THE EFFECT OF COGNITIVE CONFLICT AND CONCEPTUAL CHANGE TEXT ON STUDENTS' ACHIEVEMENT RELATED TO FIRST DEGREE EQUATIONS WITH ONE UNKNOWN

BİLİŞSEL ÇELİŞKİ VE KAVRAMSAL DEĞİŞİM METNİ YÖNTEMLERİNİN BİR BİLİNMEYENLİ BİRİNCİ DERECEDEN DENKLEMLERLE İLGİLİ ÖĞRENCİ BAŞARISINA ETKİSİ

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ABSTRACT: The main purpose of the study was to investigate the effect of cognitive conflict instruction (CCI) and conceptual change text instruction (CCTI) over traditionally designed mathematics instruction (TDI) on achievement of 7th grade students related to first degree equations with one unknown. The subjects of the study consisted of 79 7th grade students from three different classes of mathematics lessons instructed by the same teacher from a school in Ankara. Mathematics potential test (MPT) was utilized at the beginning of the study to determine students' potential in mathematics. After the treatments, achievement test results were taken. ANOVA was used for testing the hypothesis of the study. The results showed that the students at CCI got significantly higher scores on achievement comparing to CCTI.

Keywords: cognitive conflict instruction, conceptual change text instruction, traditionally designed mathematics instruction, first degree equations with one unknown, misconception.

ÖZET: Bu çalışmanın amacı, bilişsel çelişki, kavramsal değişim metni ve geleneksel matematik öğretimi yöntemlerinin 7. sınıf öğrencilerinin birinci dereceden bir bilinmeyenli denklemlerdeki kavramlarla ilgili başarılarına etkisini karşılaştırmaktır. Bu çalışma, aynı öğretmenin üç farklı sınıfındaki 79 öğrencinin katılımıyla Ankara'daki bir okulda gerçekleştirilmiştir. Matematiksel potansiyel testi öğrencilerin matematik dersindeki potansiyellerine karar vermek için çalışmanın başında uygulanmıştır. Uygulamalar sonunda tüm öğrencilere son test olarak Birinci Dereceden Bir Bilinmeyenli Denklemlerle İlgili Kavramları Ölçen Başarı Testi uygulanmıştır. Araştırmanın hipotezlerini test edebilmek için Varyans Analizi kullanılmıştır. Son test sonuçlarına göre bilişsel çelişki yöntemi uygulanan sınıfların başarı ortalaması, kavramsal değişim metni uygulanan sınıflara göre manidar bir şekilde yüksek bulunmuştur.

Anahtar Sözcükler: bilişsel çelişki yöntemi, kavramsal değişim metni yöntemi, geleneksel matematik öğretimi, birinci dereceden bir bilinmeyenli denklemler, kavram yanılgısı.

1. INTRODUCTION

A recent trend in science education emphasized the role of prior "misconceptions" in the acquisition of important scientific conceptions (Posner, Strike, Hewson and Gertzog, 1982). Generally, misconceptions cause low achievement in mathematics education. If the number of misconceptions increase, students will have difficulty in understanding. Low understanding in mathematics cause low understanding in other disciplines which include mathematical concepts i.e. physics, chemistry,, economics.... etc. If we start education by overcoming the misconceptions (if possible before they occur) students will be high achievers. Therefore, significance should be given to concepts rather than operations. In this study, cognitive conflict instruction involves the following steps: Firstly, students are confronted with a difficult problem including a conceptual obstacle and they write dwon their own responses in pairs or in small groups. After group discussions, there is a class discussion. Each group presents their opinions. Wrong responses are challenged by teacher or other groups. The teacher doesn't provide any positive or negative feedback. Teacher can sun-up the

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ideas presented. As consolidation part, students are presented with other questions.

Conceptual change texts are designed to change students' misconceptions and focus on strategies to promote conceptual change by challenging students' misconceptions, producing dissatisfaction, followed by a correct explanation which is both understandable and plausable to the students. Students are given texts which identify common misconceptions. Students' misconceptions are activated by presenting them with situations designed to elicit a prediction based on them and student's misconceptions are challenged by introducing common misconceptions followed by evidence that they are wrong . Finally, the instruction presents the correct scientific explanation.

In traditionally designed mathematics instruction, teacher used lecture and discussion methods. Students received the same examples. In the experimental group, but not the control group students were informed about possible misconceptions. They were not emphasized in traditionally designed instruction.

One of the most important areas in mathematics is algebra. In Turkey, algebra starts in 7th grade by first degree equations with one unknown.

When we go through the background of the study, there are lots of studies in Science Education related to Conceptual Change Text (Chambers and Andre, 1997; Yılmaz, 1998 and Ünlü, 2000). and they investigated conceptual change text instructions led to better conceptual understanding than traditionally designed instruction but no study has been found about the effect of conceptual change text instruction in mathematics education. However, there are some studies related to cognitive conflict instruction in science and mathematics education (Bell, 1993; Cankay, 1958, Niaz, 1995). They reported that cognitive conflict instruction was effective in improving performance on the immediate post-tests.

There are several studies related to misconceptions of students in first degree equations with one unknown (Küchemann, 1981; Payne

and Squipp, 1990; Sleeman, 1984; Perso, 1992; Sharma, 1987 and Erbaş, 1999). Küchemann (1981) used algebra test and resulted that students had misconceptions related to algebra. E.g. For "which is larger, 2n or n+2 ? ", 71 % of them wrote 2n because it is multiplication. Students didn't recognised that the relative size of two expressions (n + 2 and 2n) depends on the value of n. Payne & Squibb [9] and Sleeman [10] found mal-rules related to equations such as M*x=N $\rightarrow$ x = M - N where M & N stand for integers. Perso [11] found 19 algebra misconceptions. E.g. Parentheses do not mean anything in algebra: Errors such as 2(a + b) = 2a + b occur in algebra. Sharma (1987) has summarised seven types of errors in solving linear algebra equations, one of which is procedural: Misuse of the property of equality (wrong inverse operation). Erbaş (1999) pointed out that students have certain difficulties and common errors in elementary algebra topics like in literature. He found problems about meaning of equation (2x + 2 = 4 $\rightarrow$ 2x + 2 = 4–2 = 2)

2. METHOD

In this study, the following hypothesis is stated in null form at a significance level of 0.05: There is no sgnificant difference among post-test mean scores of students taught with cognitive conflict instruction, conceptual change text instruction and traditionally designed mathematics instruction with respect to students' achievement related to first degree equations with one unknown if students are seperated in terms of their levels of mathematics potential test results. An example of an activity for each method (CCTI & CCI) is given in Appendix.

2.1 Subjects

This study consisted of 28+28+30=86 7th grade students from 3 classes of mathematics lessons taught by randomly chosen a teacher in a private school in Ankara in 2000-2001 fall semester. Three instructional methods of the study were randomly assigned to three classes of the teacher. The sample was chosen from the school and selected by the convenience sampling procedure.

Boxplot was used to summarise information about the distribution of scores on post-test results in order to decide outliers (See Figure 2.1).

Figure 2.1 indicates that there are $3 + 2 + 2 = 7$ outliers. We see that although distribution of student scores in TDI is positively skewed, it is negatively skewed in CCI and CCTI. 7 outliers were not included in the analysis part of the study so 25+26+28=79 7th grade students were taken for the study.
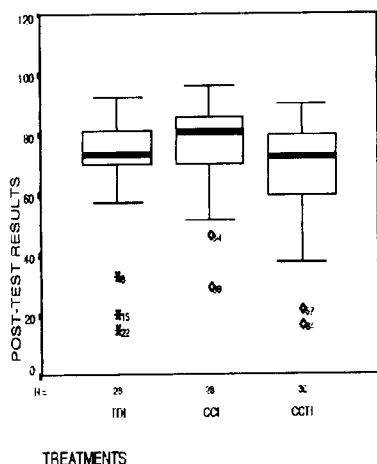

Figure 2.1 Boxplot

According to the Mathematics Potential Test results, students were categorised as high, middle and low. These were calculated as:

High if score is higher than Mean + 0,5 SD

Medium if score is between Mean ± 0,5 SD

Low if score is less than Mean - 0,5 SD (See Table 2.1).

CG: Control Group Instructed by Traditionally Designed Instruction

EG1-CC: Experimental Group Instructed by Cognitive Conflict

EG2-CCTI: Experimental Group Instructed by Conceptual Change Text

Table 2.1 The Number of Students for Each Level

	EG1-CC	EG2-CCT	CG
High	9	10	9
Middle	10	11	12
Low	7	7	4

2.2 Instruments

In the present study, two tests were used. These tests were mathematics potential test and first degree equations with one unknown achievement test.

First Degree Equations with One Unknown Achievement Test test was prepared by the researchers and a school teacher from the school that the study have been actualised. There are 40 items. 3 of them are multiple choice items, 5 of them are true-false items and 32 of them are open-ended essay type items. In multiple choice and true false items, only one correct answer is given. The conceptual questions were asked to the students to get conceptual understanding related to the subject matter. Distracters in the multiple-choice items are chosen from possible misconceptions of students using the literature. Before using as post-test, it was administered to 117 8th grade students for item analysis and a reliability. The reliability was found 0.83 using KR-21.

The topics included in the test are: Number Phrases, Number Sentences, The Addition Property of Equality, The Multiplication Property of Equality, Equations with Parentheses, Equations with Fractions. Word Problems using Equations were not taken into consideration because of the foreign language factor.

Multiple choice and true-false items were graded as 0 or 1. (0 for wrong, 1 for right answers). In essay type items, students got 1 for each item if their answer was right or if there were no misconception in the responses. If the responses involved the numerical and sign errors in calculations (i.e. $6 / 2 = 2$ or $- x - = -$ or $8+5 = 12$ and etc.) and there were no misconceptions related to equations they got 1 for each answer. However, if the responses involved misconceptions related to equations they got 0 for each answer. (e.g. Multiply $n + 5$ by 8. If the answer is $n+40$, students got 0 from the item)

For content-related evidence, post-test (achievement test) was prepared using literature review and objectives of the subject matter prepared

by T.R. Ministry of National Education (T.C. M.E.B). The reliability of the Achievement Test computed from the results of the pilot study using Kuder-Richerdson 21. It is 0.83.

Mathematics Potential Test (MPT) was developed by Blum, W, Burghes, D., Green, N., & Kaiser-Messmer, G., (1993) [14] and it was translated and adapted by Prof. Dr. Yaşar Ersoy and Dr. Erdinç Çakıroğlu for 7th and 8th grade students and administered later.

Mathematics Potential Test was utilised at the beginning of the study to determine students' potential in mathematics.

2.3 Procedures and Treatment (CCI, CCTI, TDI)

The concept was given to the students first and before using the treatments, each subtitle was taught by the teacher. After the regular lessons, examples were given using the treatments in five 40 minutes periods. The three different groups were given the same examples. The difference was in the method of instruction. Traditionally designed instruction followed the logical presentation of concepts like in mathematics books without mentioning misconceptions. Conceptual change text instruction focused on common misconceptions in texts with class discussion. Cognitive conflict instruction provided conflict and inadequancy of the prior knowledge during discussions.

3. DATA ANALYSIS

ANOVA was used to test the hypothesis at a significance level of 0.05.The analysis is summarized in Table 3.1

Table 3.1 ANOVA Summary for the Teachers

Source	DF	SS	MS	F	p
Treatment	2	939.122	469.561	3.970	0.023
Level	2	457.651	228.825	1.935	0.152
Interaction	4	549.601	137.400	1.162	0.335
Error	70	8278.862	118.269		

There is no significant mean difference among levels (high, middle, low), (p>0.05) and

there is no significant interaction between level and treatment (p>0.05).

Table 3.1 showed that there is a significant mean difference among three teaching methods with respect to post-test results related to first degree equations with one unknown. (p < 0.05). Since there is significant mean difference, we will investigate Post Hoc Tukey Test (See Table 3.2)

Table 3.2 Post Hoc Tukey Test Summary

Treatments				
I	J	Mean Difference	Std. Error	p
CC	CCT	8.5474	2.9619	0.014
TDI	CC	-3.3885	3.0462	0.510
CCT	TDI	-5.1589	2.9924	0.203

Although the mean of TDI is higher than mean of CCTI, there is no statistically significant mean difference between TDI and CCTI with respect to achievement related to first degree equations with one unknown ($\overline{X}$(CCTI)=70.49 and $\overline{X}$ (TDI)=75.65).

In spite of higher mean of CCI, there is no statistically significant mean difference between TDI and CCI with respect to achievement related to first degree equations with one unknown. ($\overline{X}$(TDI)=75.65 and $\overline{X}$ (CCI) = 79.04)

There is a significant difference between CCI and CCTI with respect to achievement related to first degree equations with one unknown ($\overline{X}$(CCTI)=70.49 and $\overline{X}$(CCI) = 79.04). The CCI group scored statistically significant higher than the CCTI group.

4. DISCUSSION AND CONCLUSION

The main purpose of the study was to compare the effects of cognitive conflict instruction, conceptual change text instruction and traditionally designed instruction on achievement of 7th grade students related to first degree equations with one unknown.

After the statistical analysis, it was found that there is a significant mean difference between CCI and CCTI. CCI leads to better acquisition.

It is consistent with (Bell, 1993; Cankoy, 1998). There is no significant difference between mean of CCTI and TDI. Even if no significant differences have been found, TDI yielded higher achievement scores than CCTI.

Though the same examples were solved, cognitive conflict sessions were longer than the others. This is because of the discussion athmosphere. Weaker students participated in discussion and they are challenged using mathematical misconceptions. The teacher who applied the treatments liked this method more than the others after each session. She said that:

- "Students found answers using predictions. Depending on answers of students, all of the students, even the weaker students, participated whether they are happy or unhappy with what they have found at the end of the discussion.".

- The teacher also said that

- "Students didn't like CCTI. Possible misconceptions are introduced directly, so sometimes they didn't understand the written text. Discussion was not meaningful as in cognitive conflict instruction. If students are already given text, they don't want to read it carefully. My exam average was the lowest for this method related to the equations. Neither I nor students liked it".

During the literature survey, it was found that there is no research study related to the use of CCTI in mathematics. It was used for science education so many times and found effective in overcoming misconceptions of the subject matters. However, contrary to (Chambers, and Andre, 1997; Yılmaz, 1988; Ünlü, 2000), in this study CCTI mean scores were the lowest comparing to mean of CCI and TDI related to the subject matter. CCTI results were significantly lower than CCI results which leads us to the understanding that awareness of misconceptions was not enough for better conceptual understanding.

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APPENDIX A

A SAMPLE OF INSTRUCTIONAL
MATERIAL FOR
COGNITIVE CONFLICT

(Equations with Parentheses)

Part 1

Following questions are taken from an exam and answers of students are given. In the second question, part of the answers is written. Read questions and choose TRUE or FALSE and write your reasons then discuss them with your desk-mate.

1. Multiply n + 5 by 4.

1. student   Answer: 4n + 5
TRUE ❑   FALSE ❑   WHY?

....

2. student   Answer: n + 20
TRUE ❑   FALSE ❑   WHY?

....

3. student   Answer: 4n + 20
TRUE ❑   FALSE ❑   WHY?

....

4. student   Answer: 20
TRUE ❑   FALSE ❑   WHY?

....

2. Simplify $2 - 3 (x + 5)$.

1. student If $2 - 3 (x - 5)$ then $-1 (x - 5)$
TRUE ❑   FALSE ❑   WHY?

....

2. student If $2 - 3 (x - 5)$ then $2 - 3x - 15$
TRUE ❑   FALSE ❑   WHY?

....

3. student If $2 - 3 (x - 5)$ then $2 - 3 x + 15$
TRUE ❑   FALSE ❑   WHY?

....

4. student If $2 - 3 (x - 5)$ then $2 - 3 x - 5$
TRUE ❑   FALSE ❑   WHY?

....

3.   Simplify $- (7 - x)$.

1. student $- 7 + x$
TRUE ❑   FALSE ❑   WHY?

....

2. student $- 7 - x$
TRUE ❑   FALSE ❑   WHY?

....

Part 2

In the following questions, solutions of some students are given. Check the result and find whether the result is true or not. If the result is wrong, find what the wrong is with the solution.

1. Solve $12 - 3 (4 - x) = -15$ in R.

1. Student:
$12 - 3 (4 - x) = -15$ Check:
$\quad 12 - 3 . 4 - 3 x = - 15$
$\quad 12 - 12 - 3x = -15$
$\quad 0 - 3 x = - 15$
$\quad -3 x = - 15$
$\quad x = 5$

2. Student:
$12 - 3 (4 - x) = -15$ Check:
$\quad 12 - 3 . 4 + 3 x = - 15$
$\quad 12 - 12 + 3x = -15$
$\quad 0 + 3 x = - 15$
$\quad 3 x = - 15$
$\quad x = -5$

3. Student:
$12 - 3 (4 - x) = -15$ Check:
$\quad 9 (4-x) = - 15$
$\quad 36 - 9x = -15$
$\quad - 9 x = - 15 - 36$
$\quad - 9 x = - 51$
$\quad x = 51 / 9$

2. Solve $-2 (3x + 5) = 16$ in R

1. Student:

$\quad -2 (3x + 5) = 16$ Check:
$\quad -6 x -10 = 16$
$\quad -6 x = 16 + 10$
$\quad -6 x = 26$
$\quad x = - 13 / 3$

2. Student:
$\quad -2 (3x + 5) = 16$ Check:
$\quad -6 x + 10 = 16$
$\quad -6 x = 16 - 10$
$\quad -6 x = 6$
$\quad x = - 1$

3. Find the area of the following rectangle.

7

5   e
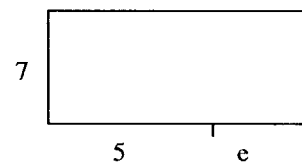
Part 3

Solve the following questions. Check your answers then change your papers with your desk-mate. Check your friend's papers.

1. Solve $- (5 x - 3) = -2$ in R.
Solution: Check:

2. Solve $8 - 5 (2x + 3) = -12$ in R.
Solution: Check:

APPENDIX B

A SAMPLE OF INSTRUCTIONAL MATERIAL FOR CONCEPTUAL CHANGE TEXT

Equations with Parentheses

Some students have problems about using DISTRIBUTIVE PROPERTY. Now, we will give examples to common errors:

1. Multiply n + 5 by 4

Right	Wrong	Wrong	Wrong
(n+5).4 = 4n+20	(n+5).4 =4n+5	(n+5).4 =n+20	(n+5).4 =20
Distributive property is used properly	Don't forget to multiply +5 by 4	Don't forget to multiply 4 by n	Don't forget to multiply 4 by n. Don't ignore n.

2. Simplify 2 – 3 (x + 5)

Right	Wrong	Wrong	Wrong
2-3(x+5)= 2-3x-15	2-3(x+5) =-1(x+5)	2-3(x+5) =2-3x+15	2-3(x+5) =2-3x-5
Dist. prop. is used.	Multiplication is done before subtraction. Firstly use dist. Prop. before subtraction	Don't forget to multiply -3 by 5.	Don't forget to multiply -3 by 5.

3. Simplify - (7 - x)

Right	Wrong
-(7-x)=-7+x	-(7-x) = -7-x
Distributive property is used properly	Don't forget to multiply - (-x) =+x

Part 2

In the following questions, solutions of some students are given. Check the results and find whether the result is true or not.

1. Solve 12 – 3 (4 – x) = -15 in R.

| Solution(Right	Check	Reason
12-3.4+3x=-15 12-12+3x=-15 0+3x =-15 +3x = -15 x = -5	When we put –5 instead of x 12-3(4- ˉ5)=-15 12-3(4+5)= -15 12-3(9) =-15 12-27 = -15 -15= -15	Dist. Prop. İs used properly

Solution (Wrong)	Check	Reason
12-3.4-3x= -15 12-12-3x= -15 0-3x =-15 x = 5	When we put 5 instead of x 12-3(4- 5)=-15 12-3(-1) =-15 12+3 = -15 15= -15	The mistake in the solution is to forget to multiply -3 by -x which is +3x

2. Solve –2 (3x + 5) = 16 in R

Solution (Right)	Check	Reason
-2(3x+5)=16 -6x-10 =16 -6x = 16+10 -6x = 26 x = -26 / 6 x = -13 / 3	Put –13 / 3 instead of x It is true	Use distributive properly

Solution(Wrong)	Check	Reason
-2(3x+5)=16 -6x+10 =16 -6x = 16-10 -6x = 6 x = -1	Put –1 instead of x It is false	The mistake s to forget to multiply -2 by +5 which is -10

3. Find the area of the following rectangle.

7
5　　e
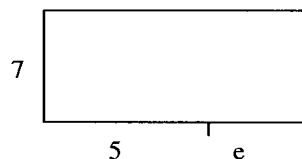
Part 3

Solve the following examples. Be careful about the mistakes which are given above. Check your results.

1. Solve – (5 x – 3) = -2 in R.

Solution:　　　　　　　　Check:

2. Solve 8 – 5 (2x + 3) = -12 in R.

Solution:　　　　　　　　Check: