

# The Effect of Conceptual Change Texts Supplemented Instruction on Students' Achievement in Electrochemistry

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## ABSTRACT

The aim of this study was to investigate the effectiveness of conceptual change texts supplemented instruction on students' understanding of electrochemistry and their attitudes towards chemistry. The participants of the study consisted of 45 junior students of a public high school. Two classes were randomly assigned as experimental and control groups. Experimental group received conceptual change texts supplemented instruction. On the other hand, control group received instruction in which lecturing, questioning and discussion methods with no consideration of the misconceptions were used. The study lasted in 3-weeks period. A 24-item multiple choice test that was developed by the researcher was administered to assess students' conceptual understanding of electrochemistry. Meanwhile attitude scale toward chemistry was provided to both groups as a pre and post tests. As a result, it was obtained that there was no significant difference between groups on understanding of electrochemistry concepts and their attitudes towards chemistry as a school subject.

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Conceptual change approach, conceptual change texts, misconception, electrochemistry

## Introduction

Students' explanations regarding scientific phenomena generally come from their experiences and sometimes they explain scientific explanations in novel ways (Wright & Bilica, 2007). These explanations are sometimes inconsistent with the scientific explanations (Keeley, Eberle & Farrin, 2005). The concepts that are inconsistent with the scientific understanding are called misconceptions. Misconceptions of students' indicate that they hold an imperfect or mistaken understanding of the concept (Pines & West, 1986). A variety of concepts have been used to describe the students' inconsistent scientific explanations. For example; preconceptions (Driver & Easley, 1978; Novak, 1977), alternative frameworks (Driver, 1981; Driver & Erickson, 1983), misconceptions (Garnett, Garnett, & Treagust, 1990; Helm, 1980; Treagust, 1988), and children's science (Gilbert, Osborne, & Fensham, 1982). In this study, the term misconception was used to indicate students' inconsistent scientific views.

Many studies have shown that students in different age groups have many misconceptions regarding science topics one of which is electrochemistry (Yürük, 2007). Students and teachers generally consider the electrochemistry and related subjects as one of the most difficult topics of chemistry (Finley, Stewart, & Yaroch, 1982; Johnstone, 1980). Electrochemistry related topics involve concepts such as electrochemical cells, electricity and oxidation-reduction which is considered as very challenging by students (Butts & Smith, 1987). The most common misconception hold by students related to electrochemistry is that electrons flow

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through a salt bridge and electrolyte solutions (Lin et al., 2002; Schmidt, Marohn, & Harrison, 2007; Yürük, 2007).

It is well known that misconceptions are persistent and it is difficult to change them (Arnaudin & Mintzes, 1985; BouJaoude, 1991). Therefore, misconceptions affects students' further learning in negative way. Therefore, more importance should be given while teaching to change misconceptions and support meaningful learning (Atasoy, Akkus & Kadayifci, 2009). Several successful remediation methods and techniques have been documented in the literature to overcome misconceptions, and to promote conceptual change (Westbrook & Marek, 1991) which are using concept maps, animations, analogies, computer-assistant simulations, conceptual change text, and laboratory activities (Dagher, 1994; Mason, 1994; Chambers & Andre, 1997; Huddle, White, & Rogers, 2000; Cakır, Uzuntiryaki, & Geban, 2002). Conceptual change texts are most widely used technique among them in the literature. Although several studies have reported the effectiveness of conceptual change texts on remediation of misconceptions (Alkhaldeh & Al Olaimat, 2010; Beşer & Geban, 2007; Özmen, 2007; Yenilmez & Tekkaya, 2006; Yürük, 2007) several studies reported some problems regarding the effectiveness of conceptual change instruction (Toka & Aşkar, 2002; Basili & Sanford, 1991; Happs, 1985; Hameed, Hackling, & Garnett, 1993). Therefore, it is clear that further research is needed to clarify the effectiveness of conception change instruction. Therefore this study amid to investigate the effect of conceptual change text supplemented instruction on eleventh grade students' understanding of the electrochemistry concepts. Furthermore, students' attitudes towards chemistry were also investigated.

### **Method**

A quasi-experimental design was used in this study. In this design the groups are matched on certain characteristics instead of relying on random assignment and existing groups of subjects such as classes, are used (Wallen & Fraenkel, 2001).

#### **Participants**

45 junior high school students from two classes of a public high school (Anatolian high school) participated to the study. Same content (electrochemistry topics) was tough in both classes by the chemistry teacher. One of the classes (Male=13, Female=11, N = 24) was randomly assigned as the experimental group (EG) and the other one (Male=8, Female=13, N= 21) as the control group (CG). The participants were 16 or 17 years orders.

#### **Instruments**

**Electrochemistry concepts test (ECT).** Students' understanding of electrochemistry concepts was assessed by a multiple choice test in which distracters were composed of students' common misconceptions. Electrochemistry misconceptions reported in the literature were used while constructing the items and each item was in coherence with the objectives of the course. The 24 items of ECT were composed of five options were one was correct and four of which was distracters. The items of the test were related to electrochemistry concepts and common misconceptions related to the topic. The content validity of the test was verified by one expert in chemistry education and one expert in chemistry. The reliability coefficient was found to be 0.73 which is sufficiently high enough (Fraenkel & Wallen, 1990). Consequently the test was included in further analyses.

**Attitude scale toward chemistry (ASTC).** The scale which was developed by Geban et al. (1994) was used to measure students' attitudes toward chemistry. The scale contains 15 Likert type items. The reliability coefficient (Cronbach's Alpha) was found to be 0.83. The scale contains both positive and negative statements. Therefore, while performing calculations the data obtained from negative statements are coded in reverse order. The maximum and minimum possible scores that can be obtained from ASTC are 15 and 75. Higher scores obtained from the scale indicate more positive attitudes.

**Conceptual change texts (CCTs).** Conceptual change texts (CCTs) were developed by the researcher considering Roth's (1985) and Posner et al.'s (1982) ideas. In CCTs, a situation or question in which students were expected to make prediction based on their misconception was presented to students. Presenting such situations to students activates their misconceptions. Then they were informed of common misconceptions students have followed by evidence that they are wrong. Then, scientific explanation of the concepts was

given by providing several examples and graphic organizers to strengthen the rationality of scientific explanations over misconceptions. This will probably make the scientific explanation more intelligible and plausible for the students. Moreover, some additional questions and some daily life examples in which scientific explanation works better were provided to make scientific explanations more fruitful to students.

### Treatment

The study lasted in 3-weeks period. There were three lessons per week and each lesson took 45 minutes. Both classes (EG and CG) received instruction from the same chemistry teacher. Before starting the implementation, researcher explained what conceptual change is and how conceptual change texts are developed and how these texts should be used while classroom instruction to the teacher. Besides, students' common misconceptions that are presented in the literature were discussed. Moreover, a detailed discussion was made on data collection procedures and each implementation to prevent both misleading points and threats to internal validity. Each group received ECT and ASCT as a pre-test a week before the implementation. While the implementation each group received instruction on same topics in same instructional time. The only difference between the groups was the conceptual change texts that are received by EG. The students in CG received instruction in which lecturing, questioning and discussion methods with no consideration of the misconceptions were used. Major concepts, equations, and definitions were presented by the teacher and students were asked to take notes while listening to the lectures. Meanwhile, some experiments and activities provided in the course book were conducted. Moreover, the teacher solved quantitative problems related to electrochemistry concepts in the control group. On the other hand, students in experimental group received instruction supplemented by CCTs. In each lesson, after a brief instruction students received the first leaf of the CCTs where conflicting conditions or questions that seek answers containing misconceptions, were presented. After obtaining students answers remaining texts were presented and asked students to read individually. Then, a detailed discussion was made. In these discussions, students tried to explain why scientific explanations are better in explaining the given situation. A week after the treatment, ECT and ASCT were administered as post-tests to both CG and EG at the same time.

### Results

The means and standard deviations for pre-test and post-test scores across experimental and control groups are presented in table 1.

**Table 1.** Mean and standard deviations of pre and post ECT, ASCT across groups

Group	N	Pre-ECT		Post-ECT		Pre-ASCT		Post-ASCT	
		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
EG	24	6.21	3.09	15.08	2.98	54.54	11.14	52.12	10.48
CG	21	6.48	2.34	13.05	4.74	51.43	10.39	51.00	8.40

EG: Experimental group, CG: Control group,  $\bar{X}$ : Mean, SD: Standard deviation, N: Number of individuals

There was not any significant difference between the control and experimental group in terms of their previous knowledge about electrochemistry concepts [ $t(43) = 0.324$ ,  $p > 0.05$ ] and attitudes toward chemistry as a school subject [ $t(43) = -0.969$ ,  $p > 0.05$ ] indicating that students in the experimental and control groups were similar regarding these two variables before the treatment.

In order to investigate whether there is a significant mean difference between control and experimental groups in terms of ECT and ASCT post test scores independent t-test analysis was performed. Independent t-test analysis revealed that there was not any statistically significant difference between the experimental and control groups mean scores on ECT post test scores [ $t(43) = -1.75$ ,  $p > 0.05$ ] and ASCT post test scores [ $t(43) = -0.393$ ,  $p > 0.05$ ]. This result indicates that the treatment did not cause any significant effect on students understanding of electrochemistry and their attitudes towards chemistry as a school subject.

### Discussion

The purpose of the study was to investigate the effectiveness of conceptual change text supplemented instruction on electrochemistry achievement and attitudes towards chemistry of 11th grade students. After

the statistical analysis, it was found that there was no significant mean difference between groups (EG and CG). Moreover, no significant difference was found in attitudes towards chemistry as a school subject. Although the result regarding students' attitudes towards chemistry is consistent with the literature, result regarding the effects of CCTs supplemented instruction is inconsistent with the literature. Most of the studies conducted on CCTs supplemented instruction indicated positive effects of that instruction on students' achievement (Yürük, 2007; Alkhaldeh & Al Olaimat, 2010; Pinarbasi et al., 2006). However, few studies on conceptual change reported some problems concerning the effectiveness of conceptual change instruction in the literature. Some of those problems are;

- Many students retain their misconceptions after the conceptual change instruction (Basili & Sanford, 1991)
- Some of the students may return to hold their previous explanations (Happs, 1985)
- It may be difficult for teachers to teach for conceptual change (Basili & Sanford, 1991)
- Misconceptions that are not specifically addressed in instruction may still exist (Hameed, Hackling, & Garnett, 1993)

Meaningful learning depends on prior knowledge students have since they construct new knowledge by the help of prior ones. If pre existing conceptions are congruent with that of scientifically accepted ones new knowledge can be comprehended easily. However, if the pre existing conceptions are inconsistent with that of scientifically accepted ones these concepts may hinder further learning. Moreover, several studies have demonstrated that prior knowledge has profound effects on text comprehension (Goldman & Bisanz, 2002; van den Broek et al., 2002). However, Lipson (1982) indicated that knowing inconsistent information regarding the passages decreases the comprehension of students. Therefore prior knowledge can affect further learning either in negative or positive way. If the results of the sample in the pre test is investigated it is clear that both EG and CG students have insufficient prior knowledge. Some of the items in the test were somewhat related with the oxidation and reduction subject that was taught before the electrochemistry subject. Therefore, they were able to respond correctly to several items of the pre-ECT (see Table 1). However, they gave incorrect answers to the majority of the items in which the distracters were designed so that to reflect students misconceptions. These results indicate that participating students hold some misconceptions before the treatment. In the literature for identifying students' misconceptions several techniques are applied one of which is using multiple choice tests similar to the test used in this study. Although there are some criticisms of using multiple choice tests while investigating students' misconceptions several studies presented the positive aspects of using multiple choice tests for that purpose (Allsop & George, 1982; Ogude & Bradley, 1994).

When post-ECT scores are investigated it was observed that EG students' scores were higher than CG students' scores but the difference was not statistically significant. That means the treatment made some effect on achievement but that effect was not significant. Therefore, it is not an easy process to overcome misconceptions and just providing CCTs probably is not enough and should be supported with some other materials and experiences to increase the effectiveness of conceptual change instruction. Another fact is that students generally do not like reading texts and in the literature it was found that there are varieties of factors that effect learning. For example, in a meta-analysis conducted by Fraser et al. (1987), it was found that teaching and learning is affected by many factors. Meanwhile, Duckworth and Seligman (2005) presented that besides teaching and teacher quality, intelligence and self-discipline also affects school achievement. Hayes and Ellison (1988), Hofstede (1997) and Yamazaki (2005) indicated that national culture can also affect students learning performance since students expectations from teaching and teacher student roles are affected by cultural variables. Moreover, it is well known that motivation enhances learning and achievement (Pintrich & Schunk, 1996). For example, as Palmer (2003) indicated "a student who voluntarily participates in a reading activity will probably be more motivated to comprehend than a student who is forced to read the same material". In addition, matching teaching style with students learning styles could also promote learning (Brown, 1978; Dunn & Griggs, 1988; Baloglu, Gadzella, & Stephens, 2002). Similarly students' learning approaches play an important role in learning (Ramsden, 2003; Rollnick et al., 2008). It is

clear that various factors effect learning and success of students and teaching method is just one of them. Therefore, teaching method (in this case CCTs supplemented instruction) could not be treated as the only factor that is responsible of the students' success.

### Conclusion and Implications

According to the results of the study it can be concluded that CCTs accompanied instruction can be useful or effective in remediation of students' misconception but should be supported by other materials or experiences to increase their effectiveness. Moreover, researchers should be aware of the other factors that affect learning while designing similar studies. The effects of conceptual change texts supported instruction on achievement and attitudes may change according to learning styles, learning approaches, thinking styles, motivation, reading comprehension and multiple intelligence. Therefore, how these variables effects CCTs supported instruction should be investigated. The study was conducted over three weeks period therefore longer studies could be conducted to see long term effects of conceptual change texts supported instruction on achievement.

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