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Effect Of Conceptual Change Texts On Senior High School Students' Cognitive Achievement In Electrochemistry

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***Abstract:** The purpose the study was to determine the effect of conceptual change texts on students' cognitive achievement and attitude towards electrochemistry. The study employed a quasi-experimental design in which intact classes were used. The experimental group (N=51) was made up of SHS2 chemistry students and the control group (N=52) was made up SHS2 chemistry students. Students' misconceptions in electrochemistry were first identified using a structured interview and Electrochemistry Concept Test (ECCT) as pre-test. The ECCT was administered to students before and after the treatment. There was a significant difference in cognitive achievement of students in the experimental group (M = 12.2, SD = 3.83) and the control group (M = 10.0, SD = 3.73), t (101) = 2.99, p = .003, d = .59. The results revealed that conceptual change texts resulted in a significantly better acquisition of scientific concepts and cognitive achievement of students in electro-chemistry than the traditional teaching approach.*

***Keywords:** Conceptual Change Texts, Electrochemistry, Cognitive Achievement, senior high school, concepts, misconceptions.*

I. INTRODUCTION

Electrochemistry is an important topic in chemistry as it has many applications from battery development to neuroscience and brain research (Miller, 2014). It also underpins later topics in the curriculum and consolidates earlier ones, having links to thermodynamics, rate of reaction and chemical equilibrium. Yet it has been found that students find the topics on electrochemistry difficult to learn as evidenced by the many misconceptions the students possess in this area. For example, some students hold that in an electrochemical cell the anode goes to the left and the cathode goes to the right (Ozkaya, 2002).

Students enter and potentially leave school with misconceptions regarding electrochemistry because they have missed the opportunity to modify the pre-existing knowledge so that it fits the new information (Sewell, 2002). With their misconceptions clouding their potential learning success, Chemistry students may conclude that electrochemistry is indeed one of the most difficult topics to learn in Chemistry.

Agung and Schwartz (2007) reported that educators and researchers have acknowledged that students' alternative conceptions in science represent an important educational problem. To overcome this problem, Chung (2011) suggested that diagnostic assessment should be used as an effective tool for teachers to determine student readiness before instruction. According to Sheeban and Childs (2008), it is beneficial to identify students' alternatives conception so that teachers are able to formulate strategies which will enable students' to conceptualize more appropriately and enable them to improve their achievement in chemistry as a whole. To promote meaningful learning various instructional methods that are based on constructivist theory of learning have been used to identify and remediate misconceptions students have about electrochemistry. Some of these methods reported in literature include computer animations (Doymus, Karacop & Simsek, 2010; Sanger & Greenbowe, 2000; Yang, Andre & Greenbowe, 2003), computer-assisted learning (Talib, Matthews & Secombe, 2005), conceptual change instruction (e.g. Huddle, White & Rogers, 2000; Sanger & Greenbowe,

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2000), cooperative learning strategies (Acar & Tarhan, 2007), conceptual change text (Yuruk, 2007) and jigsaw puzzle techniques (Doymus, Karacop & Simsek, 2010).

Computer assisted learning, jigsaw puzzle techniques and cooperative learning strategies have been investigated in Ghana but little or no work has been done on conceptual change text approach. Conceptual change occurs when learner changes misconceptions with that of scientifically accepted ones and changing misconceptions requires modifying or restructuring existing schemata (Onder & Geban 2006). To improve students' achievement in electrochemistry, it is pertinent that the aspects of the concepts which pose learning difficulties for students should be empirically and accurately identified, and teachers' attention drawn to them for proper handling during classroom interactions. Several strategies based on conceptual change approach have been developed to overcome misconceptions students have. One of these strategies involves the use of conceptual change texts. Conceptual change texts identify the misconceptions about electrochemistry concepts and correct them by giving analogies, examples, figures and scientific explanation.

In this study, conceptual change texts were used as a teaching strategy to promote meaningful understanding of electrochemistry among students. The study also investigated the effect of conceptual change texts oriented instruction on students' achievement in electrochemistry.

RESEARCH HYPOTHESIS

The following hypothesis was tested:

H_0 1: There is no significant difference between post-test scores of the students taught with conceptual change texts and those taught with traditional instruction with respect to cognitive achievement in electrochemistry.

II. LITERATURE REVIEW

The terms alternative conceptions and misconceptions are interchangeably used to refer to students' conceptions that are different from scientifically accepted ones (Ozmen, 2007; Taber & Tan, 2011). Conceptions that are inconsistent with the accepted scientific conceptions are defined as misconceptions. Researchers have used various terms for misconceptions, such as alternative conceptions, alternative frameworks, and preconceptions (Novick & Nussbaum, 1982; Nakleh, 1992). Misconceptions are generally firmly established in student's schemata, thus, the students are reluctant to transform them (Sungur, Tekkay, & Geban, 2001; Balci, 2006) and as the result students' learning difficulties often persist even after formal instruction in science classes. This is because misconceptions are integrated into a student's cognitive structure and interfere with their subsequent learning. According to Ndlovu (2014), alternative conceptions in science are often deeply held, largely unexplained, and sometimes strongly defended. Ndlovu stated that teachers frequently under estimate the importance and the persistence of these barriers to true understanding. This makes conceptual change a difficult task for teachers.

According to constructivist theory, learning can be viewed as a process of conceptual change. Conceptual change, within this realm, implies that a learner actively replaces existing pre scientific conceptions with scientifically acceptable explanations as new propositional linkages are formed in her/his conceptual framework (Kirsten, 2007). Conceptual change involves techniques of accommodation, restructuring, replacing, or reorganizing a concept (Taylor, 2001). It also points to the development and transformation of students understanding from their naive conceptions to scientific explanation (Uzuntiryaki, 2003). Teaching science should therefore focus on providing students with opportunities in which they have cognitive conflict in order for them to develop correct concepts based on their experience. Conceptual change can be accomplished if students are given opportunity to be aware of their ideas, to encounter ideas other than their own and to realize the deficiency in their reasoning. This can be promoted by group discussions which allow students to construct their own knowledge out of exchanges with their friends and the teacher. In this way, students can control their learning process (Uzuntiryaki, 2003).

Conceptual change theory takes constructivism as its foundation, and addresses how thoughts must be altered in order to coincide with scientific theory (Meyers, 2007). Based on conceptual change theory, one of the first steps in remedying misconceptions is the identification of one by the learner and teacher. It is important to identify a misconception, because then there is a better chance at changing it (Uzuntiryaki & Geban, 2005).

Vosniadou cited in Yuruk, Ozdemir and Beeth (2003) presented a different view about the nature of learners' preconceptions. Her theoretical framework suggests that learners' alternative conceptions do not result from the incoherent and inconsistent knowledge pieces, but they result from learners' attempts to create coherent mental models. According to Vosniadou (1994), conceptual change involves gradual changes in learner's ''synthetic" mental models with scientifically accepted mental models.

According to Piaget, conceptual change occurs as a result of development of a child's logical capabilities, and involves the domain-general modification of cognitive structures that affect the knowledge acquisition process (Reads, 2004). Piaget suggested that changes in these structures should influence reasoning ability and knowledge acquisition in all domains (Vosniadou, as cited in Reads (2004).

Vygotsky believed that the tools acquired from everyday experiences where closely related to real phenomena, but lacked coherence, whereas those acquired in a school environment were coherent but were isolated from real phenomena by the context in which they were acquired. Thus, the purpose of instruction is to help bring these tools together, so that concepts acquired from everyday experience could be integrated into a coherent framework, and the tools acquired from school instruction become usable in everyday situations (Reads, 2004).

The theoretical framework developed by Chi, Slotta, and Leeuw (1994) is based on the assumption that there are categorical differences between science concepts. Chi *et al.* cited in Yuruk *et al.*, (2003) argued that students have difficulty in encountering science concepts due to the existence of mismatch or incompatibility between categorical representation that students bring to an individual context, and the ontological category to which the science concepts truly belongs. According to this approach, misconceptions arise when the learner assigns a concept to a wrong ontological category. Categorization of concepts as espoused by Chi is supported by Disessa's view of intuitive concepts of learners as pieces. DiSessa (1993) claimed that learners' innate conceptions acquired from everyday experiences of the physical world do not possess a coherent structure, but rather they are isolated, fragmented knowledge pieces called phenomenological primitives. DiSessa (1993) went on to say that these knowledge pieces are primitive schemata constructed as a result of shallow interpretation of the physical reality. This means that, conceptual change occurs when there is a change in the functions of phenomenological primitives from relatively isolated, self-explanatory entities to the pieces of larger system.

III. METHODOLOGY

A. RESEARCH DESIGN

A quasi-experimental design is used for the study. A quasi-experiment is a type of experimental design in which the researcher has limited control over the selection of study participants (Levy & Ellis, 2011). The study utilized a non-equivalent pretest-posttest control group design. Intact classes were used for the study. This is because the study is a quasi-experiment. The two classes were General Science classes. The students offer general science programme with Chemistry, Biology, Physics and Elective Mathematics as their elective subjects. The subjects were not different in that the schools were category "A" schools and the students have similar characteristics. Both schools have well equipped science laboratories, achievement levels, and teachers with similar qualifications.

The experimental group consisted of 51 SHS 2 science students of Damongo Senior High School. The total number of students in the class was 56 (43 boys and 8 girls). The control group class consisted of 52 SHS 2 science students (41boys and 11 girls) from Ghana Senior High School in Tamale.

B. INSTRUMENT

In order to access students understanding of electrochemistry concepts, a test, the Electrochemistry Concept Test [ECCT] was developed. It consisted of 20 multiple choice tests items and two open ended questions. The second section consisted of two questions that required the students to draw both the electrochemical and electrolytic cell. Each question included a list of the parts that the students were required to label in their drawings.

The construction of the items was guided by the instructional objectives associated with electrochemistry in the national curriculum. Some of the objectives are presented in Table 1.

The student will be able to:

- ✓ Describe Oxidation and Reduction Processes.
- ✓ Describe an experiment to illustrate reactivity of metals.
- ✓ Describe oxidizing and reducing agents.
- ✓ explain the steps involved in balancing redox equations
- ✓ Describe the interconversion of chemical energy and electrical energy in redox reactions.
- ✓ Describe and explain the functions of a simple electrochemical cell.
- ✓ Explain some applications of electrochemical cells.
- ✓ Explain the operation of electrolytic cells.
- ✓ Illustrate the electrolysis of brine experimentally.
- ✓ Distinguish between electrolytic and electrochemical cells.

Table 1: Instructional Objectives on Electrochemistry (MoE, 2010)

Students' misconceptions were searched from chemistry literature. The questions of the test were developed according to these misconceptions and the curriculum instructional objectives. The items were distributed among a set of subtopics of electrochemistry. The details are provided in Table 2. These subtopics form part of the syllabus of SHS chemistry in Ghana. Each item of the ECCT consisted of a question or statement followed by four options with one of them being a distractor (misconception). The respondents were required to indicate the option that best represented his/her opinion about the question. The options for each items of the multiple-choice test included one correct answer and three distracters that reflect students' alternative conceptions. The test covered the following subtopics in electrochemistry.

Subtopics/concepts	**Items**	**Number of Items**
✓ Oxidation and reduction	11,12,16,18	4
✓ Electrochemical cell	3,6	2
✓ Electrolytic cell	5,8,13	3
✓ Placement of electrodes	1,2,9	3
✓ Direction and flow of electrons	10	1
✓ Function of salt bridge	7	1
✓ Direction of ions flow	4	1
✓ Writing half reactions	17	1
✓ Balancing redox reactions	19,20	2
✓ Electrode potentials	14,15	2

Table 2: Subtopics, Items and Number of Items Making the ECCT

Formal permission was sought from the Headmasters of the two schools before administering the ECCT. The ECCT was personally administered by the junior researcher. The pre-test was administered to both groups. The pre-test was to ensure that students of the two groups were not significantly different to avoid selection bias. The experimental group and the control group did not receive the intervention at the same time. The researcher first administered the intervention to the experimental group. The experimental group received conceptual change text instruction. The entire Electrochemistry unit took three weeks. The post-test was administered to the experimental group after the intervention. The researcher then moved to the control group and administered the intervention and after which the post-test was administered.

IV. RESULTS

H_0 1: There is no significant difference between post-test scores of the students taught with conceptual change texts and those taught with traditional instruction with respect to cognitive achievement in electrochemistry.

Independent samples t-test was performed to see if any significant difference exists between the experimental and control groups using pre-test and post-test scores. The significance value for Levene's Test was greater than .05 and therefore, equal variances were assumed. The results of the independent samples t-test is presented in Table 4.8.

Test	Group	*N*	*M*	*SD*	*t*	*P*
Pre-Test	Experimental	51	9.54	3.44	1.04	.299*
	Control	52	8.80	3.75		
Post-Test	Experimental	51	12.2	3.83	2.99	.003**
	Control	52	10.0	3.73		

** Not significant, p > .05, ** Significant, p < .05*

Table 3: Mean, Standard deviation and Independent Samples t-test results on Experimental and Control Group Pre and Post-Test Scores

The results showed that there was no significant difference between the means of experiment group and control group before the intervention [*t* (101) = 1.04; *p* =.299]. This indicated that the students in the control and experimental groups were similar regarding pre-test scores and prior knowledge on electrochemistry. Also, the results of the independent-samples *t*-test showed that there was a significant difference in cognitive achievement scores of the experimental group and the control group after the intervention [*t* (101) = 2.99, *p* = .003, *d* = .582]. The effect size (Cohen's *d*) indicated a substantial effect. Therefore, we reject the null hypothesis. This suggests that teaching with conceptual change texts caused a significantly better acquisition of scientific concepts than teaching with traditional instruction.

V. DISCUSSION

The results showed that there was no significant difference between experiment group and control group in terms of cognitive achievement before the treatment. This showed that the students in the control and experimental groups were similar regarding pre-test scores and prior knowledge. Independent samples *t*-test of the post-test scores showed that there was a significant difference between the experimental group and the control group in terms of cognitive achievement after the treatment. These results suggest that teaching with conceptual change texts caused a significantly better acquisition of scientific concepts than teaching with the traditional instructional method. These results are supported by studies of Cakır, Uzuntiryaki, and Geban, Yuruk and Geban, and Andre and Chambers cited in Balci (2006) which indicated that conceptual change text instruction was more effective to get better understanding of scientific conceptions. There may be several reasons for the effectiveness of conceptual change text oriented instruction. Firstly, conceptual change texts were designed by considering students' misconceptions about electrochemistry concepts. These findings are consistent with that of Ozmen, Yuruk, Tas-tan *et al.*, and Beerenwinkel *et al.*, cited in Sendur & Toprak (2013) who found that conceptual change text is effective in enhancing the understanding of students in chemistry concepts.

According to Johnstone cited in Salta and Tzougraki (2004), the application of chemistry concepts and symbols depends on the students' ability to transfer from macroscopic level to symbolic level, from symbolic level to microscopic level, and vice versa. Salta and Tzougraki (2004) found that the content of chemistry curriculum, the chemistry lessons time, the methods of teaching chemistry, and the lack of laboratory experiments might be some of the reasons that form such attitudes. In this study the method of teaching chemistry might have resulted in the findings.

VI. CONCLUSIONS AND RECOMMENDATIONS

The use of conceptual change text resulted in a better acquisition of electrochemistry concepts and improved students' cognitive achievement in electrochemistry than the traditional method of instruction. Conceptual change texts however did not change students' attitude towards electrochemistry. Conceptual change texts instruction had a significant effect on students' cognitive achievement in electrochemistry than the traditional method of instruction. For the conceptual change to occur, teachers should plan in order to create the right conditions for conceptual change to take place.

It is recommended that conceptual change texts oriented instruction should be used to teach chemistry concepts. During instruction, demonstrations and group works should be combined with conceptual change texts in order to activate students' pre-conceptions. Chemistry teachers of schools should promote active involvement of students through the use of conceptual change texts and some other strategies.

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