

## **Effect of Multi Modal Representations on the Critical Thinking Skills of the Fifth Grade Students**

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### **Abstract**

The purpose of this study was to explore the effects of multi modal representations within writing to learn activities on students' critical thinking. Mixed method was used. The participants included 32 students 5th grade from elementary school. The groups were randomly selected as a control group and the other class was selected as the experimental group. Data collection tools has been Critical Thinking Test (CTT) and writing actives. The students were asked to tell their peers about the subjects in the unit with a writing activity using the summary writing type. The students performed three writing activities, one preparation and two real practice activities, in this process. The most basic dissimilarity between the groups is the request of the use of multimodal representations asked from the students in the experimental group. The Cronbach's alpha reliability coefficient of the CTT was determined as 0.72. The results of this study show that the use of the multi modal representations in writing to learn activities improved the scientific critical thinking of the students.

**Key Words:** Writing to learn, multi modal representations, critical thinking.

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## Introduction

Writing is a communication tool we use in everyday life. Mankind has always established communication through writing no matter what time and place they were in (Graham & Perin, 2007). Writing has also become an important instrument for scientists to make science and share their thoughts with others. It is known that writing could be used in learning (Emig, 1977; Hohenshell & Hand, 2006; Sampson et al., 2013). Considering learning as a cognitive process; learning-oriented writing is related with experiences and thoughts of the writer (Greenstein, 2013). Writing studies that are conducted at schools and homework are effective upon developing the thinking processes of students (Walker, 2003). Science expects learners to develop their capacities of creative thinking and critical thinking (Hand & Prain, 2002). Sometimes things may expect to be explored and writing could be an efficient way of revealing that thing (Flower & Hayes, 1980). Learning by writing has become a new pace for students to comprehend profound concepts (Prain & Hand, 1999), distinguish misconceptions (Baker et al., 2008), develop critical thinking skills (Avcı & Akçay, 2013) and bring forward new ideas (Flower & Hayes, 1981).

One of the best ways of learning is to read many scripts and write about them, which is thought to be associated with the subject to be investigated (Condon & Riley, 2004). Writing activities in classrooms are performed for different purposes and in different ways. These writing activities generally include traditional writing applications like summarizing a book, taking notes of what are written on the board and preparing laboratory reports (Yore, 2000). In traditional writing applications, students are usually expected to show knowledge and skills they have learned inside or outside the classroom (Çavdar & Doe, 2012). In traditional sense, writing education has been a process where students conduct researches by asking questions about the script and write down important points of the subject at the end of the research (Galbraith & Rijlaarsdam, 1999). In such writings, students may not be able to make explanations through investigating and questioning or justify their thoughts. Traditional writing education aims to measure how much students learn the knowledge rather than how they learn (Yore, 2000; Atilla, Günel & Büyükkasap, 2009). Qualified as innovative writing applications; structured writing applications aim to allow students to develop their thinking and writing performances and acquire some skills (Çavdar & Doe, 2012). Students may need applications that would allow them to learn how to develop their writing skills. Hand and Prain (1996), propounded a model which could enable to learning. This model consists of five components; subject of writing, type of writing, purpose of writing, interlocutor of the text written and the production method of the text (Hand & Prain, 2002). Hand and Prain (1996), suggest that it is possible to acquire effective and strong learning by using these five different elements in various ways. This model is important as it allows teachers to guide through writing applications that are conducted in science classes and shows students how and why they learn (Hand, Lawrance & Yore, 1999).

Learning-oriented writing activities make a positive contribution to students' learning and help them develop the skills of recollection, interpretation, consolidation and communication (Günel et al., 2009a). Effective learning tools like writing, which could be applied both inside and outside the classroom develop the thinking process of students (Walker, 2003). Through writing, students are able to evaluate their thoughts on paper and develop critical thinking skills (Çavdar & Doe, 2012). One of the advantages of using the writing applications in the classroom is that it enables learning by affecting the high level critical thinking skills (Hobson & Schafermeyer, 1994; Baker et al., 2008).

Critical thinking is basically a special state of natural thinking rather than a different type of thinking (Siegel & Carey, 1989). Ennis (1993), states that critical thinking is an indicator of reasonable, rational and reflective thinking in decisions about our beliefs or actions. Critical thinking, in the broadest sense, includes cognitive or intellectual skills like proving the accuracy, trueness and reliability of information or a claim, using various criteria in deciding on an issue, trying to obtain evidence concerning something that is read or heard, asking others to prove their claims and thoughts according to various bases before accepting them, as well as fairness, honesty, consistency and accuracy (Özdemir, 2005). It is known that critical thinking is a complex and extensive process that

requires top level cognitive skills (Kuhn, 1999; Güven & Kürüm, 2006) and allows individuals to learn the knowledge better, apply them to new conditions and develop the ability of evaluation (Semerci, 2003). However, writing to learn activities can improve a combination of many skills including metacognition, self monitoring and critical thinking (Chen, Hand & McDowell, 2013). Versions of good learning, teaching and judgment is directly associated with reflection (Wang & Lin, 2008). Students use writing in many different ways to advance reflection (Boud, 2001). Reflections on the process of learning recruit students to realise critical overview and enhance making sense about knowledge (Xie, Ke & Sharma, 2008).

Critical thinking skills might be expressed as an indicator of explanation, interpretation, prediction, analysis and evaluation (Abrami et al., 2008). Establishing open and supportive classroom environments where thoughts are expressed and examined freely within a discipline and learning environments where students can share and evaluate their thoughts will have positive effects upon acquiring critical thinking skills and tendencies (Seferoğlu & Akbıyık, 2006). Examining the literature concerning critical thinking; the concept can be classified in two categories: The first one includes giving consistent and logical justification, whereas the second one includes proving and questioning the present knowledge (Vandermensbrugge, 2004). Acquisition of critical thinking skills should be associated with some elements concerning justification, such as classroom studies, determination of problem, formation of assumptions, main idea, exploration of evidences, determination of concepts and ideas, exposure of differences or similarities and finalization (Celuch & Slama, 1999). Justification of thoughts, on the other hand, is performed by using comparisons, reasoning and evidences (Siegel & Carey, 1989). In the process of justification, it is required to evaluate ideas about a purpose and relevant concepts in terms of various theories or principles and try to explain them with the help of evidences or experiences (Paul & Binker, 1990). Students will develop critical thinking skills on condition that they use critical thinking methods like justification in the process of writing (Dixon et al., 2005). Many writers and even experts know how difficult it is to show evidences and justify their thoughts while writing (Galbraith & Rijlaarsdam, 1999). Students may also have a difficulty in showing evidences and justifying their thoughts while writing. Teachers are required to use teaching strategies that involve learning activities for students to acquire critical thinking skills (Vieira, Tenreiro-Vieira & Martins, 2011). It is known that learning-oriented writing activities will allow students to think, learn the concepts and make interpretations if they are arranged in such a way that they reveal the justification abilities of students in studies (Hand, Hohenshell & Prain, 2004).

Students could form representations to show their thoughts by writing and using different modes like diagrams, pictures and images (Hoban & Nielsen, 2011). Representations contain the interpretation and explanation of a scientific idea or concept by using modes like analogies, verbal statements, written texts, diagrams, graphics and simulations (Tang, Delgado & Moje, 2013). Even if different classifications are made for different purposes, the common general opinion about the modes are the categories of their being expressed with different demonstrations of the same concepts and operations representationally (texts, graphics, charts, tables), figuratively (pictorial, metaphorical, analogical), experimentally and mathematically (Waldrup, Prain & Carolan, 2006; Günel, Atilla & Büyükkasap, 2009). Using these multiple modal representations and showing scientific reasons and findings in connection with scientific sources will describe the knowledge (Waldrup, Prain & Carolan, 2006). Using multimodal representations is to describe the same concept again and again in different ways, describing it like the modes containing pictures, diagrams, tables, graphics and mathematical calculations and doing exercises (Prain & Waldrup, 2006). Structuring the knowledge by using multiple modal representations will enable learning (Jewitt, 2008; Prain & Waldrup, 2010). Understanding science is important for the students from the points of using multimodal representations and thus their seeing that they can understand (Tolppanen et al., 2013). Multiple modal representations are an inseparable part of scientific language (Tang, Delgado & Moje, 2013). Students are required to develop their description abilities for specializing in or learning scientific subjects (Ainsworth, Prain & Tytler, 2011). Thus, students need to learn scientific concepts (Atilla, Günel & Büyükkasap, 2009) and comprehend the variability of the modes concerning processes (Ainsworth, 2006). If students acquire an awareness in interpreting and structuring multiple modal representations,

they will learn how to explain and interpret scientific texts and acquire scientific literacy (Prain & Waldrup, 2010).

Haglund, Jeppsson and Andersson (2012), were found that young children's drawings as different kind of scaffolding (providing a complement to spoken and written language) affect children's reasoning. Children make drawings and they figured out representations of their ideas, reflection, judgement. Drawings may be seen as a tool that promote reasoning and communication (Haglund, Jeppsson & Andersson, 2012). Reasoning is associated to as explaining about concept with using models and relationships, making predictions or drawing outcomes supported by the data shown in representation (So, 2016). When students used model representations embeded writing to learn activities, they establish a connection between daily language and science language that provide individual reasoning and construction of scientific knowledge (Günel & Yeşildağ-Hasançebi, 2016). Reasoning is one of the most significant component for critical thinking. There for this study investigates the effect of using multiple modal representations in learning-oriented writing activities upon the critical thinking skills of fifth grade students. In this context, the study secondarily aims to evaluate writing activities with the help of rubric and determine the quality of writing.

## **Method**

### **Research model**

In this study, mixed research method was used. While the quantitative part of the study comprised of pretest-posttest control group pattern, which is among experimental methods; the qualitative part of the study comprised of case study in integrative single-state pattern. From this point of view, the students in the experimental group were asked to do writing to learn activities in which the use of multimodal representation was expected or demanded, aimed at the purpose of the research. On the other hand, the control group was only asked to perform learning-oriented writing instead of using multiple modal representations. Critical thinking skills of students were measured by applying the Critical Thinking Test as pretest-posttest and the data were collected by evaluating the learning-oriented writing activities prepared by students.

### **Participating Student-Teacher**

The working group consisted of totally 32 fifth grade students studying in two different classes of a secondary school in a village located in Northern Turkey during the school year of 2013-2014. Groups were selected randomly as control (17 students) and experimental group (15 students). The researcher who conducted the study is a teacher with 5 years of experience who applied the writing to learn activities in the classroom environment.

### **The Application Process**

CTT was applied to the students as the preliminary test in the beginning, as aimed at the purpose of the study. Writings /articles in Children's Science Magazine of TUBITAK (The Scientific and Technological Research Council of Turkey) magazine comprising a lot of representations were distributed to the students in both groups (the Experimental and the Control Groups) before the application and the students were asked to read them and express what they understood. Later, discussions about the multimodal representations were made with the students for them to comprehend why and how they used the representations. In the continuation, after the researcher explained the representations to all of the students, he asked them to classify or determine the multimodal representations (texts, images, mathematical expressions, graphics, tables, diagrams, lists) and he introduced them the multimodal representations. Thus, awareness about the multimodal representations was provided. The basic reason why this preliminary study was actualized in both

classrooms was to limit the influence of the external variable which could affect the study (Büyüköztürk et al., 2013).

Each of the experimental and control groups determined randomly were explained how they would do the writing to learn activities they had to prepare, distributing them instructions prepared by the researcher. As it was remarked in the instructions, while the students in the experimental group were doing unit based writing to learn activities using multimodal representations for their peers, the students in the control group did writing to learn activities for their peers. Moreover, standards like subject, writing type, interlocutor and the number of pages were indicated in the instructions. It is known that the multimodal representations depend on the attention of the learners and they have a potential for providing effective learning in them (Waldrup, Prain & Carolan, 2006). Because of this reason, the only and basic difference in the homework instructions was that the students in the experimental group were asked to use the multimodal representations in the writing to learn activities, as something different than the students in the control group. A preliminary practice was done in the first unit of the 5th grade Science lesson (The Unit “Let’s Solve the Puzzle of Our Body”) for the students to cognize the application process. No evaluation was made in this practice. The intention was only to introduce the students the process. Later, the students were asked to do the same writing to learn activities for both units (“propagation of the light & voice unit (U1)” and “measuring the magnitude of force unit” (U2)). CTT was applied as the post test after all of the students did the writing to learn activities for both of the practice units in accordance with the instructions. Thus, the application stage of the study was completed.

### **Data Collection Tools and Statistical Analysis**

#### **Critical Thinking Test**

In this study, a published critical thinking test was used. CTT was from Cornell Critical thinking test series and CTT was created by Ennis and Millman (1985). The test was used to assess 4<sup>th</sup> – 14<sup>th</sup> grade students’ critical thinking skills. CTT is a 72 item multiple choice test. Each item has three choice and one keyed answer. The following is a sample item from the CTT.

“Suppose you know that

Jane is standing near Betsy.

Then would this be true?

Betsy is standing near Jane.

YES

NO

MAYBE”

The correct answer is C, “MAYBE”. Even is Jane is standing near Betsy, Betsy may be sitting. Betsy might be standing near Jane, but she might be sitting near Jane, or something else. You were not told enough to be certain about it, so “maybe” is the answer.

The CTT was translated and adopted into Turkish by Mecit (2006). The test was also checked by school teachers for provide face and content validity. After, the item analysis was done and reliability coefficient computed by Cronbach alpha estimates of internal consistency of this test was found to be 0.75. In this study, Critical Thinking Test was applied to fifth grade students. Students were given 50 minutes to do this test consisting of 72 questions. Throughout this duration, it was

observed that students were able to finish the test and had no problem with understanding the questions. Within the scope of this study, the Cronbach's alpha reliability coefficient of the test was determined as 0.71.

Critical Thinking Test was applied to the experimental and the control group as pretest before the application and posttest after the application. In the process of evaluation, blank and wrong answers were given 0 and right answers were given 1 point by ignoring the fact that wrong answers canceled right answers. In this context, the scores to be obtained by students from CTT range between 0-72.

### **Writing to learn activities**

The target of this research was the students' doing writing to learn activities in order to study the effect of the use of multimodal representations. These writing activities became an important writing to learn activity for the students to use the multimodal representations, to know them and to be able to practice and transform the modes into each other. These writing activities prepared by the students were evaluated through an evaluation rubric. The evaluation was made from on four basic dimensions. They are the evaluation of the text, the general evaluation of the summary, the general evaluation of the alternative modes and the individual mode analysis. The text's being grammatical, the students' ability to express the concepts expected to be mentioned, their correct use of the concepts, the writing characters' and the writing language's suitability for the level are the criteria in the evaluation part. The presence of the key words which should be found in the summary is also the criteria in the text evaluation part. Using alternative modes together with the text, the alternative modes' relation to each other and the alternative modes' being related to more than one concept were evaluated in the general evaluation of the summary part. Examples given or not given in the writing and the emphasis on the main idea were also evaluated in the general evaluation of the summary part. The sort and the total number of each mode used in the summary, the total number of the inappropriate (unnecessary) modes and the total number of the appropriate modes were indicated in the general evaluation of the alternative modes part. The levels and the qualities of the appropriate modes which were determined in the general evaluation part were tried to be determined in the individual mode analysis part. The total score obtained made the total score of the writing activity.

### **Analysis of Data**

While evaluating the quantitative data obtained from the study; we used the t-test for determining whether or not there was a difference between the groups in terms of critical thinking skills before the application and the ANCOVA test after the application. Using the ANCOVA, we compared the corrected posttest scores of groups in respect of the pretest. In a covariance analysis where averages are compared by controlling the effects of an independent variable, the unexplained change (error variance) will be decreased (Can, 2014). Besides, Pearson's correlation test was applied to the scores obtained by students from the writing activities and from the posttest of critical thinking skill for the purpose of determining how much (%) the writing activities of students explained the scores obtained from the Critical Thinking Skills Test. Additionally, the qualitative data of the study were analyzed by using rubric. The aforementioned rubric was developed by the researchers based on an integrative point of view.

## **Results**

### **Critical Thinking Test Pre and Post Test**

CTT was applied as a pretest at the beginning of the study for the purpose of determining whether or not there was a statistically significant difference between the groups. Examining the

independent samples t-test and the data; no statistically significant difference was determined between the groups at the level of  $p < 0.05$ . ( $t_{(30)} = -1.238$ ,  $p = 0.226$ ). Table 1 shows the score averages obtained by the groups from the pretest of CTT and the standard deviations.

**Table 1.** Critical Thinking Test Pretest

	Groups	n	Mean	SD	t	p
Pre-CTT	Control	17	27.647	6.11	-1.238	0.226
	Experiment	15	30.733	7.76		

This unit uses the scores obtained by each group from the pretest as a common variable in the ANCOVA analysis of the data. Table 2 shows the corrected CTT posttest scores of students in the control and the experimental group in respect of the CTT pretest scores.

**Table 2.** Critical Thinking Test Posttest

Groups	n	Mean	Adjusted mean
Control	17	27.65	28.57
Experiment	15	39.93	38.89

Examining Table 2; it could be stated that there is a difference between the control and the experimental group according to the corrected critical thinking posttest score averages. The following table shows the results of the ANCOVA, which was performed for determining whether this difference was significant or not.

**Table 3.** ANCOVA result of CTT

Source	Sum of squares	df	Mean squares	F	P	$\eta_p^2$
Pre-CTT	588.232	1	588.232	9.996	0.004	0.256
Group	805.326	1	805.326	13.685	0.001	0.321
Error	1706.584	29	58.848			
Total	39209.000	32				

Examining the data in Table 3; it is seen that there is a significant difference between the experimental and the control group in terms of the corrected posttest score averages in respect of the critical thinking pretest scores. ( $F_{(1,30)} = 13.685$ ,  $p < .05$ ,  $\eta_p^2 = 0.321$ ). Examining the partial eta square value ( $\eta_p^2$ ); it is seen that the use of multiple modal representations in writing to learn activities by the experimental group in contrast to the control group explains **32,1%** of the variability in the CTT posttest scores independently from the pretest variable. It could be suggested that applications in the experimental group affected the critical thinking skills of students.

### Writing to Learn Activity

Writing activities were conducted as evaluation of texts, general evaluation of abstracts and general evaluation of modes being used. The evaluations in question are given under separate titles for each unit.

## U1 writing to learn activities

*U1 text evaluation:* The writing's being grammatical, the suitability of the writing characters for the person, suitability of the writing language for the level of the student and the correct use of the rules were considered while the text was being evaluated for the writing activities. The evaluation of the concepts mentioned or not mentioned in the text was considered. The presence of the keywords in the unit in the writing activity was also considered. While the students generally mentioned the concepts of force( $f=32$ ), movement( $f=31$ ), dynamometer( $f=23$ ), force unit( $f=20$ ), frictional force( $f=26$ ) and contact force/non-contact force( $f=6$ ) in the writing activity, they mentioned the concept "contact/non-contact force"( $f=6$ ) less than the others. While each student in the experimental group included 5 concepts in the writing activity in average, each student in the control group included 4 concepts in average. When each student in the experimental and the control group was studied separately, it was seen that the students in the experimental group included the concepts "force, movement, dynamometer, force unit, friction force" more in their writing activities. However, they included the concepts "contact force / non-contact force" less in their writing activities. As for the students in the control group, they included the concepts "force, movement, friction force" more but they included the other concepts less in their writing activities.

*U1 evaluation of the summary:* The purpose of the writing activity is to enable the students to use the modal representations in a suitable way in the text. Because of this reason, whether the modal representations were used or not used in the writing, the relation between the modal representations used and whether the modal representations were related or not related to more than one concept were the aspects evaluated while the writing activity was being evaluated. Whether the examples were used or not used while doing the writing activity and the emphasis on the main idea were also the aspects evaluated while the writing activity was being evaluated.

While the use of the alternative modes was being evaluated together with the text, the writing activities which consisted of only text were evaluated as 0 (No), the writing activities in which 1 or 2 representation modes were used were evaluated as "partly". The writing activities in which more representation modes were used were evaluated as 2. When the writing activities of the students were analysed, it was determined that 10 students in the control group did not use modes at all, 6 students used one or two modes and 1 student used three or more modes. A section from the homework of the student who used most modes is given in Figure 1. When the section was analysed, it was seen that the student used a images, one of the modes, after the text. The student explained the force of friction using modes of text. In this text, the student exemplified force of friction and visualised with modes of image.

When the data about the number of the modes used by the students in the experimental group was analysed, no writing activities without any modes used were encountered and it was determined that 1 student used one or two modes and 14 students included 3 or more modes in their writing activities. Almost all of the students in the experimental group used many modes. A section from the homeworks of the students is given in Figure 2. When the writing activities are analysed, it can be said that the modes are related to each other and the modes enable the students to emphasize on the details of the subject while doing the writing activity. For instance, in the section in Figure 2, the student explained the force with his own statements and gave examples from the daily life. He also made a classification, specified the force as requiring and not requiring contact and explained the listing mode by associating it with images.

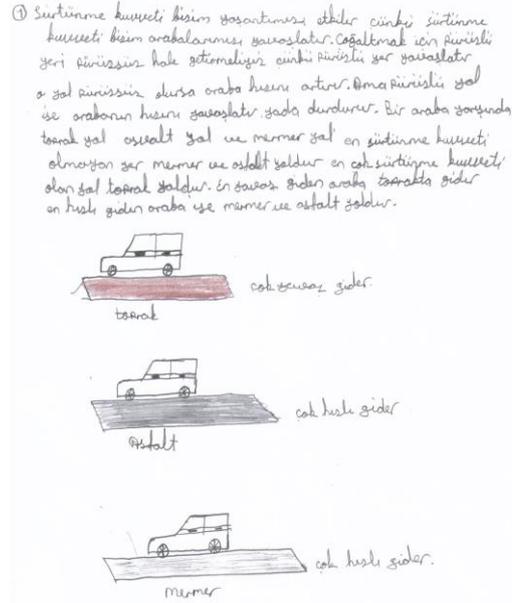


Figure 1. Example from the control group students' homework about U1

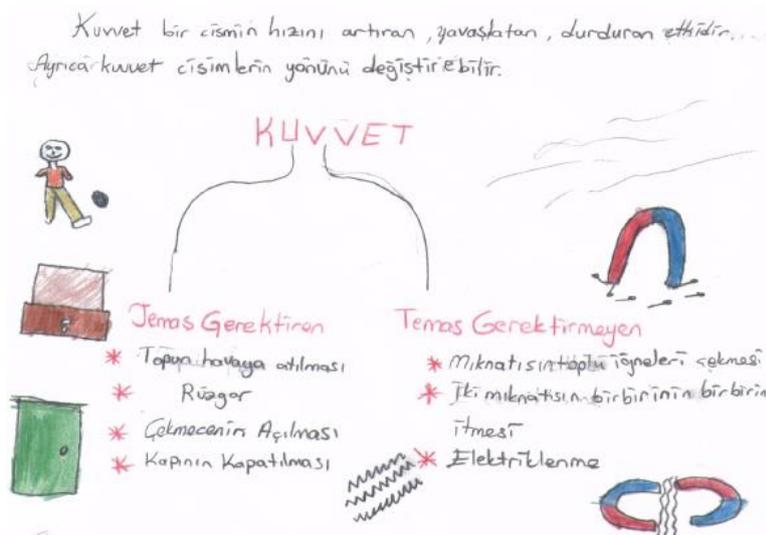
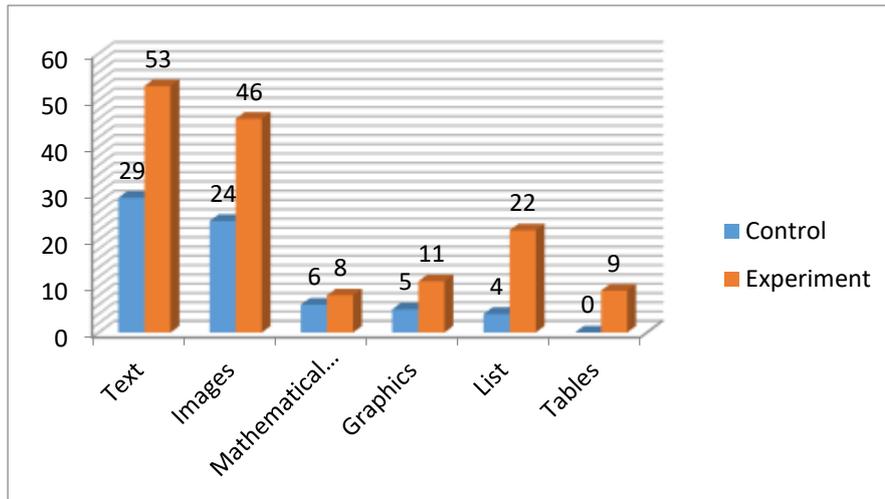


Figure 2. Example from the experimental group students' homework about U1

*U 1 general evaluation of the alternative modes:* When the writing activities were generally evaluated, it was seen that the modal representations used by the students in their writing activities were respectively texts( $f=82$ ), pictures( $f=70$ ), lists( $f=26$ ), graphics( $f=16$ ), mathematical expressions( $f=14$ ) and table representation mode( $f=9$ ). They are given from the most frequent to the least. The findings about the evaluations aimed at the kind of mode used from the point of the groups are given in Graph 1.

When Graph 1 was analysed, it was determined that texts( $f=29$ ), pictures( $f=24$ ), mathematical expressions( $f=6$ ), graphics( $f=5$ ) and lists( $f=4$ ) were the multimodal representations used by the students in the control group in their writing activities. Tables( $f=0$ ) were not used at all by them. As for the experimental group, the multimodal representations used by the students in their writing activities were texts( $f=53$ ), pictures( $f=46$ ), lists( $f=22$ ), graphics( $f=11$ ), tables( $f=9$ ) and mathematical expressions( $f=8$ ). Moreover, it was determined that the students in the control group gave more place to the inappropriate / unnecessary modes in their writing activities.



Graph 1. Alternative modes used for Unit 1.

### U2 writing to learn activities

*U2 text evaluation:* It was seen that the students generally included concepts like “light”(f=32), “sound”(f=32), “shadow”(f=9), “transparent, semi translucent and opaque matter”(f=20), “lunar and solar eclipse”(f=11) and “difference between light and sound”(f=13). In addition, while every student in the experimental group included 4-5 concepts in their writing activities in average, every student in the control group included 2-3 concepts in average. When each student in the experimental and control groups was analysed separately, it was seen that the students in the experimental group included almost all of the concepts “light, sound, transparent, semi translucent and opaque matter, lunar and solar eclipse, difference between light and sound” in their writing activities. As for the students in the control group, while they included the concepts “light and sound” more in their writing activities, they included the other concepts less.

*U2 evaluation of the summary:* When the writing activities of the students were analysed, it was determined that 10 students in the control group used no modes, 6 students used one or two modes, 1 student used three and more modes. Figure 3 shows a section of the homework of a student using modes the most in the control group. Examining the section; it is seen that the student explained how the light spread by listing. In the continuation of this listing mode, he used an image mode where a point light source formed the full shadow of a non-transparent object. Thus, he associated the listing mode with the image mode.

- \* Bir kaynaktan çıkan ışık **doğrusal olarak** yayılır
- \* Bir ışık kaynağında çıkan ışığın yolunu belirten doğrulara **ışık ışınları** denir
- \* Bir kaynaktan çıkan ışık bir engelle karşıladığı sürece her yönde yayılabilir
- \* Işığı iki nokta arasında izlediği yol, ışınlar çizerek gösterilebilir

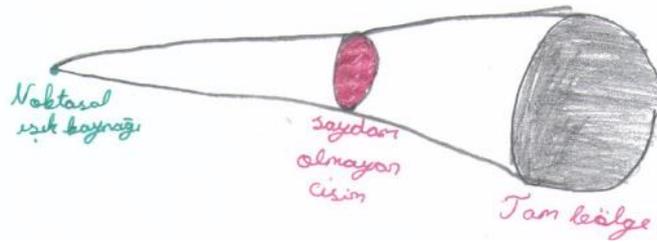


Figure 3. Example from control group students' homework about U2

When the data about the number of the modes used by the students in the experimental group was analysed, no writing activities without modes were seen and it was also determined that 2 students used one or two modes and 13 students included 3 or more modes in their writing activities. Almost all of the students in the experimental group used an exceeding number of modes. Examining the writing activities as in U1; it could be suggested that modes are related with to each other and the writing activities of modes enable emphasizing the details of the subject. For instance, the following section shows the observation of a student in the experimental group concerning the change of his shadow length within the day as data using the table mode (Figure 4). And then the student made a description with a diagram by using the data in this table. He reached a conclusion and expressed that by interpreting this table and diagram.

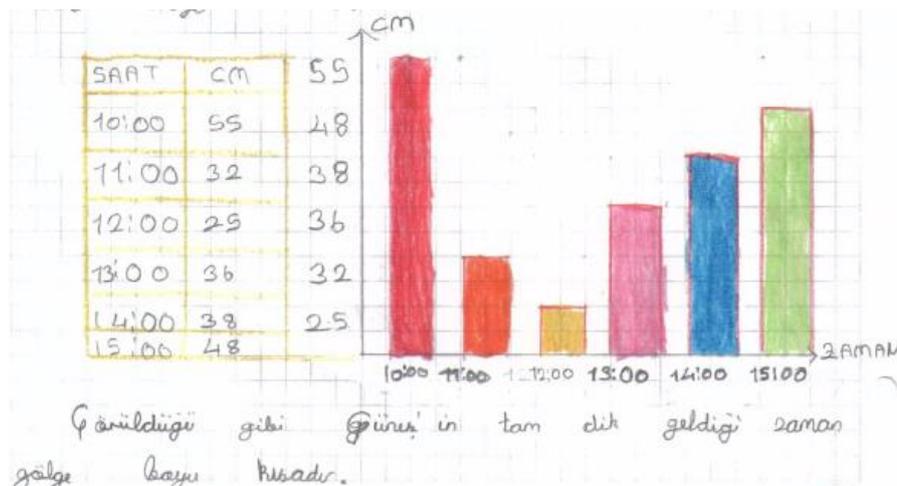
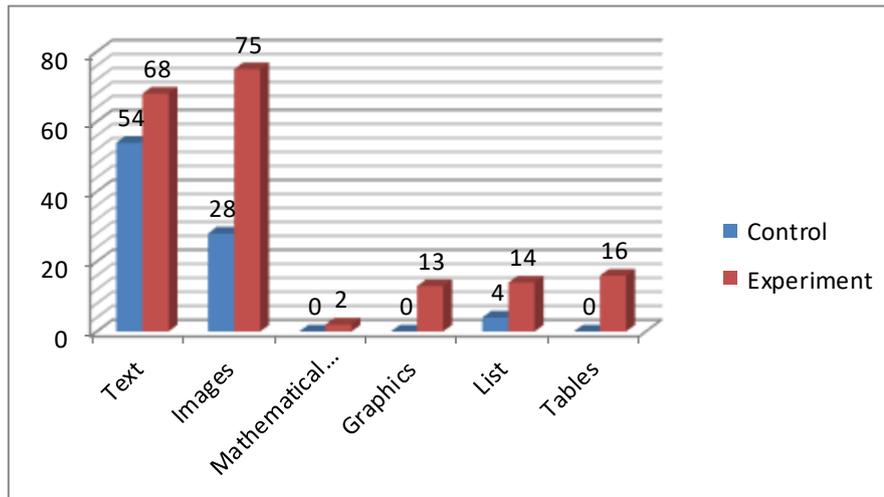


Figure 4. Example from the experimental group students' homework about U2

*U2 general evaluation of the alternative modes:* The representation modes used by the students in their writing activities were respectively determined as texts ( $f=122$ ), pictures ( $f=103$ ), lists ( $f=18$ ), tables ( $f=16$ ), graphics ( $f=13$ ) and mathematical expressions ( $f=2$ ) from the most frequent to the

least. Graph 2 showing the number of the modes from the point of both groups is given below. When Graph 2 was analysed, it was determined that the modes used by the students in the control group in their writing activities were texts ( $f=54$ ), pictures ( $f=28$ ) and lists ( $f=4$ ) but the mathematical expressions, graphics and tables were not used at all. As for the experimental group, the modes used by the students in their writing activities were determined as pictures ( $f=75$ ), texts ( $f=68$ ), tables ( $f=16$ ), lists ( $f=14$ ), graphics ( $f=13$ ) and mathematical expressions ( $f=2$ ). Similar to U1, it was determined that the students in the control group included the inappropriate / unnecessary modes more in their writing activities.



Graph 2. Alternative modes used for Unit 2

### Relation between the writing activities and CTT

The relationship between students' scores of learning-oriented writing and CTT posttest for U1 and U2 was examined with Pearson's correlation. The correlation coefficient signifies a high relation when it is between 0.700-1.000; a moderate relation when it is between 0.300-0.700; and a low relation when it is between 0.000-0.300 (Büyüköztürk et al., 2013). The results are given in Table 4.

**Table 4.** Correlation coefficient between the writing scores for U1 and the CTT score

		U1WTS	CTTS
U1WTS Sig. (2-tailed)	Pearson Correlation	1	.633**
	N	32	32
CTTS	Pearson Correlation	.633**	1
	Sig. (2-tailed)	.000	
N		32	32

\*  $p < .05$  , \*\*  $p < .01$

U1WTS: Unit 1 Writing total Score

CTTS: Critical thinking test score

It was determined that there was a moderately positive and significant relationship between the total score of U1 writing activity and the score of Critical Thinking Test ( $r= 0.633$ ,  $p< .01$ ). Considering the determination coefficient ( $r^2=0.40$ ); it could be suggested that 40% of the total score obtained from the Critical Thinking posttest is related with the score obtained by students from writing activities.

**Table 5.** Correlation coefficient between the writing scores for U2 and the CTT score

		U2WTS	CTTS
U2WTS	Pearson Correlation	1	.641**
	Sig. (2-tailed)		.000
	N	32	32
CTTS	Pearson Correlation	.641**	1
	Sig. (2-tailed)	.000	
	N	32	32

\*  $p< .05$  , \*\*  $p< .01$

U2WTS: Unit 2 Writing total Score

CTTS: Critical thinking test score

It was determined that there was a moderately positive and significant relationship between the total score of U2 writing activity and the score of Critical Thinking Test ( $r= 0.641$ ,  $p< .01$ ). Considering the determination coefficient ( $r^2=0.41$ ); it could be suggested that 41% of the total score obtained from the CTT posttest is related with the score obtained by students from writing activities.

### Discussion and Conclusion

Within the scope of this study, it was aimed to investigate the effect of the use of modal representations by fifth grade students within writing activities upon their critical thinking skills. According to that purpose, students in the experimental group were given applications enabling the use of modal representations in their writing activities, whereas students in the control group were given only writing activities. After completing the applications in two units, the critical thinking skill test that was applied in the beginning was reapplied. Data analyses showed that the use of modal descriptions had positive effects upon the critical thinking skills of students and while 40% of scores obtained from the posttest was derived from the first writing homework; 41% was derived from the second writing homework.

Students may use writing in solving a problem, explaining their opinions, thinking about possible alternative goals and explanations, and making preliminary observations (Yeşildağ, 2009). In this study, students tried to learn science subjects or show what they had learned by performing learning-oriented writing activities. Thus, it could be suggested that students actively participated in writing. Opinions and thoughts of students will allow them to transit from a mentally passive state to an active state, describe and discuss the problem, have reasoning and inference and express themselves better (Doğanay, Akbulut-Taş & Erden, 2007). It is known that students realize learning when they actively participate in writing applications and they may get tired of the process if they consider it a passive study (Prain ve Hand, 1999). Learning-oriented writing not only makes subjects more entertaining for both teachers and students, but also allows students to develop critical thinking skills. (Duron, Limbach & Waugh, 2006).

In this study, both the experimental and the control group performed learning-oriented writing activities and the experimental group was particularly demanded to use multiple modal representations in these writing activities, which caused the experimental group to use a higher number of multiple

modal representations in both writing activities and prefer using different types of multiple modal representations, compared to the control group. Experimental group used a higher number of modes and less unnecessary modes, which shows that they had adopted the modes and used them more consciously. In both writing activities, it was determined that students in the experimental group gave place to a higher number of concepts, compared to students in the control group. Thus, it could be suggested that multiple modal representations enable learning scientific concepts. As a result of his study; Kabataş Memiş (2015) determined that knowing and systematically using modal representations allowed students to learn. Moreover, studies suggest that students who study modal representations have higher science successes, argumentation skills and writing skills, compared to students in the comparison group. (Demirbağ & Günel, 2014). The result of this study shows a parallelism with studies in literature.

As a result of applications that were conducted in line with the study objective; it was determined that there was a difference between the critical thinking skills of students in the experimental and the control group in terms of using multiple modal representations in learning-oriented writing activities. Besides, examining the pretest-posttest averages of critical thinking; it was seen that there was no change in the control group, whereas the experimental group had increased averages. Writing activities explained almost half of the score obtained from the critical thinking posttest, which is also an important finding. Thus, using multiple modal representations in learning-oriented writing activities affects critical thinking skills of students. This study is important as one of the main goals of education is to “raise students as individuals with critical thinking skills (MNE, 2013)”. Ennis (1987), defines critical thinking as the ability of debating and reflective thinking. It could be suggested that obliging students to use modes will allow them to debate and develop reflective thinking.

Educational applications may guide students in two different ways: Firstly, they may allow students to learn the subjects and concepts in the course content and find an answer to what to think/learn; secondly, they may allow students to know how to think concerning the accurate comprehension and evaluation of the subjects (Schafersman, 1991). Students’ ability of reviewing or evaluating what they learn is related with their ability of writing, depicting/describing what they learn, in other words expressing their thoughts. In this respect, it is recommended for students to practice multiple modal representations in classes, reinforce multiple modal representations with easy activities like learning-oriented writing activities, question their thoughts by using evidences and express this with logical justifications. Students will be able to comprehend and solve problems in their lives through using representations efficiently.

Writing practises provide to reveal students’ ideas and reflections at the same time peer feedback can gain a different point of view (Xie, Ke & Sharma, 2008). Students construct written works as a learning experiences for to be a scientific literate person that may affect and develop their critical thinking even they’re grade 6 (Vieira & Tenreiro- Vieira, 2016). Critical thinking is related reasoning (Kong, 2014; Heijltjes et al., 2014; Whiley et al., 2017). Analogical reasoning is accessible for younger children, if domains are familiar and the children have understood the task by their teacher (May, Hummer & Roy, 2006; Haglund, Jeppsson & Andersson, 2012). Different from traditional writing, such as in this study the task of writing to learn activities is explicit and visible. Tolppanen and his colleagues (2013) found a link between students writing skills and use of multi modal representations. The effective use of multi modal representations can provide resource in thinking and learning process, also it can enable to cognitive diversty (Günel & Yeşildağ-Hasançebi, 2016). Young children are able to generate representations and they realised representations’ symbolic functioning (Danish & Enyedy, 2007). Even though all advantages, students may not always get to full benefits of using multiple representations for their learning (Won, Yoon & Treagust, 2014). However classroom environment has been designed by teachers to support students efficiently generate multi modal representations and construct deeper understanding (Cook, 2006). Accordingly, a further research may be about how teachers can best support students to use of representations within writing (Ainsworth, Prain & Tytler, 2011). Thus, it is recommended to allow students to recognize and use representations.

Further research exploring the role of learning with multi modal representations and critical thinking is needed.

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