EFFECTS OF CONCEPTUAL CHANGE INSTRUCTIONAL APPROACH ON ACHIEVEMENT OF PRE-SERVICE CHEMISTRY TEACHERS IN ALIPHATIC HYDROCARBON CONCEPTS

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ABSTRACT

College students face difficulties in Organic Chemistry because the concepts are generally abstract, especially functionality chemistry. This study explored college level pre-service chemistry teachers' achievement in aliphatic hydrocarbon concepts through conceptual change instructional approach (CCIA). The participants were 87 pre-service chemistry teachers in Arbaminch College of Teacher Education, Southern Nations, Nationalities and Peoples Regional State (SNNPRS), Ethiopia. Two intact classes, taking Introductory Organic Chemistry I, were randomly assigned as Experimental group and Comparison group. The data collection instrument was the aliphatic hydrocarbon achievement test (AHAT). A non-equivalent pre-test-posttest control group design was used to investigate participant's achievement in aliphatic hydrocarbon chemistry. Data were collected and analyzed using independent samples t-test and paired samples t-test. A pre-test established that CCIA group and conventional instructional approach (CIA) group were similar at the beginning. After interventions, analysis of students' response indicated that students in the CCIA group scored significantly higher than those in the CIA group. Based on these findings and discussions, conclusions were made. *[African Journal of Chemical Education—AJCE 8(2), July 2018]*

INTRODUCTION

Chemistry is one of the subjects offered in Ethiopian schools starting from grade seven. However, the teacher-centered approach followed by instructors is affecting the learning process in chemistry [1], albeit policy documents and different guidelines prepared in line with the policy maintain on the use of student-centered approach. Instructors attribute students' problems in relation to chemistry learning generally to poor teaching environment [1][2] like absence of facilities. But when teaching materials are fulfilled, other reasons are given by instructors [3]. Thus, chemistry teachers are expected to make chemistry lessons more relevant, enjoyable, easy and meaningful to their students with concrete understanding ensured. Lee and Byun have described problems related to teaching using a clear explanation [4]. They indicated that bringing successful teaching approaches has been a major challenge for both teachers and researchers. In relation to this challenge it has become apparent that the gap, between what is important from researchers' viewpoint and what can be set in to actual exercise by teachers, has increased [5].

Learning Chemistry requires a set of skills [6][7]. This makes the subject to be considered as difficult. Its profoundly abstract nature [8][9][10][11] not only causes problems to many students, but also brands it as an unpopular subject. Despite the enthusiasm of chemistry educators, as well as several interventions, chemistry continues to be challenging [12][13]. In particular, Organic chemistry is considered to be a difficult course and is source of major impediments that college students face [14][15]. Researchers [14][15] blame the memorize-oriented approach of teaching used by many course instructors.

Also, research work demystified that student achievement in Organic chemistry is affected by their achievement in General chemistry, their high school performance in chemistry, their test scores, and cognitive variables like spatial ability performance [16][17]. Additionally, chemistry achievement problems have been attributed to poor teaching methods used by teachers [18][1][19][2] especially in Organic chemistry [20][21]. Strategies like using simulations [22][23] [24][25], peer-lead instructional approach [26], concept mapping [27], concept cartoons [23], Conceptual change texts [28][29][30] and flipped class rooms [31] have showed improvement in understanding and achievement of students in chemistry classes.

For lots of students, Organic chemistry is a course in which they must think critically with understanding rather than memorizing [21]. Understanding basic concepts in Organic chemistry and using this knowledge as a source of prediction are huge challenges for students [20]. Hassana, Hill, and Reida [32] indicated that performance in a first level chemistry course in specific areas of Organic chemistry at college level reflects the grasp of specific underlying ideas gained from school. Organic chemistry text book writers like Bruice [33] have clearly stipulated that meaningful learning occurs when learners grasp contents by a thorough understanding of fundamentals.

STATEMENT OF THE PROBLEM

Teacher Education College students, in the Ethiopian context, take two Organic chemistry courses in which aliphatic hydrocarbon concepts are treated in the Introductory organic chemistry I course. It has been reported that aliphatic hydrocarbon chemistry is among key areas of trouble for students [34] [35]. Investigator's experience shows that students' performance in the two Organic chemistry courses is poor. The problem starts with Functionality chemistry which encompasses aliphatic hydrocarbon concepts, also many other concepts are generally abstract to students [20].

There are research works that spotlight on aspects of Conceptual change instructional approach, but there is paucity of studies focusing on the effects of this approach on achievement in aliphaticity. The ways how using Conceptual change texts affect achievement in aliphatic hydrocarbon chemistry as a whole is uncharted and deserves further exploration. Thus, this study focuses on the effects of Conceptual change instructional approach (using Conceptual change texts) on pre-service chemistry teachers' achievement in aliphatic hydrocarbon concepts.

Purpose of the Study and Research Questions

The principal purpose of this study is to investigate effects of Conceptual change instructional approach through the use of conceptual change texts (CCTs) on achievement of pre-service teachers' in aliphatic hydrocarbon concepts.

To achieve the above major purpose of the study the following research questions are given:

1. Is there statistically significant difference between Experimental and Comparison group in reference to Pre-achievement test mean scores?
2. Is there statistically significant difference within Experimental and Comparison group in reference to Pre-and post- achievement test mean scores?
3. Is there statistically significant difference between Experimental and Comparison group in reference to Post-achievement test mean scores when CCIA is used in aliphatic hydrocarbon concepts?

RESEARCH DESIGN

In order to study the effect of Conceptual change instructional approach using Conceptual change text on achievement in aliphatic hydrocarbon concepts the Pretest-Posttest Nonequivalent-Groups quasi-experimental design was used in this study. The quantitative quasi-experimental approach with nonequivalent Control group design with pretest and posttest was selected in this study to use intact classrooms as it is not ethical to conduct a randomized, controlled experiment

[36][37] in settings like the college environment. The nonequivalent Control group design with pretest and posttest is represented in Table 1.

Two existing student groups were assigned to Experimental and Comparison group, both groups took the pretest. The Experimental group conducted the CCIA treatment while the Comparison group was taught in the traditional way. Both groups administered the posttest.

Table-1: The nonequivalent Control group design (O1=pretest, O2=Posttest, X=treatment)

Group	Measurement (Pretest)	Treatment/intervention	Measurement (Posttest)
EG	O_1	X	O_2
CG	O_1	---	O_2

Population and Participants

The research was conducted in Arbaminch College in SNNPRS of Ethiopia, with an enrollment of 3,500 regular Diploma pre-service teachers. The participants in this study were from a convenience sample of 87 pre-service chemistry teachers aged 18 to 24 years (M_{age}=20.01, SD=1.28) enrolled in Introductory organic chemistry I.

Instruments

The instrument used in this study was Aliphatic hydrocarbon achievement test AHAT (see Appendix-A). The students' scores on AHAT served as the basis for judging students' achievement in this study. It was designed to assess pre-service teachers' achievement in aliphatic hydrocarbon concepts. This test was developed by the researcher based on Bloom, Engelhart, Furst, Hill, and Krathwohl [38] objectives classification in relation to the content under study. The cognitive process dimensions of those taxonomies are: knowledge, comprehension, application and analysis, they were used based on the nature of the content.

The purpose of AHAT was to measure overall achievement and progress of students and covered pretest and posttest in relation to conceptual contents in aliphatic hydrocarbon concepts.

Reliability and Validity of the Instruments

To ensure validity the AHAT was checked by three Senior chemistry lecturers of the college. Also, construct validity was checked by running correlation of pilot data with students' previous chemistry results [39]. The internal consistency reliability was checked based on appropriate literature [40][41].

Pilot study

The Conceptual change instructional approach using CCTs (see Appendix-B) is an approach that is not familiar to study area and therefore piloting was required. The approach was piloted with 33 students in college context with a lesson plan format designed for the approach. Pilot study was conducted in a different college than the study site. It helped in predicting teacher's progress from one phase to another phase based on the format. It also helped to see how the CCTs could be used in the classroom setting appropriately.

The participants took part during piloting of AHAT with 20 multiple choice items and four alternatives focusing on factual and procedural knowledge from which respondents were to select responses. Item analysis was carried out for all the items in the AHAT.

First, item difficulty index was computed based on appropriate literature [42] [43] which is the relative frequency of test takers who provided correct answers to an item [44] [45]. Also, the range of discrimination among these respondents was computed using item discrimination analysis [44] [46]. For this purpose, the AHAT is scored, scores were rank ordered: 27% of the highest and 27% lowest scores were selected. This means, respondents were divided into three groups (upper 27%, lower 27% and middle 46%) based on their test results on that item. Then Item discrimination index was computed by subtracting number of test takers in the lower 27% who pass the test from the number of test takers in the upper 27% who pass that item [47][48], the value was divided to the total number of test takers in the upper group. According to Ebel and Frisbie [48] selecting upper and lower groups for item analysis has an advantage in terms of relevance and convenience. Based on the results of item analysis some items were accepted and some others items were rejected. After piloting, from 20 AHAT only 13 items retained for the main study. The reliability Kuder-Richardson -20 (KR-20) of this tool was found to be 0.70 which is acceptable [40][41].

Procedures of data collection

The AHAT should indicate achievement of participants. The Experimental group and Comparison group were given pre-test before the intervention. After the intervention (this took seven weeks), the researcher with the assistance of Organic chemistry instructors administered the post-test in both groups. The administration of this instrument was by creating test or assessment mood among pre-service teachers. The creation of assessment outlook was done in collaboration with Organic chemistry instructors. The next steps were, scoring the responses and generating quantitative data. These steps were completed accordingly.

Data Analysis

In this study data were available through AHAT which was normally distributed based on skewness and kurtosis values [49]. For perfectly normally distributed data, skewness and kurtosis value are nearly zero [50][51]. Lack of symmetry (skewness) and pointiness (kurtosis) are two main ways in which a distribution can deviate from normal [50]. However, skewness and kurtosis values in the range between -2 and +2 can be accepted as normal distribution [49][50]. The AHAT data did not deviate from these ranges in this study. After normality check the researcher used parametric tests (independent t-test, paired samples T-test) to analyze and interpret the collected data on AHAT (pre- and posttest). For this purpose, statistical analysis SPSS 20 version was used.

RESULTS, DISCUSSION AND CONCLUSION

Results

Prior to examining the effect of Conceptual change approach on pre-service chemistry teachers' achievement in aliphatic hydrocarbon concepts in this study, an attempt was made to ensure equivalence of Experimental Group (EG) and Comparison Group (CG). For this purpose, an independent sample t-test was performed on the AHAT pretest.

Table-2: Independent-samples t-test results for PRE-AHAT with respect to groups

Group	Variable	N	M	SD	SE	df	t	p
	Pre-AHAT				.37	*85*	*-.398*	*.691*
EG		44	6.39	1.75				
CG		43	6.53	1.72				

Independent samples t-test analysis (see Table-2) shows that the differences between the AHAT mean scores of both groups were similar. The maximum possible score of AHAT was 13%. A paired samples t-test was performed to check if there was a change in the mean scores between pre- and posttest results of both groups (see Table-3). Compared to the pretest scores the Experimental group and Comparison and post test scores for achievement test were found to be significant at p=0.001 level. This confirms the evidence to prove change in the mean scores after implementation of CCIA. However, this does not confirm that the CCIA is better than traditional instruction since the two teaching approaches show significant difference using paired samples t-test. To check if there is a significant difference in scores of achievement independent samples test was employed on post test scores of groups. As the Post-AHAT data were normally distributed, independent samples t-test was used to measure the effect of treatment on participants' achievement (Post-AHAT) (see Table-4).

Table-3: Paired T-test results of both groups (M=Mean, SD=Standard Deviation, SEM=Standard Error Mean)

Group			Paired Differences			t	df	P
			M	SD	SEM			
Comparison group	Pair 1	PRE-AHAT - POST-AHAT	-1.23	2.01	.31	-4.02	42	.000
Experimental group	Pair 1	PRE-AHAT - POST-AHAT	-2.59	2.38	.36	-7.23	43	.000

Table-4: Independent-samples t-test results for Post-AHAT

Group	**Variable**	**N**	**M**	**SD**	**SE**	**df**	**t**	**p**
	Post-AHAT				.42	*85*	*2.86*	*.005*
EG		44	8.98	1.95				
CG		43	7.77	1.99				

Independent samples t-test analysis shows that the differences between the AHAT mean scores of both groups implying that after the intervention the groups were different. Thus, a significant difference for treatment was obtained for Post-AHAT, $p<0.01$, $d=0.61$ (manually computed value). This is of medium effect size for Post-AHAT [52]. This result indicated that the groups differ significantly after intervention in favor of CCIA. In addition, the line graph depicts the difference between groups in terms of Post-AHAT (see Figure-1).

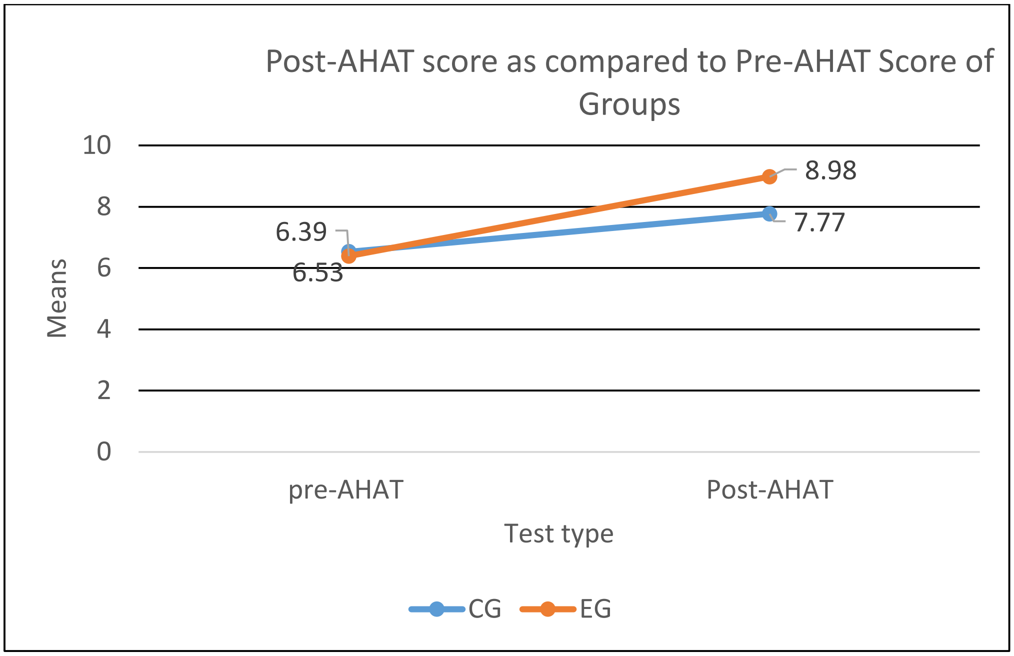

Figure-1: Line-graph of Post-AHAT scores in comparison to pre-AHAT scores

DISCUSSION

In this study, an independent sample t-test was carried out to test differences between the Experimental and Comparison group on pretest mean scores. The groups were not significantly different based on the pre-AHAT mean score: both groups were similar. This means, before treatment the effectiveness of the instructional approaches on pre-service chemistry teachers' achievement could not be attributed to prior knowledge difference.

In addition, a paired samples t-test was performed to check if there was a change in the mean scores due to the intervention. Compared to the pre-test scores the post-test scores for achievement were found to be significant at $p = 0.001$ level-the Experimental group post-test scores were found to be better. These confirm the existence of evidence to prove change in the mean scores after implementation of CCIA. To check differences by another way the test independent samples t-test was employed. The test results indicated that the Experimental group scores were significantly (at P=0.01) higher than the Comparison group scores. This is due to the use of Conceptual change instructional approach using Conceptual change texts in the Experimental group.

This finding is consistent with the findings in other studies and support the fact that when students are exposed to Conceptual change instructional approach their achievement increases significantly [53][54][55][28][30][56]. For instance, Ozkan and Selcuk [56] found that students in the Conceptual change text group scored significantly higher than those in the traditional instructional group instructing pressure and buoyancy concepts in physics. Also, Sendur and Toprak [30] found that students in the Conceptual change text group scored significantly higher than those in the traditional instructional group teaching alkenes.

CONCLUSION

In a quantitative study, an intervention according to the effectiveness of the use of Conceptual change texts was carried out for seven consecutive weeks. After intervention, analysis of the results revealed that the Experimental group outperformed the Comparison group in a special achievement test. Due to the significant and meaningful results by the Experimental group the superiority of CCIA is confirmed.

In general, through learning by using Conceptual change texts the well-known misconceptions of many students have changed. The knowledge of participants has increasing in

Organic chemistry. By making discussions on those texts during the treatment, students got the advantage to know which answers are scientifically right and which answers with misconceptions.

The results of this study revealed that during preparation for teaching chemistry and Organic chemistry in particular misconceptions well known from literature should be included. Barke, Hazari and Sileshi [59] indicated that students perform better by discussing those wrong answers and with the help of the teacher they grab successfully the scientific mental model.

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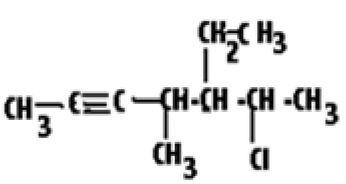
APPENDIXES

Appendix-A: Some Items of the Aliphatic Hydrocarbon Achievement Test

Directions: Each of the questions below is followed by four suggested answers. Select the correct one and encircle the letter of your choice.

1. A molecule of a saturated compound is one that
   - A. contains only carbon-carbon sigma bonds
   - B. contains at least one carbon-carbon pi bond
   - C. contains at least one carbon-carbon multiple bond
   - D. undergoes addition reaction
2. The molecular structure below is given – what is the IUPAC name?

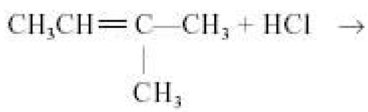


   - A. 2-chloro-3-ethyl-4-methyl-5-heptyne
   - B. 6-Chloro-5-ethyl-4-methyl-2-heptyne
   - C. 5-Chloro-6-ethyl-4-methyl-2-heptyne
   - D. 6-Chloro-5-ethyl-4-methyl-5-heptyne

3. The removal of water from alcohol leaving an alkene is
    A. Hydration
    B. Dehydration
    C. Hydrogenation
    D. Dehydrogenation
4. If an unsymmetrically substituted alkene molecule reacts with a hydrogen halide molecule,
    A. the H atom adds to the C atom with greatest number of H atoms
    B. the halogen atom adds to the C atom having fewer H atoms
    C. the addition follows Markovnikov's rule
    D. All of the above

Appendix-B: Alkene Reactions (Markovnikov's Rule)

What is the name of the compound formed when the following molecules react? Why? Explain.

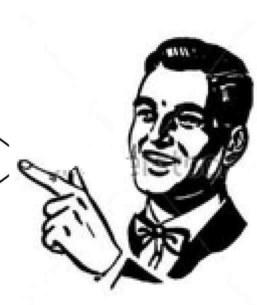


(I) 2-chloro-2-methylbutane

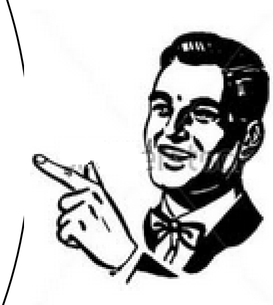
(II) 2-chloro-3-methylbutane

How do we predict the addition product of multiple bond or double bond containing hydrocarbon molecules?

Some students select option II, because they assume that addition of the HCl molecule takes place at the C atom with the double bond on the side of the longest chain. This is not an idea accepted by scientific community, it is a misconception.



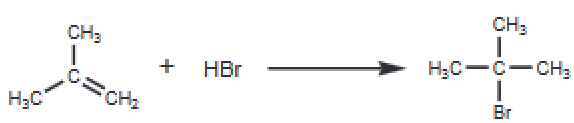
The two C atoms of a double bond can add HCl molecules during addition reactions with reagents such as HCl, HBr, and HOH. For example, two different compounds might possibly be formed by reaction of 1-butene with HCl. In conditions of this sort, the rule that predicts which of the two products is formed is called **Markovnikov's rule**: *In the addition of reagents like HCl to an alkene, H atoms add to the double-bonded C atom that has the greater number of H atoms already bonded to it.* In HCl, HBr and H_2O molecules the H atoms have a partially positive charge because they are bonded to more electronegative atoms. Thus, in the reactions of the type indicated above, the H atom from HCl molecule bonds to the C atom with more H atoms, and the Cl atom bonds to the C atom with less H atoms.



Thus, the name of the compound formed is **2-chloro-2-methylbutane**:

1) $CH_3CH_2CH{=}CH_2 + HCl \rightarrow CH_3CH_2CHCl{-}CH_3$

2)



3)