opinions and the answers were opened up for discussion. Students were also given the opportunity to question the type of text, the reliability of the information given by the author, the relevancy of the information, and the author's values and attitudes towards the subject. The questions in this part aimed to reveal students' prior knowledge by associating the subject with their own lives.

*Part 5*: The final part involved the evaluation of the text. In this part, the students were given an activity worksheet consisting of questions that include critical reading objectives that enabled them to question the main idea of the text, supporting ideas, the sources of information used by the author, and the conclusions the author reached. After each question, students' views were taken and opened up for discussion. Students were asked questions that encouraged them to relate what they deduced from the text to their own lives.

## *Data Collection Tools*

In the study, the MCAAT was used to determine students' academic achievement levels in the "People and Environment" unit, the SPLT to determine students' science performance levels and the TTCT to determine students' creative thinking levels.

## *Multiple Choice Academic Achievement Test (MCAAT)*

The MCAAT includes questions on the learning objectives of "Biodiversity" and "Relationship between People and Environment". While most of the questions are at the knowledge, comprehension, and application level, there are also questions at the analysis and evaluation levels. After reviewing various resources related to the test, thirty multiple-choice questions, five for each learning objective, were developed. For the content validity of the test, three experts in science were consulted and necessary revisions were made based on their input. For the reliability of the test, the test was also administered to 67 students currently in the $6^{th}$ grade. According to the results of the item analysis performed using the Iteman program, the Cronbach's alpha reliability coefficient of the 30-question test was found to be 0.80. The minimum score that can be obtained from the test is 0, whereas the maximum score that can be obtained from the test is 100. The MCAAT was ad-

ministered to the experimental and control groups as a pre-test and post-test. The administration of the MCAAT lasted 40 minutes.

The minimum score that can be obtained from the test is 0, whereas the maximum score that can be obtained from the test is 100.

## *Science Performance Level Test (SPLT)*

Developed to determine students' science performance levels, the Science Performance Level test (SPLT) includes questions on the learning objectives of the "People and Environment" unit. The questions are at the analysis, synthesis, and evaluation levels of Bloom's cognitive domain taxonomy. For the development of the test, the last 15 years' Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMMS) questions were examined. The test included seven open-ended questions related to five questions, which were taken among the PISA and TIMMS questions as written or with minor revisions. In order to ensure the suitability of the questions used in the SPLT to the learning objectives of the $5^{th}$ grade "People and Environment" unit and students' levels, the test was reviewed by three Science experts and found to be appropriate. In addition, in order to determine the appropriateness of the questions for $5^{th}$ grade in terms of language skills, two Turkish Language experts were consulted and they found the test appropriate. The SPLT was administered to the experimental and control groups as a pre-test and post-test. The administration of the SPLT lasted 40 minutes. The inter-rater reliability coefficient of the test was determined as 0.92.

The minimum score that can be taken from the test is 0, and the maximum score is 100.

## *Torrance Test of Creative Thinking (TTCT)*

Developed to determine students' creativity, the TTCT assesses the dimensions of creativity, fluency, flexibility, originality, and elaboration. According to Sternberg and O'Hara, fluency refers to the total number of pictures completed by the individual in the activities and flexibility refers to the inclusion of different subjects in the pictures completed in the activities and the number of them in different categories. While originality refers to the number of pictures with an original thought in the completed pictures, elaboration refers to how much detail the individual can give in the completed drawings (cited in Aksoy 2005). Developed by Torrance, the TTCT was found a valid and reliable measurement tool in the studies conducted with children in the United States, and its validity and reliability were approved by many researchers (cited in Aslan, 2001). The TTCT is made up of two parts, a "Verbal Test" and a "Figural Test". There are 2 different types of

TTCT Formal Test, Form A, and Form B. In this study, the Figural A form was administered to the students. The Figural A Form has three subsets of activities, namely Picture Construction, Picture Completions, and Parallel Lines. All three activities involve picture completion (Torrance, Ball, & Safter 2008). The TTCT's Form A was administered to the experimental and control groups as a pre-test and post-test. The administration of the test lasted 30 minutes. Necessary explanations were made to the students for the activity parts of the test. While completing the pictures, they were informed that they could create any object they imagined, and they should not restrict their thoughts. The data were evaluated by the researcher and another expert, and the inter-rater reliability was calculated as .88. The minimum score that can be obtained from TYDT is 0, and the maximum score is 120.

## *Data Analysis*

In the study, how the variables of academic achievement, science performance and creativity were distributed among the experimental and control groups were examined. The suitability of the pre-test and post-test scores of the experimental and control groups to normality for all variables was analyzed with the Shapiro-Wilks test. As a result of the analysis, the normality test p significance values determined for both groups were found to be greater than .05, thus meeting the normality assumptions. In order to test whether there was a significant difference between the variables of academic achievement, science performance level and creativity between the experimental and control groups, the data obtained were analyzed with the independent samples t-Test using the SPSS package program. In the independent samples t-Test analyzes, calculations were made on the difference (gain) scores between the post-test and pre-test scores of these four variables. The dependent samples t-Test analysis was performed to determine whether there was a difference between the experimental and control groups before and after the study. Thus, the study findings were obtained, and the related interpretations were made by accepting the significance level of. 05.

## *Measures Taken against Threats to the Internal Validity of the Study*

For the threats against the internal validity of the study, first, selection bias was examined by taking into account students' grade point averages of the previous year, their science grades of the previous semester, as well as their pre-test results. It was determined that there was no difference between the groups in terms of these variables. It was assumed that the maturity effect would occur equally in all experimental conditions by using random assign-

ment. In the present study, it was assumed that the maturity effect was taken under control by assigning the groups randomly. None of the students in the study groups had previously participated in critical reading practices. In addition, since there was no significant event related to the dependent variables of the study and the utilization process before the application, any past effects did not affect the study. There was also no loss or gain of participants during the study with both groups remaining constant. Measuring tool effect, as a different threat type, was mitigated in both applications using the same items, the same order of administration of tools, and the same data collector. Additionally, regarding the administration of the measurement tool, five weeks is considered sufficient to prevent the pre-test effect. Furthermore, researcher bias was prevented by using an independent observer in both groups.

# Findings

In this section, study findings are presented in order of the sub-problems.

## *Findings and Comments on the First Sub-Problem*

In order to examine the first sub-problem of the study, independent samples t-Test was performed, and the results are given in **Table 2**.

**Table 2** shows that although the academic achievement score of the experimental group ($\overline{x}$ = 11.06) seemed to be slightly higher than the control group ($\overline{x}$=10.24), there was no significant difference between these two groups ($t_{(32)}$ = 0.33, p > 0.05). According to this finding, critical reading practices did not make a significant difference between the groups in terms of the academic achievement variable.

The results of the dependent samples t-Test analysis regarding "item a" of the first sub-problem are shown in **Table** 3.

**Table 3** shows that there was a significant difference between the academic achievement pre-test and post-test scores of the experimental group ($t_{(16)}$ = 8.70, p < 0.01, $\eta^2$ = 0.83). The academic achievement post-test scores of the experimental group ($\overline{x}$ = 73.53) were higher than their pre-test scores ($\overline{x}$ = 62.47). According to this finding, critical reading practice was effective in increasing the academic achievement scores of the experimental group.

The results of the dependent samples t-Test analysis regarding the item b of the first sub-problem are shown in **Table 4**.

Table 4 shows that there was a significant difference between the academic achievement pre-test and post-test scores of the control group ($t_{(16)}$ = 4.87, p < 0.01, $\eta^2$ = 0.6). The academic achievement post-test scores of the experimental group ($\overline{x}$ = 72.18) were higher than their pre-test scores ($\overline{x}$ =

**Table 2. Independent Samples t-Test Analysis Results of the Experimental and Control Groups according to the Academic Achievement Variable.**

| Group | N | x̄ | S | SD | t | p |
|---|---|---|---|---|---|---|
| Experimental | 17 | 11.06 | 5.24 | 32 | 0.33 | 0.74 |
| Control | 17 | 10.24 | 8.67 | | | |

**Table 3. Dependent Samples t-Test Analysis Results of the Experimental Group according to the Academic Achievement Variable.**

| Measurement | N | x̄ | S | SD | t | p |
|---|---|---|---|---|---|---|
| Pretest | 17 | 62.47 | 15.54 | 16 | 8.70 | 0.00 |
| Posttest | 17 | 73.53 | 17.36 | | | |

**Table 4. Dependent Samples t-Test Analysis Results of the Control Group according to the Academic Achievement Variable.**

| Measurement | N | x̄ | S | SD | t | p |
|---|---|---|---|---|---|---|
| Pretest | 17 | 61.94 | 18.46 | 16 | 4.87 | 0.00 |
| Posttest | 17 | 72.18 | 21.18 | | | |

**Table 5. Independent Samples t-Test Analysis Results of the Experimental and Control Groups according to the Science Performance Variable.**

| Group | N | x̄ | S | SD | t | p |
|---|---|---|---|---|---|---|
| Experimental | 17 | 30 | 17.59 | 32 | 2.55 | 0.016 |
| Control | 17 | 15.88 | 14.60 | | | |

**Table 6. Dependent Samples t-Test Analysis Results of the Experimental Group according to the Science Performance Variable.**

| Measurement | N | x̄ | S | SD | t | p |
|---|---|---|---|---|---|---|
| Pretest | 17 | 29.71 | 18.58 | 16 | 7.03 | 0.00 |
| Posttest | 17 | 59.71 | 17.54 | | | |

61.94). According to this finding, teaching based on the science curriculum was effective in increasing the academic achievement scores of the control group.

## *Findings and Comments on the Second Sub-Problem*

In order to examine the second sub-problem of the study, independent samples t-Test was performed, and the results are given in **Table** 5.

**Table 5** shows that there was a significant difference between the science performance level scores of the experimental and control groups ($t_{(32)} = 2.55$, $p < 0.05$, $\eta^2 = 0.17$). The science performance level scores of the experimental group ($\overline{x} = 30$) were higher than the control group scores ($\overline{x} = 15.88$). According to this finding, critical reading practices caused a significant difference between the experimental and control groups according to the science performance variable in favor of the experimental group.

The results of the dependent samples t-Test analysis regarding item a of the second sub-problem are shown in **Table 6**.

**Table 6** shows that there was a significant difference between the science performance pre-test and post-test scores of the experimental group ($t_{(16)} = 7.03$, $p < 0.01$, $\eta^2 = 0.76$). The science performance post-test scores of the experimental group ($\overline{x} = 59.71$) were higher than their pre-test scores ($\overline{x} = 29.71$). According to this finding, critical reading practices were effective in increasing the science performance scores of the experimental group.

The results of the dependent samples t-Test analysis regarding the item b of the second sub-problem are shown in **Table 7**.

**Table 7** shows that there was a significant difference between the science performance pre-test and post-test scores of the control group ($t_{(16)} = 4.48$, $p < 0.01$, $\eta^2 = 0.56$). The science performance post-test scores of the control group ($\overline{x} = 51.18$) were higher than their pre-test scores ($\overline{x} = 35.29$). According to this finding, teaching based on the science curriculum was effective in increasing the academic achievement scores of the control group.

## *Findings and Comments on the Third Sub-Problem*

In order to examine the third sub-problem of the study, independent samples t-Test was performed, and the results are given in **Table 8**.

**Table 8** shows that a significant difference was found between the creativity scores of the experimental and control groups ($t_{(32)} = 2.68$, $p< 0.05$ $\eta^2 = 0.18$). The creativity scores of the experimental group ($\overline{x} = 4$) were higher than the scores of the control group ($\overline{x} = -2.47$) (the negative value of the score is due to the "gain" score, that is, the difference between the post-test and pre-test and the group's post-test scores were lower than the pre-test

**Table 7. Dependent Samples t-Test Analysis Results of the Control Group according to the Science Performance Variable.**

| Measurement | N | x̄ | S | SD | t | p |
|---|---|---|---|---|---|---|
| Pretest | 17 | 35.29 | 27.87 | 16 | 4.48 | 0.00 |
| Posttest | 17 | 51.18 | 29.40 | | | |

**Table 8. Independent Samples t-Test Analysis Results of the Experimental and Control Groups according to the Creativity Variable.**

| Group | N | x̄ | S | SD | t | p |
|---|---|---|---|---|---|---|
| Experimental | 17 | 4 | 7.77 | 32 | 2.68 | 0.012 |
| Control | 17 | -2.47 | 6.21 | | | |

**Table 9. Dependent Samples t-Test Analysis Results of the Experimental Group according to the Creativity Variable.**

| Measurement | N | x̄ | S | SD | t | p |
|---|---|---|---|---|---|---|
| Pretest | 17 | 67.24 | 9.23 | 16 | 7.03 | 0.05 |
| Posttest | 17 | 71.24 | 9.86 | | | |

**Table 10. Dependent samples t-Test Analysis Results of the Control Group according to the Creativity Variable.**

| Measurement | N | x̄ | S | SD | t | p |
|---|---|---|---|---|---|---|
| Pretest | 17 | 68.24 | 7.08 | 16 | 1.64 | 0.12 |
| Posttest | 17 | 65.76 | 7.36 | | | |

scores). According to this finding, critical reading practices were effective in increasing the creativity scores of the experimental group.

The results of the dependent samples t-Test analysis regarding the item of the third sub-problem are shown in **Table 9**.

**Table 9** shows that there was a significant difference between the pre-test and post-test scores of the experimental group according to creativity ($t_{(16)} = 7.03$, $p = 0.05$, $\eta^2 = 0{,}22$). The creativity post-test scores of the experimental group ($\bar{x} = 71.24$) were higher than their pre-test scores ($\bar{x} = 67.24$). According to this finding, critical reading practices were effective in increasing the creativity scores of the experimental group.

The results of the dependent samples t-Test analysis regarding the item b of the third sub-problem are shown in **Table 10**.

**Table 10** shows that there was no significant difference between the pre-test and post-test scores of the control group according to creativity ($t_{(16)} = 1.64$, $p > 0.05$). The pre-test scores of the control group ($\bar{x} = 68.24$) were higher than their post-test scores ($\bar{x} = 65.76$). According to this finding, curriculum-based education was not effective in increasing the creativity scores of the control group.

# Discussion

According to the study findings, there was a significant increase in the academic achievement scores of the experimental group using the critical reading practices and the control group using 5$^{th}$ grade science curriculum activities. However, there was no significant academic achievement gain score difference between the experimental and control group. Additionally, the study found a significant increase in the science performance levels of both the experimental and control groups. Even though both groups improved, the significant science performance level difference between experimental and control group favored the experimental group and showed the effectiveness of critical reading practices on increasing students' science performance levels. Although critical reading practices were not effective in increasing the success in multiple-choice tests containing questions from the lower levels of the cognitive domain taxonomy (knowledge, comprehension, and application), critical reading practices were effective in increasing the success in questions from the upper levels of the cognitive domain taxonomy (analysis, synthesis, and evaluation). Multiple studies and research concur with this study's findings showing the upper level cognitive domain benefit of using critical reading practices (Çetinkılıç, 2017; Akın, 2014; Çam, 2016). Çetinkılıç (2017), in his study with 7th grade students, concluded that critical reading practices in science were effective in increasing students' academic achievement and science performance level. Working with 8th grade students, Akın (2014) put forth that critical reading practice in science increased

students' academic achievement. Çam (2016) revealed that critical reading increased academic achievement in Turkish in her study conducted with 5th grade students. In his study with 4th grade students, Alkaya (2006) concluded that science teaching based on critical thinking skills was effective in increasing students' academic achievement. In addition, Gyuris and Castell (2013) determined that university students with low performance were the students who benefited most from the short-term critical reading practice of scientific texts. Aşılıoğlu (2008) believes that cognitive learning largely depends on the individual's success in reading and that learning can only be realized at the upper levels of the cognitive domain taxonomy, specifically analysis, synthesis, and evaluation when reading is performed critically.

After application, there was a significant increase in creativity levels between students in the experimental group in which the critical reading practices were carried out and the students in the control group who were taught in accordance with the 5$^{th}$ grade science curriculum highlighting the benefit of critical reading practices in the classroom. Another study result showed a significant increase between creativity pre-test and post-test scores of the experimental group, but such an increase was not detected in the control group. According to Glaveanu (2014), critical reading is the first step toward awareness of creativity and taking responsibility. Also, according to Hoskins (2010), if the scientific articles in the newspapers are read according to the structured critical reading program he called "create", students will move away from passivity by taking responsibility for their own learning with exercises that require them to use their creativity. Liu (2019) is of the opinions that since English classes focus more on students' language proficiency, their critical thinking skills do not develop, and thus, their creative and innovative competencies do not increase. Another study conducted by Baki (2020) revealed that critical reading skills are an important determinant of the assessment skills of the creative reading process, and found a strong and positive relationship between critical reading skills and the assessment skills of the creative reading process. In her study examining the impact of an effective thinking education program on 9th grade students' creative thinking and problem-solving skills, Sarmaşık Kaya (2018) concluded that an effective thinking education program improved students' creative thinking and problem solving skills. Yurdakal (2018) found out that Turkish lessons constructed with creative reading increased students' creative reading perceptions, and attitudes towards reading, reading achievement and creative thinking skills.

One of the most important goals of science education is science literacy. Acquiring this skill is very important for individuals to relate scientific information to the real world, make correct inferences, and make appropriate decisions. The most important learning tools that contain scientific information are texts. It is considered that the scientific knowledge acquired by indi-

viduals who cannot read or write texts is seriously limited (Norris & Phillips, 2003). Critical reading requires an active communication process in which comments and evaluations can be made about the text material. In critical reading, the reader reads by asking questions about the contradictions, coherences, or incoherences in the thoughts or expressions in the text, and the reasons behind the writing of the text (Altunsöz, 2016). The critical reading of scientific information from scientifically prepared texts can give individuals an advantage in producing reliable and efficient solutions to very difficult real-life problems. Therefore, reading should not be seen only as a language course activity, but should also be included in science and other courses.

The use of such innovative practices, in which different disciplines are used together and which enables the perfection of a basic skill such as reading, at all levels of education is of great importance in terms of raising young people who are the guarantee of our future. In this context, the following recommendations can be made in line with the study results:

- Critical reading practices can be used in science so that students can develop their high-level skills.
- Critical reading activities including scientific texts can be developed for different grade levels.
- Science learning environments can be enriched in terms of students' other critical thinking skills such as researching, questioning, commenting, thinking, discussing, and creating a critical perspective.
- Measurement and evaluation tools can be prepared for the assessment of critical thinking and critical reading skills.
- Teachers who have an important role in teaching critical thinking and reading skills can be provided activity and skill-based training.

In addition, the effects of critical reading practices on different subjects and different course contents of science on various variables can be examined. The effectiveness of different methods and techniques can be tested in the context of teaching critical thinking and critical reading skills to students. Studies using different methodologies related to critical reading practices can be designed. This research was conducted with a limited number of students. Similar experimental studies can be designed with a larger number of participants for the use of critical reading activities in science lessons. The effectiveness of the applications for many variables such as learning science, critical thinking, reasoning, and problem solving can be tested by performing critical reading practices for all content, primarily socio-scientific subjects. Critical reading is only one of the critical thinking skills. At this point, the effectiveness of applications in which other critical thinking skills such as critical listening, open thinking, and Socratic inquiry are used and integrated with science contents can be tested through additional research. In this study, the main focus of critical reading practices involved reading text material and answering questions about the text. In future research, activities can be

prepared which not only utilize critical reading but also other critical thinking skills, and their effectiveness can be tested with experimental studies. This research was carried out using experimental design, one of the quantitative research methods. Further studies using qualitative research methods may provide evidence to gain in-depth knowledge about the overall research process.

***Limitations***

*The present study is limited to the "People and Environment" unit and was carried out over a period of five weeks, excluding the pre-test and post-test applications. The study was conducted with 34 students, and it was the first time students in the experimental group have encountered critical reading practices.*

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