CONCEPTUAL CHANGE INSTRUCTIONAL APPROACH THROUGH THE USE OF CONCEPTUAL CHANGE TEXTS AND PRE-SERVICE CHEMISTRY TEACHERS' MOTIVATION

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ABSTRACT

This study explored College level pre-service chemistry teachers motivation in organic chemistry, especially in concepts of aliphatic hydrocarbons. Motivation as an affective domain is an important area of attention in chemistry education in general and organic chemistry education in particular. To capture students learning processes and behavior the investigation on students' motivation has been done while using Conceptual Change Texts (CCTs) during the instructional process. Participants were 87 pre-service chemistry teachers in Arbaminch College of Teachers 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 Chemistry Motivation Rating Scale (CMRS) items. A non-equivalent pre-test-posttest control group design was used to investigate pre-service chemistry teachers' motivation. Data were collected from pre-service teachers and analyzed using independent samples t-test, Wilcoxon-Ranked test and Mann-Whitney U test. A pre-CMRS established that Conceptual Change Instructional Approach (CCIA) group and Conventional Instructional Approach (CIA) group were comparable at the start. Analysis of students' responses indicated that students in the CCIA group rated themselves higher than those in the CIA group in Post-CMRS after intervention. Based on the findings and discussions, conclusions were made. *[African Journal of Chemical Education—AJCE 9(1), January 2019]*

INTRODUCTION

Academic success is contingent on various determinants. Some are cognitive aspects and some others are non-cognitive. Motivation belongs to the non-cognitive strands. This psychological construct has immense pedagogical importance in science education in general and chemistry education in particular. However, it is often an overlooked variable. Increasing the motivation of students to learn science subjects is core to major reforms in science education [1]. Motivation is associated with enhanced student learning [2] provided that students devote time and energy to their studies [3].

Non-cognitive components like motivation should be viewed with the same eye glass as cognitive components [4] but this is not the case in most circumstances in science education. Because of the focus given to cognitive aspects and not for recognizing affective factors like motivation conceptual change theory of Posner and co-researchers [5] was called cold conceptual change [6]. These authors suggest including motivation aspects in conceptual change approach, which recently is evolved as hot conceptual change model [7]. In addition, different studies suggest multidimensional nature of conceptual changes [8] [9] supporting the argument above. Researchers like Dole and Sinatra [10] have given attention to information processing in conceptual change and have also portrayed the impact of motivation on conceptual change in their Cognitive Reconstruction of Knowledge Model. These authors explained how the affective and cognitive characteristics work together.

Approaches to learning have a strategy and a motive component [11]. For instance, intrinsic motivation is the motive component of a deep approach (a strategy aspect) and extrinsic motivation corresponds to a surface approach [12]. By its very nature, chemistry is highly conceptual [13] requiring students to get intrinsically motivated. Even though much can be gained by rote learning, real understanding in chemistry requires bringing together conceptual understandings of students. When students are not motivated to seek for understanding, teachers face problems. Students will be engaged more easily on problems that are challenging and real-world context related [14]. Which means, students tend to be intrinsically motivated if the problems are interesting, meaningful, challenging, and engaging [13]. This makes motivation as an important factor in the construction of knowledge and the process of conceptual change [15]. Classroom strategies (such as conceptual change instructional approach) optimize student motivation [15].

There is limited research work focusing on motivation in organic chemistry domain. Thus, this research work was intended to study students' motivation in aliphatic hydrocarbon concepts of organic chemistry education through the use of CCIA-conceptual change texts (CCTs).

THE PROBLEM, PURPOSE OF THE STUDY AND RESEARCH QUESTIONS

College level pre-service chemistry teachers, 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 concepts are among key areas of concern for students [16] [17]. The determination of structural formulae, International Union of Pure and Applied Chemistry (IUPAC) nomenclature, identification and description of functional groups, characteristics of organic compounds, reaction types and reaction mechanisms are among problem areas [17] for college students. These concepts connote barrier for a great majority of students everywhere [18]. Based on the experience and observation of the researcher at the study site, the teaching approach used by lecturers is not in a way to assure meaningful learning. Though it is possible to provide different reasons for performance related problems of students, evidence shows that the reason behind students' poor performance can be related to instructional approach employed [19] [20] and motivation [21]. The principal investigator's experience as a lecturer offering the courses and evidence from registrar office of the study site showed students' motivation in the two organic chemistry courses is poor. Thus, this study focuses on the effects of Conceptual change instructional approach (using CCTs) on pre-service chemistry teachers' motivation in relation to aliphatic hydrocarbon concepts.

The primary purpose of this study was to investigate effects of conceptual change instructional approach through the use of conceptual change texts (CCTs) on motivation of pre-service teachers' in relation to aliphatic hydrocarbon concepts.

To attain the above major purpose of the study the following research questions were articulated:

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

METHODOLOGY

Design Type

In order to study the effect of conceptual change instructional approach using conceptual change text on motivation in aliphatic hydrocarbon concepts, the Pretest-Posttest Nonequivalent-

Groups quasi-experimental Design was used. The quantitative quasi-experimental approach with nonequivalent control group design with pretest and posttest was selected in this study.

Research site, Population and Participants

This research was conducted in Arbaminch College of Teachers Education, SNNPRS, Ethiopia. The college is a public institution with an enrollment capacity 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) registered in Introductory Organic Chemistry I in the same college in regular Program.

Instrument

The instrument used in this study was Chemistry motivation rating Scale (CMRS). The students' ratings on CMRS served as the basis for judging students' motivation in this study. It was designed to assess pre-service teachers' motivation while learning aliphatic hydrocarbon concepts through the use of CCTs. The CMRS (Appendix) used in this study was adapted from appropriate literature [22, 23].

Reliability and Validity

Although the authors [22, 23] of the CMRS validated the tool with large sample, to ensure validity in the Ethiopian/study site context CMRS was checked by three senior lecturers of the college/study area. The internal consistency reliability was checked through piloting based on appropriate literature [24, 25].

Pilot study

The CMRS was piloted with thirty-three students in a different college in the region. After piloting, the tools' appropriateness for the main study was ensured through reliability check. The reliability Cronbach's alpha (using SPSS 20 version) was found to be 0.89 which is good [24-25].

Procedures of data collection

The CMRS was anticipated to show/indicate motivation related data of participants. The experimental Group and comparison group were given pre-CMRS before the intervention. After the intervention (this took seven weeks), post-CMRS was administered to the two groups. Then, scoring the responses from pre-service teachers and generating quantitative data was carried out.

Data Analysis

Quantitative data was made available using CMRS score. Pre-CMRS was normally distributed based on skewness and Kurtosis values [26]. Independent samples t-test was used for analyzing pre-CMRS. Post-CMRS was not normally distributed. For Post-CMRS data, Wilcoxon Signed Ranks Test and Mann-Whitney U test were used to compare groups. For the statistical analysis SPSS 20 version was used.

RESULTS, DISCUSSION AND CONCLUSION

Results

Comparison of Mean Scores of PRE-CMRS

Prior to examining the effect of conceptual change approach on pre-service chemistry teachers' motivation 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 pre-CMRS.

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

Group	**Variable**	**N**	**M**	**SD**	**SE**	**df**	**t**	**p**
	Pre-CMRS				.069	85	1.885	.063
EG		44	3.62	.30				
CG		43	3.48	.35				

Independent samples t-test analysis (table-2) showsthe differences between the Pre-CMRS mean scores of the groups (MExP =3.62, SDexp =0.30, Nexp =44 and MCom= 3.48, SDcom =0.35, Ncom = 43; t(85)= 1.885, p>0.05). The Pre-CMRS scores of the groups were not significant (p=0.05), implying that prior to the intervention the groups were similar.

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

To compare Pre-CMRS scores with post-CMRS scores of groups Wilcoxon Signed Ranks Test Analysis was employed.

Table-3: Descriptive Statistics of Comparison Group for Pre-and post-CMRS

	N	M	SD	Minimum	Maximum
PRE-CMRS	43	3.48	.35	2.48	4.00
POST-CMRS	43	3.38	.48	1.72	3.96

Table-4: Comparison Group Ranks for Chemistry motivation Rating Scale (Pre-post)

		N	Mean Rank	Sum of Ranks
POST-CMRS - PRE-CMRS	Negative Ranks	26[a]	21.10	548.50
	Positive Ranks	14[b]	19.39	271.50
	Ties	3[c]		
	Total	43		

a. POST-CMRS < PRE-CMRS
b. POST-CMRS > PRE-CMRS
c. POST-CMRS = PRE-CMRS

Table-5: Comparison Group Wilcoxon Signed Ranks test results

	POST-CMRS - PRE-CMRS
Z	-1.867[a]
Asymp. Sig. (2-tailed)	.062

a. Based on positive ranks.

Table-3, Table-4 and Table-5 show descriptive statistics, group ranks and Wilcoxon Signed Ranks test of comparison group respectively. In Table-5, a Wilcoxon Signed Ranks test was performed to check if there was a change in the scores due to CIA. Compared to the pretest scores the comparison group post test scores for CMRS was not significant at p=0.05 level. Wilcoxon Signed Ranks test value was, Z = -1.867, p =.062.

Table-6: Descriptive Statistics of Experimental Group for Pre-and post-CMRS

	N	M	SD	Minimum	Maximum
PRE-CMRS	44	3.61	.30	2.64	4.00
POST-CMRS	44	3.59	.36	1.80	4.00

Table-7: Experimental Group Ranks for Chemistry motivation Rating Scale (Pre-post)

		N	Mean Rank	Sum of Ranks
POST-CMRS - PRE-CMRS	Negative Ranks	21[a]	19.98	419.50
	Positive Ranks	17[b]	18.91	321.50
	Ties	6[c]		
	Total	44		

a. POST-CMRS < PRE-CMRS
b. POST-CMRS > PRE-CMRS
c. POST-CMRS = PRE-CMRS

Table-8: Experimental Group Wilcoxon Signed Ranks test results

	POST-CMRS - PRE-CMRS
Z	-.712[a]
Asymp. Sig. (2-tailed)	.477

a. Based on positive ranks.

Similarly, table-6, table-7 and table-8 show descriptive statistics, group ranks and Wilcoxon Signed Ranks test of Experimental group respectively. In Table-8, a Wilcoxon Signed Ranks test was performed to check if there was a change in the scores due to CCIA. Compared to the pretest scores the Experimental group post test scores for CMRS was not significant at p=0.05 level. Wilcoxon Signed Ranks test value was, Z = -.712, p =.477. However, this does not confirm that the CCIA is better than CIA in terms of CMRS since the two treatments show non-significant difference using Wilcoxon Signed Ranks test. To check if there is a significant difference exists in scores of CMRS (which was not normally distributed) Mann-Whitney U test was employed.

Comparison of Post-Chemistry Motivation Rating Scale Scores of Groups

As the Post-CMRS data was not normally distributed for the groups, the most appropriate statistical test for POST-CMRS was Mann-Whitney U test.

Table-9: Chemistry motivation Rating Scale (Post-test) means, standard deviations and medians of the study groups

	N	**M**	**SD**	**Minimum**	**Maximum**	**Percentiles**		
						25th	50th (Median)	75th
POST-CMRS	87	3.48	.43	1.72	4.00	3.32	3.56	3.84
TREATMENT	87	1.49	.50	1.00	2.00	1.00	1.00	2.00

Table-10: Mann-Whitney U test results of groups for Chemistry motivation Rating Scale (Post-test)

Groups	**N**	**Mean Rank**	**U**	**P**
Experimental Group	44	49.89	687.00	.028
Comparison Group	43	37.98		

Statistics (Table-9) showed that Experimental group chemistry pre-service teachers (median = 3.84; mean rank = 49.89) scored higher on POST-CMRS scales than comparison group chemistry pre-service teachers (median = 3.32; mean rank = 37.98). Mann-Whitney U value (Table-10) was found to be statistically significant U = 687.00, $p < 0.05$, and the difference between the Experimental group chemistry pre-service teachers and comparison group chemistry pre-service teachers was of size small effect (Eta = 0.24) according to Cohen [27].

Comparison of Post-Chemistry Motivation Rating Sub-Scale Scores of Groups

Mann-Whitney U test was used to determine the effect of conceptual change instructional approach on each motivation subscales.

Table-11(below) shows Chemistry Motivation Rating Subscale (Post-test) means, standard deviations and medians of the study groups. The medians of the two groups in the motivation subscales look somewhat different. This might be due to chance. Therefore, it is necessary to check using Mann-Whitney U test.

Table-12 (below) offers Mann-Whitney U test results for Chemistry Motivation Rating Subscales. For motivation subscales IPOST-CMRS, SDPOST-CMRS, and GPOST-CMRS, Mann-Whitney U values were found to be statistically significant (P= 0.05 level).

Descriptive statistics showed that Experimental group chemistry pre-service teachers (median = 3.80; mean rank = 49.52) scored higher on IPOST-CMRS scales than comparison group chemistry pre-service teachers (median = 3.20; mean rank = 38.35). Mann-Whitney U value was found to be statistically significant U = 703.00, $p <0.05$, and the difference between the Experimental group chemistry pre-service teachers and comparison group chemistry pre-service teachers was of size small effect (Eta = 0.22) according to Cohen [27].

Table-11: Chemistry motivation Rating Subscales (Post-test) means, standard deviations and medians of the study groups

	N	M	SD	Minimum	Maximum	Percentiles (Median)		
						25th	50th	75th
IPOST-CMRS	87	3.54	.44	2.20	4.00	3.20	3.60	3.80
CPOST-CMRS	87	3.60	.46	2.20	4.00	3.40	3.80	4.00
SDPOST-CMRS	87	3.46	.53	1.00	4.00	3.20	3.60	3.80
SPOST-CMRS	87	3.22	.64	.60	4.00	3.00	3.40	3.80
GPOST-CMRS	87	3.61	.44	1.60	4.00	3.40	3.80	4.00
TREATMENT	87	1.49	.50	1.00	2.00	1.00	1.00	2.00

IPOST-CMRS=intrinsic motivation posttest, CPOST-CMRS=Career motivation posttest, SDPOST-CMRS=self-determination posttest, SPOST-CMRS=self-efficacy posttest, GPOST-CMRS=grade motivation posttest

Descriptive statistics showed that Experimental group chemistry pre-service teachers (median = 3.80; mean rank = 49.51) scored higher on SDPOST-CMRS scales than comparison group chemistry pre-service teachers (median = 3.20; mean rank = 38.36). Mann-Whitney U value was found to be statistically significant U = 705.50, $p < 0.05$, and the difference between the Experimental group chemistry pre-service teachers and comparison group chemistry pre-service teachers was of size small effect (Eta = 0.22) according to Cohen [27].

Table-12: Mann-Whitney U test results for Chemistry Motivation Rating Subscales (Post-test)

Groups	Subscale	N	Mean Rank	U	P
	IPOST-CMRS			703.00	.036
Experimental Group		44	49.52		
Comparison Group		43	38.35		
	CPOST-CMRS			747.50	.084
Experimental Group		44	48.51		
Comparison Group		43	39.38		
	SDPOST-CMRS			703.50	.037
Experimental Group		44	49.51		
Comparison Group		43	38.36		
	SPOST-CMRS			751.00	.095
Experimental Group		44	48.43		
Comparison Group		43	39.47		
	GPOST-CMRS			671.00	.017
Experimental Group		44	50.25		
Comparison Group		43	37.60		

Descriptive statistics showed that Experimental group chemistry pre-service teachers (median = 4.00; mean rank = 50.25) scored higher on GPOST-CMRS subscales than comparison group chemistry pre-service teachers (median = 3.40; mean rank = 37.60). Mann-Whitney U value was found to be statistically significant U = 671.00, $p < 0.05$, and the difference between the Experimental group chemistry pre-service teachers and comparison group chemistry pre-service teachers was of size small effect (Eta = 0.26) according to Cohen [27].

DISCUSSION

In this study, groups were not significantly different based on the CMRS pretest mean scores. Independent-samples t-test confirmed this. A Wilcoxon Signed Ranks test was performed on CMRS scores to check if there was a change in the scores due to CIA and CCIA. Compared to the pretest scores (in the Comparison and Experimental group) post test scores for CMRS were not significant at $p=0.05$ level. This means, Wilcoxon Signed Ranks test values were not statistically significant for both groups. To check if there is a significant difference between groups in scores of Post-CMRS, the pre-service chemistry teachers' motivation was assessed through the use of Mann-Whitney U test as post test data was not normally distributed. The Mann-Whitney U test result indicated that the Experimental group chemistry pre-service teachers scored higher on POST-CMRS than comparison group chemistry pre-service teachers. This finding corroborates with the findings of other similar studies [28] [29] when conceptual change instructional approach is employed.

Moreover, the pre-service chemistry teachers' motivation sub-scales were assessed through the use of Mann-Whitney U test as post test data was not normally distributed. The Mann-Whitney U test result indicated that the Experimental group chemistry pre-service teachers scored higher on IPOST-CMRS, SDPOST-CMRS and GPOST-CMRS scales than comparison group chemistry pre-service teachers. This finding confirms, in part, the fact that students compare their ability to others by obtaining good grades [15]. Also, this is consistent with the findings in other constructivist-informed instructional methods [30] [31] where students are active like CCIA. For instance, Tosun and Taskesengil [30] obtained similar results by employing problem-based learning. These researchers found positive effects on subscales of motivation when problem-based approach was used. Besides, in Tuan et al. [31] study conducted in Taiwan findings indicated that after inquiry instruction motivation of students in the experimental group increased significantly than the students in the control group. In this research undertaking, the significance difference between experimental and comparison group in terms of motivation attests the effectiveness of CCIA which was employed in the experimental group. This is perhaps associated with the fact that CCIA has the potential to boost understanding of concepts which are highly linked with practical aspects as this has been confirmed in other studies [32] [33]. The study proved that students taught using CCIA rated high in motivation scales than those in the CIA setting.

CONCLUSION

The main purpose of this study was to investigate effects of conceptual change instructional approach through the use of conceptual change texts on motivation of pre-service teachers'. In this quantitative study, the experimental group participants rated themselves more motivated than the comparison group with small effect size magnitude. At the sub-scales level, the experimental group participants rated high in intrinsic motivation, self-determination and grade motivation sub-scales. Thus, a significant result (though with small effect size magnitude) was obtained in the experimental group confirming the superiority of CCIA over CIA.

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APPENDIX

Chemistry Motivation Rating Scales Questionnaire adapted from [22] [23]

Part-I: General information

1. Sex(Put √ mark): Male_____ Female _____
2. Age(Put √ mark): 16-18:____ 19-21:____22 and above:____
3. Year: (write here)_________________
4. Department (write here)_________

Part-II: Motivation towards chemistry (Put mark on each item response)

In order to better understand what you think and how you feel about your chemistry courses, please respond to each of the following statements from the perspective of "When I am in a chemistry course…"

01. The chemistry I learn is relevant to my life

O Never
O Rarely
O Sometimes
O Usually
O Always

02. I like to do better than other students on chemistry tests
O Never
O Rarely
O Sometimes
O Usually
O Always
03. Learning chemistry is interesting
O Never
O Rarely
O Sometimes
O Usually
O Always
04. Getting a good chemistry grade is important to me
O Never
O Rarely
O Sometimes
O Usually
O Always
05. I put enough effort into learning chemistry
O Never
O Rarely
O Sometimes
O Usually
O Always
06. I use strategies to learn chemistry well
O Never
O Rarely
O Sometimes
O Usually
O Always
07. Learning chemistry will help me get a good job
O Never
O Rarely
O Sometimes
O Usually
O Always
08. It is important that I get an ‘‘A’’ in chemistry
O Never
O Rarely
O Sometimes
O Usually
O Always
09. I am confident I will do well on chemistry tests
O Never
O Rarely
O Sometimes
O Usually
O Always
10. Knowing chemistry will give me a career advantage
O Never
O Rarely
O Sometimes
O Usually
O Always

11. I spend a lot of time learning chemistry
O Never
O Rarely
O Sometimes
O Usually
O Always
12. Learning chemistry makes my life more meaningful
O Never
O Rarely
O Sometimes
O Usually
O Always
13. Understanding chemistry will benefit me in my career
O Never
O Rarely
O Sometimes
O Usually
O Always
14. I am confident I will do well on chemistry labs and projects
O Never
O Rarely
O Sometimes
O Usually
O Always
15. I believe I can master chemistry knowledge and skills
O Never
O Rarely
O Sometimes
O Usually
O Always
16. I prepare well for chemistry tests and labs
O Never
O Rarely
O Sometimes
O Usually
O Always
17. I am curious about discoveries in chemistry
O Never
O Rarely
O Sometimes
O Usually
O Always
18. I believe I can earn a grade of ''A'' in chemistry
O Never
O Rarely
O Sometimes
O Usually
O Always
19. I enjoy learning chemistry
O Never
O Rarely
O Sometimes
O Usually
O Always

20. I think about the grade I will get in chemistry
O Never
O Rarely
O Sometimes
O Usually
O Always
21. I am sure I can understand chemistry
O Never
O Rarely
O Sometimes
O Usually
O Always
22. I study hard to learn chemistry
O Never
O Rarely
O Sometimes
O Usually
O Always
23. My career will involve chemistry
O Never
O Rarely
O Sometimes
O Usually
O Always
24. Scoring high on chemistry tests and labs matters to me
O Never
O Rarely
O Sometimes
O Usually
O Always
25. I will use chemistry problem-solving skills in my career
O Never
O Rarely
O Sometimes
O Usually
O Always