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THE EFFECT OF CONCEPTUAL CHANGE TEXTS ON FOURTH GRADE STUDENTS' ACADEMIC ACHIEVEMENT, SCIENTIFIC PROCESS SKILLS, ATTITUDES TOWARDS SCIENCE AND OVERCOMING OF MISCONCEPTIONS

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Abstract

This study examines the effects of conceptual change texts on fourth grade students' academic achievement, scientific process skills, attitudes towards science, and misconceptions. A total of 46 students participated in the study. They were from two different classrooms in a same school located in the eastern part of Turkey. The classrooms were randomly assigned as the experimental group and the control group. The implementation took six weeks and three hours per week. At the beginning of the implementation, pre-tests were administered to all participants. In the experimental group, conceptual change texts were integrated into instruction. On the other hand, the control group was instructed based on regular teaching methods and techniques. The results revealed that the conceptual change texts positively increased students' academic achievement, scientific process skills, and attitudes towards science. In addition, despite non-significant, an increase was observed in favor of the experimental group in terms of their misconceptions. Considering the positive effects of conceptual change texts, they should be included in fourth grade science curriculum.

Anahtar Kelimeler: Academic achievement; attitudes**;** conceptual change texts; misconceptions; scientific process skills

INTRODUCTION

Teaching the subjects at school by associating them with events that affect the daily life of an individual makes a great contribution to the individual's being literate (Köse, 2004). Therefore, individuals need to know the concepts of science in order to be literate. For this reason, the main purpose of science education should be teaching science concepts and related dimensions should be given while teaching those concepts (Kavak, Tufan & Demirelli, 2006). However, misconceptions are an obstacle for learning and they create resistance against to transformation (Pimthong, 2015). Through appropriate learning environments, teachers may identify students' misconceptions and those misconceptions may be transformed to true knowledge (Adugyamfi, Ampiah, Agyei, 2020).

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In the constructivist approach, students' prejudices, knowledge, and beliefs are considered as the basic elements of teaching and learning (Grospietsch and Mayer, 2018). For real learning and overcoming of students' misconceptions, teachers need to create learning environments in which students can structure the concepts correctly (Polat, 2007). In addition, for meaningful learning and persistency, students need to actively participate in learning activities (Cerit Berber & Sarı, 2009). The conceptual change approach is a model that organize students' preliminary knowledge according to Piaget's philosophy and enables students to re-construct knowledge (Posner, 1982; Ercan, Taşdere & Ercan, 2010; Pletier et al., 2020). Through this approach, the concepts are restructured and undergo radical changes, which leads to the replacement of previous concepts with new concepts (Nadelson et al. 2018; Thomas and Kirby, 2020). In order to achieve the conceptual change, there are various methods to implement and the conceptual change texts (CCT) are one of them. CCT explains misconceptions and their rationale with examples to students and enables them to learn the exact meaning of the concepts (Özkan & Sezgin-Selçuk, 2015). These texts are prepared in a way that enables students to question their thinking and schemas about concepts and cause them to feel that their knowledge is insufficient. Thus, the concepts that teachers tend to explain to students scientifically is reached through CCTs (Akbal, 2009). CCTs begin with a question to elicit misconceptions students have (Aydın & Balım, 2013). Then, students' misconceptions are determined and scientific explanations about why these misconceptions are wrong are provided to students (Kılıcoglu, 2017). As a result, they are expected to feel insufficient to explain the current new situations (Demirel & Anıl, 2017). Then, students are provided with scientific knowledge about the subject enriched with examples, which results in conceptual changes (Birinci Konur & Ayas, 2017).

Considering the fact that it is critical for elementary school students to comprehend the science related concepts since elementary school years are the basis for further years in school (Osborne, 2007), CCTs are needed especially in primary school level. However, in studies related to the use of CCTs, secondary education or university students were chosen as target population (Birinci Konur & Ayas, 2017). One of the few studies focused on fourth grade students also pointed out the gap in the literature related to the CCTs and elementary school students (Uyanık & Dindar, 2016). Indeed, related studies mainly focused on identification of students' misconceptions (Cayci, 2007; Uyanık, 2014). However, in addition to identification of misconceptions, it is extremely important to determine the causes of these misconceptions and the ways to eliminate them (Ecevit & Simsek Ozdemir, 2017). In this context, the fact that this study includes the science-related misconceptions at the elementary school level and the CCTs prepared based on the overcoming of these misconceptions reveal the importance of the study. The aim of this study is to examine the effects of the CCTs used in fourth grade science curriculum on students' academic achievement, scientific process skills, misconceptions, and attitudes towards science. Considering the fact that there are a limited number of studies conducted at elementary school level, this study fills out the gap in the literature and becomes a critical source for future research. In this study, four research questions were proposed:

1. Is there any significant difference between the experimental and the control groups' pre-test scores of academic achievement, scientific process skills, attitudes towards science, and misconceptions' determination?
2. Is there any significant difference between the experimental and the control groups' post-test scores of academic achievement, scientific process skills, attitudes towards science, and misconceptions' determination?

3. Is there any significant difference between the control group's pre- test and post-test scores of academic achievement, scientific process skills, attitudes towards science, and misconceptions' determination ?
4. Is there any significant difference between the experimental group's misconceptions pre-test and post-test scores of academic achievement, scientific process skills, attitudes towards science, and misconceptions' determination?

METHOD

Research Model

By employing a semi-experimental research design (Karasar, 2002), it was investigated the influence of independent variable of CCTs on dependent variables of academic achievement, scientific process skills, attitudes towards science and overcoming of misconceptions in the 4th grade science course' the effects of force and getting to know matter units. In semi-experimental research designs, experimental and control groups were randomly selected and both groups were administered the pre-tests just before the implementation process. After the implementation, post-tests were administered to the both groups and pre- and post-test results were compared in order to identify any effects of independent variable on dependent variables (Çepni, 2012). Table 1 provides details about the research design.

Table 1. Research Model

Groups	Pre-tests	Teaching method	Post-tests
Experimental group	*Academic achievement test* Basic Process Skills Test Attitude towards Science Scale Misconception Identification Test	(CCTs)	*Academic achievement test* Basic Process Skills Test Attitude towards Science Scale Misconception Identification Test
Control group	*Academic achievement test* Basic Process Skills Test Attitude towards Science Scale Misconception Identification Test	(Regular program)	*Academic achievement test* Basic Process Skills Test Attitude towards Science Scale Misconception Identification Test

Participants

For the current study, 46 fourth grade students from a school located in a city center in the eastern religion of Turkey participated in. Among the participants, while 25 students (12 female and 13 male) were in classroom-D, the remaining students (6 female and 15 male) were in classroom –C. Through random selection, classroom-D and classroom-C were assigned to be the experimental group and the control group, respectively.

Data Collection Tools

There was four data collection tools in the current study: an academic achievement test, basic process skills scale, an attitude toward science scale, and a misconception identification test. The data collection tools are introduced below.

Academic Achievement Test

An academic achievement test was developed by the researchers based on literature review and expert views. The questions in the test included 35 multiple choice questions related to force, motion and properties of matter. The test was reviewed by three primary school teachers and four faculty members in the Department of Elementary Education in terms of content and face validity. After the revisions based on the expert views, item difficulty and discrimination indices were calculated. According to the findings, five questions were dropped out from the test, which left 30 items with four choices. Based on students' answers, the items were coded as either zero for wrong answer or one for correct answer.

Test of Basic Process Skills

In order to identify participants' scientific process skills, a questionnaire developed by Padilla, Cronin and Twiest (1985) was used. Aydoğdu and Karakuş (2015) translated the questionnaire into Turkish and it consists of 31 items with six factors: observation (5 items), categorization (5 items), inference (5 items), measurement (5 items), estimation (6 items), and communication (5 items). The reliability of the scale (KR-20) and the average difficulty level of the scale were calculated as .83 and .55, respectively. The items were coded either zero or one for data analysis.

Attitudes towards Science Course Scale

In order to identify participants' attitudes towards science, a scale developed by Geban, Ertepınar, Yılmaz, Altın and Şahbaz (1994) was used. The scale consists of 15 items with only one factor. The participants responded to the items on five-point scale: from strongly disagree to strongly agree. The reliability coefficient value of the scale was calculated as .83.

Misconception Identification Test

The researchers reviewed the literature and developed a list of items related to misconceptions that fourth grade students may have in science. There was a total of 27 items. After the calculation of item difficulty and discrimination indices, six items were deleted, which left 21 items in the test.

Data Collection Process

After getting necessary permissions and consents from parents of the participants, the researchers met the participants and introduced the study. The implementation lasted six weeks from November 27, 2017 to January 3, 2018. The units covered in the implementation were about force and motion and properties of matter. At the beginning of the implementation, the pre-tests were administered to the students in the experimental and control groups. During the implementation, while the experimental group was exposed to CCTs, the control group received regular education related to the topics. The CCTs were designed based on the national fourth grade science curriculum. After the implementation, the post-tests were administered to the groups.

The Implementation Process

Before the implementation, the students in the experimental group were provided information about CCTs and how lessons would be managed. The CCTs were prepared in two different types. CCT-1 included questions related to misconceptions about force and motion and properties of matter. Students were able to write their answers to the questions in the texts. CCT-2 included scientific explanations of misconceptions and a section where students wrote down their answers again. The experimental group received the CCT-1 first. After they became ready for conceptual change, they were provided with the CCT-2.

The control group received instruction based on the current curriculum. The force and motion and the properties of matter were taught through the methods and techniques suggested in the fourth grade science curriculum. During the lessons, necessary arrangements were made for students' active participation. Also, at the end of each lessons, evaluation questions that were included in the textbook were answered with the students.

Data Analysis

Before the analysis, the data was examined to determine distribution of the data. For this purpose, the Shapiro-Wilk test was run; kurtosis and skewness values were calculated; and Q-Q graph, stem-and-leaf plots, and box plot graphs were drawn. For normally distributed data, an independent samples t test and a paired samples t test were performed. In order to calculate the effect size for both tests, a formula (t2 / t2 +(N1+N2-2); Balcı & Ahi, 2017) was used. The effect size is considered small if the value is about .01; medium if the value is about .06; and high if the value is about .14. For the other data in which normal distribution was not observed, Mann Whitney U test was used. The effect size for this test was calculated through a formula ($r = z/\sqrt{N}$; sum of squares between groups/ sum of squares) (Balcı & Ahi, 2017). For Mann Whitney U test, the effect size is considered small if the value is about .1; medium if the value is about .3; and high if the value is about .5 (Cohen, 1988, Balcı & Ahi, 2017). The p value was accepted as being meaningful if $p < .05$. Also, arithmetic mean (x), standard deviation (s), and frequencies (f) were calculated. For data analysis, IBM SPSS version 22.0 was used.

FINDINGS

Findings regarding the pre-test scores

The first analysis was related to groups' pre-test scores. In order to identify any possible difference between the groups, parametric and non-parametric tests were performed. The results of the parametric test are provided in Table 2 and the results of non-parametric test are provided in Table 3 and 4.

Table 2. Independent Samples T Test Results: The Pre-Test Scores

Groups	N	$\bar{x}$	sd	t	p	η2
Academic achievement						
Control group	21	17,38	5,1	,877	,385	0,01
Experimental group	25	18,64	4,62			
Misconceptions						
Control group	21	14,14	3,36	1,063	,293	0,02
Experimental group	25	15,04	2,33			

The pretest scores of academic achievement and the misconceptions' determination of the control and experimental groups were calculated as 17.38 and 18.64, respectively and no significant difference was observed between the groups (p>.05; Table 2).

Table 3. Mann Whitney U Test Results: Comparison of the Pre-Test Scores For Basic Process Skills

Groups	N	Mean ranks	Sum of ranks	U	p	r
Control group	21	24.74	519,5	236,5	,565	.08
Experimental group	25	22,46	561,5			

Pre-test scores for basic process skills showed that no significant difference was observed between control and experimental groups (p>.05; Table 3).

Table 4. Mann Whitney U Test Results: Comparison of the Pre-Test Scores For Attitudes Towards Science

Groups	N	Mean ranks	Sum of ranks	U	p	r
Control group	21	27,69	581,5	174,5	0,5	.28
Experimental group	25	19,98	499,5			

Pre-test scores for attitudes towards science showed that no significant difference was observed between control and experimental groups (p>.05; Table 4).

Findings on the post-test scores

In order to identify any possible differences in the post-test scores of the experimental and the control groups, an independent samples t test was performed. The results are provided in Table 5.

Table 5. Independent Samples t Test Results: The Post-Test Scores

Groups	N	$\bar{x}$	sd	t	p	η2
Academic achievement						
Control group	21	19,23	5,22	2,723	,009*	0,14
Experimental group	25	23,08	4,34			
Basic process skills						
Control group	21	17,66	3,03	3,12	,003*	0,18
Experimental group	25	20,08	2,19			
Attitudes towards science						
Control group	21	32,52	2,13	2,169	,036*	0,09
Experimental group	25	34,12	2,74			
Misconceptions						
Control group	21	15,23	3,74	1,212	,232	0,03
Experimental group	25	16,8	4,8			

*p < .05

The post-test scores of academic achievement and basic process skills of the control and the experimental groups were calculated as 19,23 and 23,08 for academic achievement and 17.66 and 20,08 for the basic process skills, respectively (Table 5). Also, the post-test scores of attitudes towards science and misconceptions of the control and the experimental groups were calculated as 32,52, 34,12; and 15.23, 16,8, respectively. (Table 5). As seen from the table, significant differences were observed in favor of experimental group except for their misconceptions (p>.05).

Findings on the pre- and post-test scores: the control group

The pre- and post-test scores of the control group were compared by conducting a paired samples t test. The results are given in Table 6.

Table 6. Paired Samples T Test Results For The Control Group

Groups	N	x̄	sd	t	p	η2
Academic achievement						
Pre-test	21	17,38	5,1	1,856	, 078	0,07
Post-test	21	19,23	5,22			
Basic process skills						
Pre-test	21	17,80	4,47	0,174	, 864	0,0006
Post-test	21	17,66	3,03			
Attitudes towards science						
Pre-test	21	33,95	1,65	2,14	,045*	0,09
Post-test	21	32,52	2,13			
Misconceptions						
Pre-test	21	14,14	3,36	1,244	,228	0,03
Post-test	21	15,23	3,74			

* $p < .05$

Only significant difference was observed in the control group's attitudes towards science. While their pre-test average score was 33.95, it decreased to 32.52 in the post-test (Table 6).

Findings regarding the pre- and post-test scores: the experimental group

In order to compare the pre- and post-test scores of the experimental group, a paired samples t test was performed. The results are given in Table 6.

Table 7. Paired Samples T Test Results For The Experimental Group

Groups	N	x̄	sd	t	p	η2
Academic achievement						
Pre-test	25	18,64	4,62	4,7	, 000*	0,33
Post-test	25	23,08	4,34			
Basic process skills						
Pre-test	25	17,76	3,09	3,88	, 001*	0,25
Post-test	25	20,08	2,19			
Attitudes towards science						
Pre-test	25	32,4	2,9	2,808	, 01*	0,15
Post-test	25	34,12	2,74			
Misconceptions						
Pre-test	25	15,04	2,33	1,831	,08	0,07
Post-test	25	16,8	4,80			

* $p < .05$

The results revealed that the experimental group had significantly higher scores in all post-tests except for misconceptions, comparing with their scores in the pre-tests (Table 7).

CONCLUSION AND DISCUSSION

Students' Academic Achievement and CCTs

CCTs encourage students to question their thinking and to realize their misconceptions (Akbal, 2009; Özkan & Sezgin-Selçuk, 2015). Well-designed CCTs enable students to better understand the scientific concepts (Onder, 2006; Cayci, 2018) and have positive effects on students' learning due to its features to activate students' prior knowledge, create connections between the old and new knowledge, and provide scientific proofs (Sungur, Tekkaya & Geban, 2001; Cayci, 2018). In this study, it was found that academic achievement scores of the students in the experimental group were significantly higher than those of the control group. Similar result was found in other studies as well (Dilber, 2006; Cayci, 2007; Akbal, 2009; Cetin, Ertepinar & Geban, 2015; Adzape & Akpoghol, 2015; Suma, Suriyasmini & Pujani, 2018). In addition to academic achievement, Cetin and colleagues (2015) and Suma and colleagues (2018) also revealed that use of CCTs increased students' motivation, which is directly related to learning.

Scientific Process Skills and CCTs

In this study, while the groups were equivalent in their scientific process skills at the beginning of the implementation, a significant difference was observed at the end of the implementation between the experimental and the control groups in terms of their scientific process skills. This implies that comparing with the regular education, CCTs are an effective way for students to acquire scientific process skills. There are other studies that support this finding (Karslı & Ayas, 2017; Pınarbaşı, 2002; Sahhyar & Nst; 2017). In a study, although Cetingul and Geban (2011) found no difference between the experimental and the control group in terms of their scientific process skills, they revealed that students with high scientific process skills were more successful in learning science related concepts.

Attitudes towards Science and CCTs

Students' attitudes towards science is a critical factor that affects learning science related concepts (Genc, 2015). Although the groups had similar scores in the pre-test in terms of their attitudes towards science, a significant difference was observed between the experimental and the control groups in terms of their attitude at the end of the implementation, which implies the effect of CCTs on students' attitudes towards science. Similarly, there exist studies in the literature providing evidence proving that CCTs influenced students' attitudes towards science positively and, in turn, increased students' academic achievement (Yüksel Gülçiçek, 2004; Sevim, 2007; Yılmaz, 2010). In addition, Uyanık (2014) observed a non-significant positive increase in students' attitudes towards science in the experimental group comparing with the control group. On the other hand, there are studies revealing that CCTs did not affect students' attitudes towards science (Cetin, Ertepinar & Geban, 2015; Onder, 2017; Balcı, 2006). Balcı (2006) explained this situation with the duration of the implementation and bias in teachers' behavior in both groups.

Misconceptions and CCTs

The conceptual change approach asserts that without correcting students' misconceptions, they cannot learn the scientific concepts (Cayci, 2018). Also, traditional methods are insufficient in teaching abstract concepts of science and eliminating misconceptions about those concepts (Ozmen, 2007). Since new knowledge is linked to already existing knowledge in students' mind, if any, misconceptions prevent learning and make it difficult for students to understand the association between scientific concepts and principals and adapt them to daily life (Sungur, Tekkaya, & Geban, 2001). In addition, Cayci (2018) points out that students make meaningful connections between old and new concepts and the replacement of misconceptions with correct scientific knowledge has a positive relationship with learning. Ausubel (1968) clearly states that students' prior knowledge is the most important single factor that affect learning. While CCTs allow students to play an active role in their learning, dissatisfaction in their minds enables information to be restructured and the misconceptions to be replaced through scientific explanations

(Balcı, 2006). While there exist studies disclosing the positive effects of CCTs on eliminating misconceptions (Durmuş, 2009; Altuntaş Aydın, 2011; Ertaş, 2013; Perdana, Suma and Pujan, 2018; Asgari, Rajaeee and Ahmadi, 2018), there also exist opposite results in the literature (Toka & Aşkar, 2002; Onder, 2017). According to the results of this study, although a difference was found in favor of the experimental group in terms of misconceptions, this difference was not statistically significant. In a study, participants reported that they did not like CCTs since misconceptions were directly explained in them and, as a result, they had difficulty understanding the texts (Toka & Aşkar, 2002). Also, Sungur, Tekkaya and Geban (2001) stated that students still had misconceptions at the end of their implementation, which may imply that students were not able to clarify science concepts in their minds according to the researchers. A similar conclusion may be drawn for the current study. The fact that this was the first time for students to be exposed to CCTs and the implementation took only six weeks might be considered as a reason for the non-significant difference in students' misconceptions between the experimental and the control groups.

In conclusion, this study revealed the effects of conceptual change texts on fourth grade students' academic achievement, scientific process skills, attitude towards science, and misconceptions. More research is needed in terms of teachers' use of CCTs in classrooms, the association between CCTs and technologies including mobile devices, online games, animations, and so on, and the ways to integrate CCT in current science curriculum.

Limitations of the Study

There exist three critical limitations of the current study. The first one is related to the duration of the implementation. The study was carried out in a six-week time period and three hours per week. Therefore, in order to ensure about the effectiveness of CCTs, it is suggested that the implementation is spread over a wider time period. The second limitation is about the topics chosen for the implementation. In the current study, CCTs were applied to two subjects in fourth grade science curriculum: force and motion and the properties of matter. It is suggested to choose different topics to examine their effectiveness. The last limitation is related to the participants. In this study, fourth grade students were chosen as a study sample. Future research might consider younger age groups to determine the possible effects of CCTs on learning science concepts.

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