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11th Grade Students' Conceptual Understanding about Torque Concept: A Longitudinal Study

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Abstract

In this study, it is aimed to reveal the effect of instruction on students' ideas about torque before instruction, after instruction and fifteen weeks after instruction. The working group consists of twenty five high school eleventh grade students. To reveal these students' ideas about the concept of torque a concept test consisting of seven open-ended questions was prepared. These questions analyzed at three themes. Instruction was carried out for the students' meaning making. Before instruction not faced with scientific answers about the concept of torque and students' scientific answers has increased at post test and delayed post test. Faced with alternative concept frequency are decreased after instruction. Meaning making instruction is effective in realization of permanent conceptual change on students' ideas about the concept of torque. Effective studies can be carried out in the realization of conceptual change in all of the students.

Keywords: Torque, High school students, Conceptual change, Conceptual durable

Introduction

During the recent years, the number of researches carried out particularly on physics education in national and international literature is increasing rapidly. Studies are performed in order to reveal the students' opinions on many physics concepts in these researches. When those studies are examined, it is seen that the most common subject matters on physics education are energy, force and movement, substance and its characteristics, waves, electrostatic, quantum mechanics, thermodynamics, Newton's movement law (Doğru, Gençosman, Ataalkın & Şeker, 2012; Duit, 2009).

There are a limited number of studies in the literature that investigate students' opinions on torque concept. Ortiz (1999; cited in Redish, 2004) and Lising and Elby (2005) focused only on students' misconceptions in their studies. They aimed at revealing students' misconceptions regarding the torque concept; however, they could not carry out an education on conceptual change. Pol, Harskamp, Suhre and Goedhart (2008) and Pol, Harskamp and Suhre (2008) investigated the effect of computer program usage in education on students' problem solving skills regarding the torque concept in their studies. However, it is not stated which kinds of opinions the students have before instruction or after instruction on torque concept. These studies are not only carried out in order to determine the students' opinions on only torque concept, but they also included various concepts on force subject in their studies. Therefore, the determined findings on torque concept are limited. On the other hand, there are

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no studies aimed at determining students' opinions on torque concept and at changing the misconceptions (in other words: alternative concepts) in those opinions towards scientific opinions. Yet, Ortiz (1999; cited in Redish, 2004) mentioned in his study that it is hard to understand the torque concept and the relevant lessons on teaching this concept should be organized.

The students' opinions that are inconsistent with scientific knowledge will be mentioned as "alternative concept" in this study. Vosniadou (1991) defines alternative concept as a mental model that is formed with students' daily experiences and that is inconsistent with scientific knowledge. Many conceptual change theories have come forward for changing students' opinions that are inconsistent with scientific knowledge. While there are many conceptual change theories that explain conceptual change with different angles, this study only mentions conceptual change theories that form the structure of the study. The first and most commonly accepted is the conceptual change theory developed by Posner, Strike, Hewson and Gertzog (1982). In this theory, authors state the need for a discontent in the student about the current concept in order to provide a conceptual change. Then the student should find the new concept understandable, reasonable and useful so that a change may occur in students' opinions in the end. In the conceptual change theory, Vosniadou and Brewer (1994) considers conceptual change as removing the belief and mental models which students have before instruction and which limit learning. Vosinadou (1994) classifies students' opinions as beginner, synthesis and scientific. While the beginner mental model is inconsistent with scientific knowledge, synthesis model involves scientific knowledge along with current conceptual structures. In this conceptual change theory, conceptual change occurs when the beginner mental models of the students change towards scientific mental model.

In order to see that conceptual change really occurs, there should be studies that examine the long term changes in students' opinions. However, there are a limited number of studies that examine conceptual permanence (Küçüközer, 2013; Trundle & Bell, 2006). Determining whether the conceptual comprehension and conceptual change occur right after instruction may not provide so much information on the efficiency of instruction. If students can show conceptual comprehension even after a long time after instruction, we can say that the instruction was actually efficient. Long term longitudinal studies may give information on conceptual comprehension and change (Küçüközer, 2013).

Various teaching methods aimed at conceptual change are tried and meaning formation method (Mortimer & Scott, 2003) is used in this study. Mortimer and Scott (2003) indicated that in-class interaction in science classes is realized under five main titles. This teaching method is explained with teaching purposes, content, communication approach, interaction models and teacher interference. It states the need for the class environments where students are active and interact with each other and their teachers in this kind of teaching. The content of class communication can be in daily language as well as in scientific language. This method aims at the usage of scientific language in content by post-instruction students. Various communication periods occur between teachers-students and between students. Interactive communication between the teacher and students is more appropriate for student-centered instruction. The question-answer periods of teacher and students are analyzed in interaction models. The teacher makes some interference in the teaching period in order to steer teaching and these interferences aim at the students' reaching scientific knowledge.

The Purpose and Importance of the Research

The purpose of this research is to discuss the conceptual change that occur in post-instruction period in high school 11th grade students regarding the Torque concept and the conceptual permanence in these thoughts. There has been an increase in the number of studies aimed at the change of students' thoughts. Although various conceptual change strategies are used in these studies, there is no study that investigates the effect of teaching aimed at meaning formation on the change in students' thoughts. This study aims to investigate the effect of teaching aimed at meaning formation on conceptual change and conceptual permanence.

It is important that the students configure their thoughts on Torque concept correctly. Students that do not have any scientific knowledge on this concept will find it hard to understand the rotational movement associated with this concept. Students who correctly configure the Torque concept will explain how bicycle gears work and the working principles of peg-tops, ship helms and teeterboards, lawn mowers more easily. Therefore, there is a need for studies aimed at organizing the teaching aimed at determining students' thoughts on Torque concept, on which there are not much researches made until now, and changing the alternative thoughts within these thoughts.

Methodology

Research Design

Single group pretest-posttest design, delayed posttest, which is one of the weak experimental designs, is used in this study as the research design. In this design, pretest is implemented on the research group, experimental research is made on this group, posttest is implemented at the end of teaching and after a while, delayed posttest is implemented on the group (Cohen, Manion & Morrison, 2005). The answers of students given to concept test before teaching, after teaching and fifteen weeks after teaching are compared in this study. A longitudinal study is performed on determining the conceptual permanence in the thoughts of the same student group.

Study Group

This study is performed with twenty-five eleventh grade high school students who study in a state high school. These students have not received formal education on Torque concept in physics lessons until eleventh grade. Therefore, the thoughts of students before teaching are in the form of naive ideas (starting ideas) stated by Vosniadou, who is affected by daily experiences.

Period of Instruction

An instruction that lasts for two class hours aimed at students' meaning formation regarding the torque concept is organized. The instruction is aimed at students' forming scientific meanings regarding the torque concept. The instruction is organized to form meaning which is developed by Mortimer and Scott (2003) and explained under five titles. Students are separated into study groups and they are allowed to discuss their thoughts freely in groups. An active learning environment where students can interact with each other and with their teachers is provided. By this means, it aims to enable the students to discuss with each other and to provide a change in their alternative thoughts.

Data Collection Tool

A conceptual comprehension test that consists of seven open-ended questions developed by researchers as data collection tools is used. In the pilot study of the concept test, the test is

initially implemented on fifty-five eleventh grade students in pre-instruction and post-instruction period. Then, this test is implemented during concept test developing period on 133 tenth grade students and the test is put into final form. This developed concept test is implemented on students before instruction, after instruction and fifteen weeks after instruction and the students are asked to write their thoughts regarding these concepts and their reasons.

Data Analysis

Seven questions regarding the torque concept in the conceptual comprehension test is analyzed under three themes. Questions that are aimed at the same attainment are analyzed under the same theme together. The content of the answers given to the questions in every theme determined in which answer category the student will be. The students that give correct answers to every question within the theme are in the scientific answer category, while the students that state their opinions regarding the alternative concept in every question are in the alternative answer category.

"Constant comparative method" is used in the analysis of open-ended questions that take part in the conceptual comprehension test. According to the constant comparative method, the data are put down on paper line-by-line, temporary codes are formed and it is compared to another transcript in order to provide the consistency of these codes and to determine negative situations (Goulding, 2005). The categories used in the studies of Trundle, Atwood and Christopher (2002) and Uçar (2007) are used for the comparison of open-ended question analysis in the concept test. Analysis methods of six categories that slightly differ from these categories are determined as a result of the analysis. The categories used in the analysis of questions in the concept test and their explanations are as follows:

- *Scientific:* If the student's explanation complies with the scientifically accepted answer of the question, it takes part in this category. The answer given for this category should involve every aspect of the scientifically correct answer and the student should give the correct answer to all questions.

- *Scientific fragment:* If the explanation does not include alternative concepts yet involves some aspects in the correct answer, it takes part in this category. All factors needed for the correct answer are not included in the answer.

- *Scientific fragment with alternative fragment:* It includes a part of the correct answer, yet it also includes the answer that has an alternative concept value.

- *Alternative:* If the student's explanations and thoughts on alternative concepts are shown in every relevant question, the answer takes part in this category.

- *Alternative fragment:* In the answers of this category, the alternative concept is encountered in only one question and the student does not reveal his thoughts on this alternative concept in all questions. Or if the student uses a different alternative concept in every question, it takes part in this category.

- *No understanding:* Answers in this category involves explanations that do not reflect scientific or alternative conceptual comprehension or the students do not state their opinions on the concept.

If the student's explanation takes part in one of "scientific fragment with alternative fragment", "alternative" or "alternative fragment" categories before instruction, and his explanation takes part in "scientific" or "scientific fragment" category after the instruction and in delayed post-test, it is accepted in this study that there is a permanent conceptual change in the student (Küçüközer, 2013).

The questions in conceptual comprehension test are analyzed by a secondary researcher independently from the researcher himself so as to increase the credibility of the analysis. As

the researchers' analysis results get close to each other, the credibility of the study increases (Gay & Airasion, 2000). The secondary researcher analyzed fourteen randomly determined papers independently from the researcher. The coherency percentage between two researchers is calculated as 91% in the study. The fact that the coherency between the two researchers is above 90% indicates that the coherency is high (Miles & Huberman, 1994) and it can be said that the analysis does not involve any biasness of the researcher.

Results

The findings that are obtained from analyzing the questions in torque concept theme together are as follows.

Table 1. Findings That Are Obtained From the Analysis via Using Torque Concept Theme Response Categories

Response Category	Pre-test n (%)(SN)	Post-test n (%)(SN)	Delayed Post-test n (%) (SN)
Scientific	0	2 (%8) (S9, 21)	8 (%32) (S2, 7, 8, 9, 12, 17, 18, 23)
Scientific fragment	5 (%20) (S7, 9, 12, 17, 21)	11 (%44) (S2, 7, 11, 12, 13, 14, 15, 16, 17, 18, 23)	9 (%36) (S6, 10, 11, 13, 14, 16, 21, 24, 25)
Scientific fragment with alternative fragment	1 (%4) (S11)	3 (%12) (S5, 10, 20)	5 (%20) (S1, 3, 4, 5, 20)
Alternative	6 (%24) (S1, 4, 5, 19, 22, 25)	4 (%16) (S4, 22, 24, 25)	3 (%12) (S15, 19, 22)
Alternative fragment	4 (%16) (S3, 10, 14, 15)	3 (%12) (S1, 3, 19)	0
No understanding	9 (%36) (S2, 6, 8, 13, 16, 18, 20, 23, 24)	2 (%8) (S6, 8)	0

The study has not encountered any students that give scientific answers before instruction to questions in torque concept theme. The instruction is effective on the conversion of two students' ideas towards scientific answers. These two students gave answers that take part in scientific fragment answer category before instruction. Eight students gave scientific answers regarding this concept in delayed post-test and there has been a substantial increase in this rate when compared to post-instruction period. One of the students that gave a scientific answer after instruction gave a scientific answer also in the delayed posttest, while the other student gave answers that take part in scientific fragment answer category.

The study encountered five students that give answers in scientific fragment category before instruction. The frequency of encountering scientific fragment answer category after instruction is increased and eleven students gave answers in this category. Nine students are ranked in this category in delayed post-test. Six of these students in this category in posttest are within the scientific answer category in the delayed post-test. This situation explains the

increase in the answer rate in delayed posttest. The students who deficiently explain the scientific answer after instruction were able to give scientific answers after weeks after the instruction.

Along with the scientific fragment, there is one student in alternative fragment answer category before instruction. The instruction is effective on the conversion of the student's alternative ideas and he/she stated ideas on the scientific fragment in posttest and delayed posttest. Answers given by three students take part in this category after instruction. The students started to show scientific opinions along with the alternative opinions they have before instruction. The opinions of these three students are affected by instruction; however, it could not completely change their opinions on the alternative concepts they have before instruction. This situation is similar to the synthesis mental model in Vosniadou's (1994) conceptual change theory. Students maintain their daily opinions along with the scientific opinion in the synthesis mental model. Five students take part in this category in delayed posttest. Two students who have alternative opinions in post-test have shown scientific opinions along with the alternative opinions in delayed posttest.

The most frequent themes encountered in students are alternative and alternative fragment themes. While six students gave answers in alternative answer category, four students gave answers in alternative fragment answer category. The frequency of encountering alternative answers after instruction is decreased. Three in four students within the alternative answer category after instruction gave the same answer before instruction. This situation shows that alternative opinions of some students are resistant to alteration. The other student did not state any opinion on this concept before instruction. Answers given by three students take part in this category in delayed posttest. All of these three students have alternative opinions before instruction. Instruction has not been effective on changing the students' opinions permanently and they maintained their opinions on alternative concepts in delayed posttest. Nine students did not state their opinions on this concept before instruction. This rate decreases after instruction and similarly only two students did not state their opinions on this concept before instruction. There has not been any student in this category in delayed posttest.

The torque concept theme includes alternative concepts encountered in students before instruction, after instruction and fifteen weeks after instruction.

In torque concept theme, four different alternative concepts in ten students before instruction, three different alternative concept in six students after instruction and two different alternative concepts in three students in delayed posttest are encountered.

The alternative concept that says "equal forces cannot spin the object" is encountered in three students before instruction and in two students after instruction. No opinion regarding this alternative concept is encountered in delayed posttest. Two students maintained their opinions on the same alternative concept both before and after instruction and the instruction were not effective on the alteration of these students' opinions on the alternative concept. The other student who has this alternative concept before instruction came up with a different alternative concept after the instruction. The instruction could not so effective on the short-term alteration of the students' opinions that have this alternative concept, however, after weeks passed over the instruction, this alternative concept is not encountered in the students.

Table 2. Alternative Concepts Encountered in Students in Pretest, Posttest and Delayed Posttest in Torque Concept Theme

Alternative Concepts Encountered Before Instruction	n (SN)
Equal forces cannot spin objects (the distance from the turning point is not considered)	3 (S3, S22, S25)
As the distance of the force from the turning point decreases, the balance is provided with a little force.	1 (S10)
If the forces that affect the object are equal, it turns in the direction of the force applied from a shorter distance.	3 (S4, S15, S19)
The object turns in the direction of the greater force that is applied (the distance from the turning point is not considered)	3 (S1, S5, S14)
Alternative Concepts Encountered After Instruction	**n (SN)**
Equal forces cannot spin the object (the distance from the turning point is not considered)	2 (S22, S25)
If the forces that affect the object are equal, it turns in the direction of the force applied from a shorter distance.	4 (S3, S4, S19, S24)
The object turns in the direction of the greater force that is applied (in cases when the distance is not considered)	1 (S1)
Alternative Concepts Encountered After Delayed Posttest	**n (SN)**
If the forces that affect the object are equal, it turns in the direction of the force applied from a shorter distance.	2 (S15, S19)
The object turns in the direction of the greater force that is applied (in cases when the distance is not considered)	1 (S22)

The alternative concept that says "if the forces that affect the object are equal, it turns in the direction of the force applied from a shorter distance" is encountered in three students before instruction, in four students after instruction, and in two students in delayed posttest. No alteration is observed after the instruction in the opinions of these two students who encountered this alternative concept before instruction. The instruction could not be effective on the alteration of these students' opinions. Alternative concept showed resistance to alteration in these students. The other student who has this alternative concept before instruction gave answers that take part in "scientific fragment" answer category after instruction, while he turned to the same alternative concept in delayed posttest. The opinions of this student changed after instruction, however, long term conceptual permanence could not be provided. After the instruction, this alternative concept is encountered in two students who were different than they were before instruction. One of these students had a different alternative concept, while the other was in "no comprehension before instruction" category. The instruction might have caused the formation of opinions on this alternative concept in two students. This alternative concept is encountered after instruction in the students where this alternative concept is not encountered before instruction. The content of instruction might have caused an increase in this alternative concept. Although it is given in the activities performed that torque is the multiplication of the force and the distance from the turning point, the students that have this alternative concept could not configure the distance from the turning point correctly.

The alternative concept that says "The object turns in the direction of the greater force that is applied" is encountered in three students before instruction, in one student after instruction and in one student in delayed posttest. The student, in which this alternative concept is encountered after instruction, has opinions on this alternative concept also before instruction and the instruction could not be effective on the alteration of this student's

opinions. The instruction was effective on the opinions of the other two students who have this alternative concept before instruction.

The findings that are obtained by analyzing the two questions that take part in the force direction theme in torque concept are given below.

Table 3. Findings That Are Obtained by Analyzing the Force Direction Theme in Torque Concept by Using Response Categories

Response Category	Pre-test n (%)(SN)	Post-test n (%)(SN)	Delayed Post-test n (%) (SN)
Scientific	0	4 (%16) (Ö2, 7, 9, 18)	7 (%28) (Ö2, 4, 9, 11, 18, 23, 25)
Scientific fragment	3 (%12) (Ö1, 14, 17)	12 (%48) (Ö1, 3, 6, 11, 13, 14, 16, 17, 20, 21, 23, 25)	5 (%20) (Ö3, 6, 14, 16, 22)
Scientific fragment with alternative fragment	7 (%28) (Ö7, 9, 11, 20, 22, 23, 25)	6 (%24) (Ö4, 10, 15, 19, 22, 24)	10 (%40) (Ö1, 7, 10, 12, 13, 15, 17, 19, 21, 24)
Alternative	0	0	2 (%8) (Ö8, 20)
Alternative fragment	9 (%36) (Ö2, 3, 4, 8, 10, 12, 15, 19, 21)	3 (%12) (Ö5, 8, 12)	1 (%4) (Ö5)
No understanding	6 (%24) (Ö5, 6, 13, 16, 18, 24)	0	0

No answer from scientific answer category before instruction is encountered in this theme. Four students gave scientific answers after instruction; seven students gave scientific answers after fifteen weeks passed over the instruction. Three out of these seven students have scientific answers also after the instruction. The other four students who gave scientific answers in delayed posttest gave answers that take part in scientific fragment answer category after instruction.

The answers of three students before instruction take part in scientific fragment answer category. These students correctly reflected some aspects of the scientific answer regarding this concept despite they did not receive instruction. Twelve students after instruction take part in scientific fragment answer category. After fifteen weeks passed over the instruction, the opinion of four students did not change and they maintained their place in this category. Other students take part in delayed posttest, scientific answer category or alternative fragment answer category along with the scientific fragment.

In alternative fragment with scientific fragment answer category, the answers given by seven students before instruction, by six students after instruction and by ten students fifteen weeks after instruction are included. While the numbers of students that take part in this category before and after instruction are close, the students in this category have changed. The number of students that take part in this category in delayed posttest showed increase.

No alternative answers that take part in alternative answer category before and after instruction are encountered. Alternative opinions are encountered in two students in delayed posttest. While one of these two students takes part in alternative answer category after

instruction, the other is included in scientific fragment answer category. This student takes part in alternative fragment with scientific fragment answer category before instruction. The opinions regarding the student's alternative concept before instruction come up in delayed posttest.

In alternative fragment answer category, nine students take part before instruction, three students take part after instruction and one student takes part in delayed posttest. The frequency of encountering answers in this answer category is decreased in time. While S5, which takes part in this category in delayed posttest, do not have any opinions on this concept before instruction, he takes part in this category after instruction and in delayed posttest. Other students take part in scientific fragment after instruction, and in alternative fragment with scientific fragment answer category.

While six students did not state their opinions on this concept before instruction, there was no student who did not state his/her opinion on this concept in delayed posttest.

Alternative concepts encountered before instruction, after instruction and fifteen weeks after the instruction in the force direction theme of torque concept are given below.

Table 4. Alternative Concepts Encountered in Students in Pretest, Posttest and Delayed Posttest in the Force Direction Theme of Torque Concept

Alternative Concepts Encountered Before Instruction	n (SN)
Forces that are applied from the furthest point from the object center can spin the object.	3 (S3, S15, S19)
Forces that are applied perpendicular to the bottom cannot spin the object. The forces that do not balance each other among those that are applied perpendicular to each other can spin the object.	1 (S4)
The force that is applied with a certain size of angle on the object spins the object more.	4 (S2, S8, S10, S12)
Alternative Concepts Encountered After Instruction	**n (SN)**
The force that is applied on the object with a certain size of angle spins the object more.	2 (S8, S12)
As equal forces applied on the object balance the object no force can spin the object (in cases when distance is not considered)	1 (S5)
Alternative Concepts Encountered After Delayed Posttest	**n (SN)**
The force that is applied on the object with a certain size of angle spins the object more.	2 (S8, S20)
As equal forces applied on the object balance the object no force can spin the object (in cases when distance is not considered)	1 (S5)

The alternative concept that says "Forces that are applied from the furthest point from the object center can spin the object" is encountered in three students before instruction. S3 gave a scientific answer on this concept after instruction. The instruction is effective in changing this student's opinions on the alternative concept. S15 and S19 used their opinions on their alternative concept along with scientific knowledge in explaining their answers. According to Vosniadou's (1994) conceptual change theory, these two students take part in daily mental model before instruction, whereas they are in synthesis mental model after instruction. This alternative concept is not encountered after instruction and in delayed posttest. The instruction is effective in changing the opinions on this alternative concept and these alternative opinions did not show up even a long time after the instruction.

The alternative concept that says "The force that is applied on the object with a certain size of angle spins the object more" is encountered in four students before instruction, in two students after instruction and in two students in delayed posttest. The instruction could not be effective on the opinions of two students who had this alternative concept. It is seen that S8 maintains his opinion on this alternative concept in delayed posttest. Although S20 gave scientific answer after instruction, he used this alternative concept again in delayed posttest. While this student had opinion on the alternative concept before instruction, the instruction changed these opinions towards scientific knowledge yet this change could not be permanent.

The alternative concept that says "No force can spin the object as equal forces applied on the object balance it" is not encountered before instruction. One student stated opinion regarding this alternative concept after instruction and in delayed posttest. This student did not state opinion regarding this concept before instruction. We can say that the instruction enabled opinions on this alternative concept to rise in the student.

The findings that are obtained by analyzing the two questions together that take part in the theme of determining the direction of torque are stated below.

Table 5. The Findings that are obtained by Analyzing the Theme of Determining the Direction of Torque by Using Response Categories

Response Category	Pre-test n (%)(SN)	Post-test n (%)(SN)	Delayed Post-test n (%) (SN)
Scientific	0	1 (%4) (S18)	4 (%16) (S4, 13, 17, 18)
Scientific fragment	6 (%24) (S3, 4, 9, 14, 15, 23)	13 (%52) (S1, 2, 4, 9, 11, 12, 13, 14, 15, 17, 19, 20, 23)	7 (%28) (S7, 8, 9, 12, 14, 15, 19)
Scientific fragment with alternative fragment	9 (%36) (S1, 5, 7, 8, 10, 12, 16, 17, 20)	8 (%32) (S3, 5, 6, 7, 10, 16, 21, 22)	10 (%40) (S1, 2, 5, 6, 10, 16, 20, 21, 23, 24)
Alternative	0	1 (%4) (S8)	3 (%12) (S3, 22, 25)
Alternative fragment	6 (%24) (S2, 11, 13, 19, 22, 25)	1 (%4) (S25)	1 (%4) (S11)
No understanding	4 (%16) (S6, 18, 21, 24)	1 (%4) (S24)	0

No scientific answers are encountered in this theme before instruction. While one student gave scientific answer after instruction, four students gave scientific answers in delayed post-test. The instruction provided an increase in students' scientific answer rates.

The answers that take part in scientific fragment answer category are encountered in six students before instruction, in thirteen students after instruction and in seven students in delayed posttest. The instruction provided an increase in the rates of encountering scientific fragment answer category. The number of students that take part in delayed posttest is decreased in comparison those after instruction. Three students who were in this category after instruction gave scientific answers in delayed post-test.

The rates of encountering alternative fragment with scientific fragment answer category before instruction, after instruction and in delayed posttest are close to each other. It is encountered in nine students before instruction, in eight students after instruction and in ten students in delayed post-test. The opinions of the most students in this category are not much affected by instruction and the students in this category did not show too much change. There have been students whose opinions changed after instruction and in delayed posttest for this category.

No alternative opinion is encountered for this theme before instruction. While an alternative concept is encountered in one student after instruction, it is encountered in three students in delayed posttest. The rate of encountering alternative concepts in delayed posttest has increased.

In alternative fragment answer category, six students take part before instruction, one student takes part after instruction and one student takes part in delayed post-test. The instruction decreased the frequency of encountering answers in this category. While only 'S25' gave answers in this category after instruction, this student takes part in alternative answer category in delayed posttest. "S11" gave answers aimed at the opinion he had before instruction in delayed post-test. The instruction could not be successful in realizing permanent conceptual change in this student.

While four students take part in no comprehension before instruction theme, this number decreased to one after instruction. No student is encountered in this theme in delayed posttest.

The alternative concepts encountered before instruction, after instruction and in delayed posttest in the theme of determining the direction of torque are stated below.

Table 6. Alternative Concepts Encountered in Determining the Direction of Torque Theme in Students before Instruction, after Instruction and in Delayed Posttest

Alternative Concepts Encountered Before Instruction	n (SN)
Bolts come loose when screwed in the direction of waves on it	2 (S2, S13)
Screws and bolts come loose when screwed to the left	4 (S11, S19, S22, S25)
Alternative Concepts Encountered After Instruction	n (SN)
According to the right hand rule, the bolt comes loose when screwed clockwise	2 (S8, S25)
Alternative Concepts Encountered in Delayed Posttest	n (SN)
According to the right hand rule, the bolt comes loose when screwed clockwise	1 (S3)
Screws and bolts come loose when screwed to the left	3 (S11, S22, S25)

The alternative concept that says "Bolts come loose when screwed in the direction of waves on it" is encountered in two students before instruction. No opinions are encountered after instruction and in delayed posttest regarding this alternative concept. The opinions of these students changed after instruction.

The alternative concept that says "screws and bolts come loose when screwed to the left" is encountered in four students before instruction, while it is not encountered after instruction. This alternative concept is encountered in three students in delayed posttest. The instruction was effective on changing the opinions on this alternative concept, yet it could not provide any permanent conceptual change in these students' opinions. One student who had

this alternative concept before instruction, stated "according to the right hand rule, the bolt comes loose when screwed clockwise" after the instruction. The instruction enabled the student to use the scientific knowledge he learned in explaining opinion regarding his alternative concept. This alternative concept is affected by the instruction and enabled this alternative concept to rise in the student. This student used scientific knowledge in explaining his opinion on the alternative concept. Similarly, a student showed the alternative concept that says "According to the right hand rule, the bolt comes loose when screwed clockwise" after instruction. This alternative concept is encountered in one student in delayed posttest.

Discussion

This study has not encountered students that give scientific answers before instruction in all three themes about torque concept. There is an increase in the frequency of encountering scientific answers after instruction and in delayed post-test. There is an increase in the frequency of encountering answers in scientific answer category in delayed posttest, in comparison to the period after instruction. An increase is observed in the scientific answer rates of the students in time. The instruction has been effective on the change of students' opinions towards scientific knowledge and permanent conceptual change is observed in many students. Based on this result, we may indicate that the instruction organized for teaching torque concept is effective on changing students' opinions.

The frequency of encountering alternative opinions regarding the torque concept in students after instruction is decreased. While there are more students who have alternative concepts before instruction, this rate decreases after instruction. Some students maintain their opinions on their alternative concepts in delayed posttest, whereas others opinions' change. Permanent conceptual change can occur when the recently learned concept sounds reasonable to the student. If the student can not fit their recent learning into a logical framework, he/she continues to store his/her old knowledge with the new ones. Vosniadou explains this situation with synthesis mental model. The knowledge that is inconsistent with scientific knowledge is stored to be used in future cases. Therefore, students should have learned using scientific knowledge in every case in order to observe permanent conceptual change. Permanent conceptual change is observed in some students in this study. These students learned the torque concept and scientific knowledge so as to implement them on every case. However, the scientific knowledge may not have sounded reasonable for students where permanent conceptual change is not observed, and they may have rejected this knowledge. The instruction has not been effective on changing these students' opinions on alternative opinions. Consequently, the instruction organized to form meaning has been successful in realizing conceptual change in students and permanent conceptual change is observed in some of these students. However, there have also been students whose opinions did not change at all after instruction and who maintain their alternative opinions.

The study has encountered students that cannot give scientific answers after instruction, yet can give scientific answers in delayed posttest. This situation can be explained with their receiving instruction from different resources on torque concept within the period of fifteen weeks between the two tests and their learning in the period of preparation for the exam.

All of the alternative concepts regarding the torque concepts which are encountered before instruction, after instruction and in delayed posttest, are encountered for the first time in this study. As there are not many studies aimed at determining students' opinions on this subject, it is not so likely for the results of this study to be compared with different studies.

Conclusion and Recommendations

There is an increase in the number of conceptual change studies that examine the change in students' opinions, yet the numbers of studies that investigate conceptual permanence are not so many. Examining the long term conceptual change in students' opinions is important for discussing whether the conceptual change occurs or not. Therefore, studies that analyze conceptual change should be carried out after a long time passes over the instruction. Studies may be performed not only about torque concept but also on the conceptual change and permanence of other physics and science concepts.

Various conceptual change studies on the change of alternative concepts encountered in students about the torque concept may be carried out. One can discuss how this concept can be learned better by conducting more studies in this field.

In this study, an instruction aimed at students' forming a meaning is organized and the effect of this instruction on their opinions is investigated. Conceptual change studies where different conceptual change methods are used may be carried out and the effect of these methods on the change and permanence of students' opinions may be investigated. As a result of this study, it is observed that no permanent conceptual change occurred in all students. Studies that discuss which teaching methods should be used to provide permanent conceptual change can be carried out. It can discuss in which cases a permanent conceptual change occurs in students and which elements should be included to provide conceptual change. This study has some limitations. The biggest one is that it is carried out with a limited number of students. Generalizability problems of qualitative researches carried out with a limited number of students are mentioned (Yıldırım & Şimşek, 2005). The generalizability of the results can be increased by conducting studies with greater study groups.

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