CONCEPTUAL CHANGE TEXTS AND PRE-SERVICE CHEMISTRY TEACHERS CONCEPTUAL UNDERSTANDING OF ALIPHATIC HYDROCARBON CONCEPTS

Woldie Belachew*[1], Hans-Dieter Barke[2] and Sileshi Yitbarek[3]
[1]Addis Ababa University, Addis Ababa, Ethiopia
[2]University of Muenster, Germany
[3]Kotebe Metropolitan University, Addis Ababa, Ethiopia
*Corresponding author email: woldbe@yahoo.com

ABSTRACT

Students at College level struggle with organic chemistry concepts. This problem starts from the very first course offered to them at the introductory level indicating the mysterious nature of concepts in it. This investigation explored college level pre-service chemistry teachers' conceptual understanding in aliphatic hydrocarbon concepts through conceptual change instructional approach (CCIA). Conceptual change texts (CCTs)- based –instruction as one variety of conceptual change approaches was used during the intervention in the experimental group. Eighty-seven pre-service chemistry teachers (Mean Age=20.01 yrs) in Arbaminch College of Teacher Education, Southern Nations, Nationalities and Peoples Regional State (SNNPRS), Ethiopia took part in the study in 2017 G.C. Two classes taking introductory organic chemistry I, were randomly assigned as experimental group and comparison group. The data collection instrument was Aliphatic Hydrocarbon Diagnostic test (AHDT). A non-equivalent pre-test-posttest control group design was used to investigate pre-service chemistry teachers' conceptual understanding in aliphatic hydrocarbon concepts. Data were collected from pre-service teachers 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 alike at the commencement. Analysis of students' response showed that students in the CCIA group scored significantly higher than those in the CIA group in AHDAT after intervention. A significant or meaningful result was obtained in the experimental group confirming the preeminence of CCIA through the use of CCTs over CIA**.** *[African Journal of Chemical Education—AJCE 11(1), January 2021]*

INTRODUCTION

Chemistry in general and organic chemistry in particular are effort-intensive. Due to this, students are expected to think critically with understanding rather than memorizing ideas [1]. Understanding problems are quite ubiquitous and rampant among students [2] during instructions in classroom settings. Research endeavors [3] [4] indicated that students' understanding of organic chemistry concepts is shallow and with alternative conceptions. Duffy [5], in her thesis work, clearly stipulated that informing students to avoid memorization alone does not suffice. She suggested that instructors should go beyond stating the disadvantages of memorization and teach towards conceptual understanding. Also, Sendur [6] in her study on alkene concept, made a call to make understanding related studies through investigating learners' understanding levels and misconceptions using teaching strategies like conceptual change texts (CCTs). The clear meaning of conceptual understanding and the approaches to be followed in this line are open to debate [7] as there are diverse approaches to address students' conception problems. However, until now conceptual change is a prevailing agenda in science education literature.

Traditional science texts are tricky for student to learn meaningfully because most are full of technical terms, which are very difficult to comprehend [8]. This is associated with the problem of text book writers [8]. Choosing the right strategy such as the use of CCT is suggested in science education literature [9] [6] [10]. Preferring the right strategy to be used in the organic chemistry courses at college level may require applying the constructivist approach to bringing conceptual understanding. This entails using texts, which can make learning more meaningful and discuss their alternative conceptions overtly. Conceptual change instruction can be of assistance for students to conquer misconceptions and learn intricate concepts in all subjects [11]. Instruction based on constructivist approach focuses on students' ideas, encourages students to think about situations, and use their knowledge and share their ideas-making students active in the learning process [12] [13] [14]. Conceptual change texts (CCTs) with alternative conceptions of learners, reasons for correct responses, justifications for alternative or nuanced ideas and sufficient examples [15] satisfy the requirements of constructivists' view. CCTs present new theories to refute the old ones [9]. CCTs are particularly effective in promoting conceptual change. These texts contrast common alternative conceptions with scientific conceptions. It is imperative to examine conceptual change text-based strategy that may enhance students' learning with understanding in organic chemistry domain such as aliphatic hydrocarbons.

Documents from study site and experience of the principal researcher have attested that students' performance in the organic chemistry courses at college level is poor. Many organic chemistry concepts are generally abstract to students [2], the problem starts with functionality chemistry which encompasses aliphatic hydrocarbon concepts. In different studies [16] [17], it has been reported that aliphatic hydrocarbon concepts are among key areas of worry for students. However, there is little research work focusing on aliphatic hydrocarbons [10] through the use of conceptual change approach (using conceptual change texts). Therefore, effects of CCTs based instruction on understanding of aliphatic hydrocarbons needs investigation.

Objectives of the Study and Research Questions

The prime purpose of this study was to investigate effects of conceptual change instructional approach on conceptual understanding of pre-service teachers' in aliphatic hydrocarbon concepts. To attain the above major purpose of the study the following research questions were framed:

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

METHODOLOGY

Design Type

The study design employed in this study was the Pretest-Posttest Nonequivalent-Groups quasi-experimental Design. The quantitative quasi-experimental approach with nonequivalent control group design with pretest and posttest was selected in this study with intact classrooms.

Study Site, Population and Participants

The study was conducted in Arbaminch College, Southern Nations, Nationalities Regional State, (SNNPRS), Ethiopia. The college has an enrollment capacity 3,500 regular Diploma pre-service teachers. Eighty-seven pre-service chemistry teachers aged 18 to 24 years (Mean age=20.01 years) took part in this study in the academic year 2017 G.C. The participants were the pre-service chemistry teachers registered in Introductory Organic Chemistry I course in the same college in regular Program.

Instruments

The instrument used in this study was Aliphatic Hydrocarbon Diagnostic Test (AHDT). The purpose of AHDT was to measure overall understanding and progress of students. This test was partly developed by the principal researcher based on procedures of the development of the diagnostic tests [18]. In addition, the principal researchers used literature sources for some items [6] [10]. The AHDT (See Appendix-A) covered the main topics of aliphatic hydrocarbons. The AHDT was developed for pretest and posttest in relation to conceptual contents in aliphatic hydrocarbon concepts.

Reliability and Validity of the Instruments

The internal consistency reliability was checked based on appropriate literature [19] [20]. To ensure validity the AHDT was checked by three senior Chemistry lecturers of the study area. Also, construct validity was checked by running correlation of pilot data with students' previous chemistry result [21].

Pilot study

Piloting is important in any study. The same thirty-three participants took part during piloting of AHDT. The AHAT had 20 two-tier multiple-choice items. Item analysis was carried out for all the twenty items in the AHDT. Based on the item analysis, from 20 AHDT only 13 items retained (Appendix-A) for the main study. All items were dichotomously scored as zero for not answering both tiers correctly and one for answering both tiers correctly. Also, from the pilot test the reliability Kuder-Richardson -20 (KR-20) of this tool was found to be 0.71 which is acceptable [19] [20]. Also, the conceptual change instructional approach through using CCTs (Appendix-B) was piloted as it is an approach that is not familiar to study area.

Procedures of the Data collection

To assess the difference between groups after intervention, the principal investigator assigned intact groups to experimental and comparison treatments, administered a pretest to both groups, conducted experimental treatment activities with the experimental group only, administered a posttest to judge the differences between the two groups, and finally comparison of the mean scores of groups was made. These steps were accomplished consequently.

Data Analysis

In this study data was generated from scores of the AHDT. The AHDT (Pre-and post) was normally distributed based on skewness and Kurtosis values [22]. After normality check the researcher used independent t-test and paired samples T-test to analyze and interpret the collected data on AHDT (Pre-and post). For the purpose statistical analysis SPSS 20 version was used.

RESULTS, DISCUSSION AND CONCLUSION

Results

Comparison of Pre-AHDT Mean Scores of Experimental and Comparison Groups

Before examining the effect of conceptual change approach on pre-service chemistry teachers' understanding in aliphatic hydrocarbon concepts, 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 pretest AHDT.

Table-1: Independent-samples t-test results for PRE-AHDT with respect to groups

Treatment	**Variable**	**N**	**M**	**SD**	**SE**	**df**	**t**	**p**
	Pre-AHDT				.42	*64.8*	*.978*	*.332*
EG		44	4.18	2.49				
CG		43	3.77	1.29				

Independent samples t-test analysis shows the differences between the AHDT mean scores of the groups (M_{EG} =4.18, SD_{EG} =2.49, N_{EG} =44 and M_{CG}= 3.77, SD_{CG} =1.29, N_{CG} = 43; t(85)= .978, p>0.05). The Pre-AHDT scores of the groups were not significant (p=0.05), implying that prior to the intervention the groups were comparable.

Comparison of Groups in terms of Pre-and Post-AHAT

A paired samples t-test was performed to check if there was a change in the mean scores due to CIA in the comparison group and CCIA in the experimental group.

Table-2: Paired Samples T-test result of groups

Group			Paired Differences			t	df	P
			M	SD	SEM			
CG	Pair 1	PRE-AHDT - POST-AHDT	-1.16	2.48	.38	-3.08	42	.004
EG	Pair 1	PRE-AHDT - POST-AHDT	-2.25	2.41	.36	-6.19	43	.000

M=Mean, SD=Standard Deviation, SEM=Standard Error Mean

As indicated in Table-2, compared to the pretest scores the comparison and Experimental group post test scores for understanding test were found to be significant (p<0.01 for CG and P<0.001 for CG). This confirms the existence of evidence to prove change in the mean scores after implementation of CIA and CCIA. However, this does not confirm that the CCIA is better than CIA since the two treatments show significant difference using paired samples t-test. To check if there is a significant difference exists in scores of understanding test independent samples t-test was employed on post test scores of groups.

Table-3: Independent-samples t-test results for Post-AHAT with respect to groups

Group	Variable	N	M	SD	SE	df	t	p
	Post-AHDT				.48	*85*	*3.15*	*.002*
EG		44	6.43	2.31				
CG		43	4.93	2.13				

Independent samples t-test was used (as the Post-AHDT data were normally distributed) to measure the effect of treatment on pre-service chemistry teachers' understanding (Post-AHDT). Independent samples t-test analysis (table-3) shows that the differences between the AHDT mean scores of the groups (M_{EG} =6.43, SD_{EG} =2.31, N_{EG} =44 and M_{CG}= 4.93, SD_{CG} =2.13, N_{CG} = 43; t(85)= 3.15, p<0.01) implying that after the intervention the groups were different. Thus, a significant difference for treatment was obtained for Post-AHDT, p<0.01, d=0.68. This is of medium effect size for Post-AHDT [23]. This result indicated that the groups differ significantly after intervention in favor of CCIA. In addition, the column- graph below depicts the difference between groups in terms of Post-AHDT.

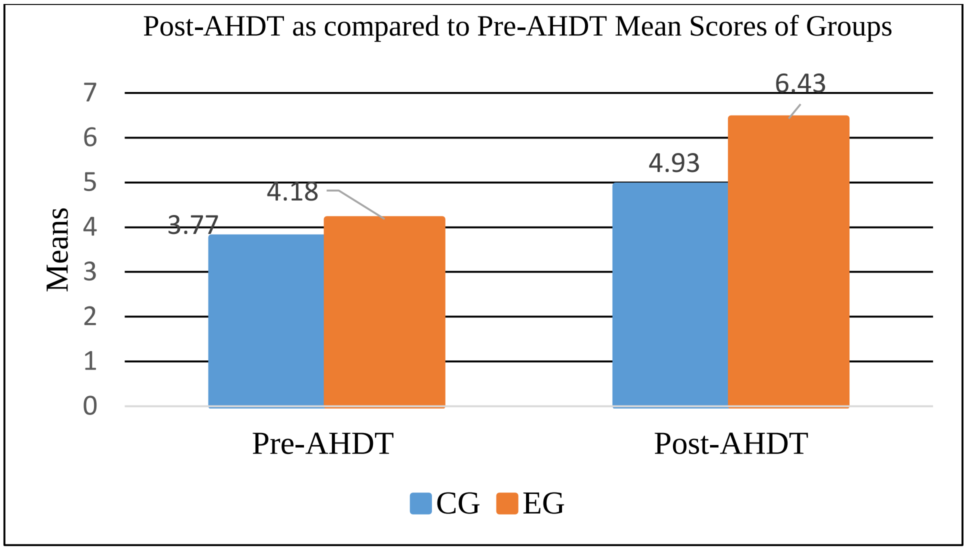

Figure-1: Column-graph of Post-AHDT score as compared to pre-AHDT Score to depict the change after intervention

Discussion

Before the treatment, in this study, an independent sample t-test was carried out to test significant difference between the groups on pretest mean scores. The groups were not significantly different based on the pre-AHDT mean score. The pretest data showed that at baseline the two groups were alike. This means, before treatment the effectiveness of the instructional approaches on pre-service chemistry teachers' understanding 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 both types of intervention. Compared to the pretest score the comparison group post test score for understanding test was found to be significant. Similarly, compared to the pretest score the experimental group post test score for understanding test was found to be significant. These confirm the presence of evidence to prove change in the mean scores after implementation of CIA and CCIA. However, this paired samples t-test result does not confirm whether the CCIA is better than CIA or not.

To check this independent samples t-test was employed. The independent samples t-test result showed that the CCIA group pre-service chemistry teachers' score is significantly higher than the CIA group pre-service chemistry teachers' score. This is due to the use of conceptual change texts in the experimental/CCIA group. The reason for the change can be ascribed to the nature of texts used and the interactive nature of the CCIA class. The texts used in the study took students alternative conceptions in to account and the classroom of the intervention group was with productive interactions (teacher-student interaction and student-student interaction). This finding is consistent with the findings in other studies [24] [25] [6] [10] and support the fact that when students are exposed to conceptual change instructional approach their understanding increases significantly. For instance, Ceylan and Geban [24] in their recent study found that students in conceptual change-oriented instruction group scored significantly higher than those in the traditionally designed chemistry instruction group with respect to the understanding of matter and solubility concepts.

CONCLUSIONS

The principal purpose of this study was to investigate effects of conceptual change instructional approach on conceptual understanding of pre-service teachers' in aliphatic hydrocarbon concepts. After intervention, data was gathered using the AHDT and analysis was made. Though a thorough understanding of concepts is difficult [26] [27], intervention showed improved understanding. Analysis of the result revealed that the experimental group outperformed the comparison group in understanding test with medium effect size magnitude. In this study, a more significant or meaningful result was obtained in the experimental group confirming the preeminence of CCIA over CIA.

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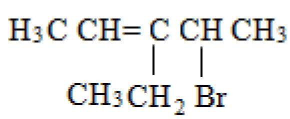
APPENDICES

Appendix-A: Sample Aliphatic Hydrocarbon Understanding Test Items

Directions: For questions below, select the correct answer from alternatives given for the content knowledge tier (first tier) and the reasons for content response or understanding tier (second tier). After selecting the answer, encircle your choice for both tiers.

1. Given the structure:



The IUPAC Name of the Compound is

I. 4-bromo-3-ethyl-2-pentene
II. 2-bromo-3-ethyl-3-pentene

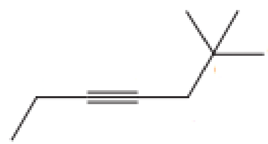
The reason for my answer is because

A) when C = C precedes alkyl groups and halogens in the numbering of the main carbon chain of alkenes, the C = C takes the lower number
B) when alkyl groups and halogens appear with C=C double bond in naming alkenes, the C = C takes the highest number.
C) in numbering the main carbon chain, the alphabetical order of the groups attached to the carbon chain is given priority.
D) the main carbon chain starts with the C atom to which the halogen atom is attached, priority is given to the halogen in assigning numbers

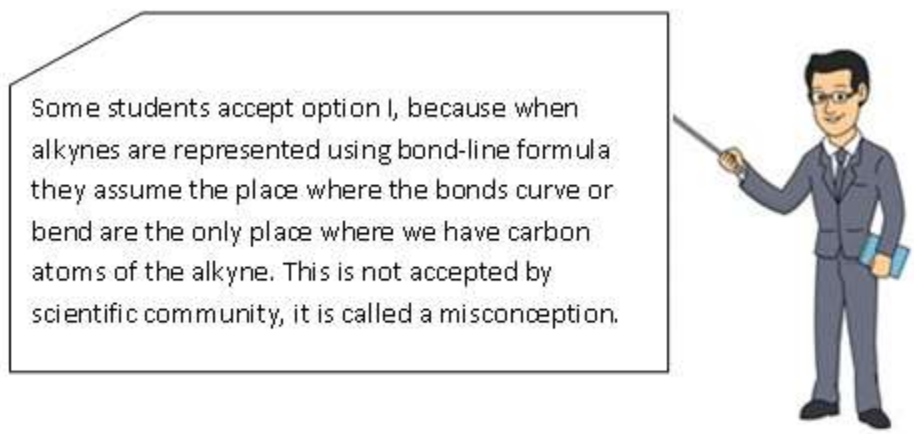
2. Given the condensed structural formulas of two compounds below,
   H_3 C CH_2 CH= CH_2 and H_3 C CH= CH CH_3
   What can be said about these two compounds?
   I. they are position isomers of each other
   II. they are geometric isomers of each other
   The reason for my answer is because
A) both can show cis and trans forms regardless of groups attached to the double bond containing carbon atoms
B) they have the same molecular formula but they differ in the position of the double bond
C) they have similarity in both structure and functionality
D) both can show cis and trans forms when a halogen atom attaches to each of the double bond containing carbon atoms

Appendix-B: Sample Conceptual Change Text: Naming Alkynes

What is the IUPAC name of the following Alkyne? Explain.



(I) 4,4-dimethyl-2-pentyne
(II) 2,2-dimethyl-3-pentyne



Some students accept option II, because when alkynes are represented using bond-line formula they assume numbering should start in the direction where we have more substituents to take the lowest possible numbers. This is not accepted by scientific community, it is called a misconception.

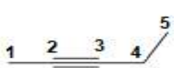
Naming alkynes with bond-line formula

Alkynes are named using the same IUPAc rule which is applied in naming condensed structural formulas. For larger molecules, number the longest carbon chain that contains the triple bond from the end that gives the triply bonded carbons the lower numbers. Show the location of the triple bond by the number of its first carbon. Since Alkynes have linear geometry or shape, we draw them with four carbon atoms in a straight line while using bond-line representations.

Thus, the above molecule is 6,6-dimethyl-3-heptyne

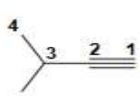
Examples:

1)



2-Pentyne

2)



3-Methyl-1-butyne