Research Paper EDUCATION

Effectiveness of Activities Based on 5E Model of Constructivist Approach on Tenth-Grade Students' Understanding of Covalent and Ionic Compounds

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ABSTRACT
This paper investigated the effects of teaching one of the most fundamental concepts of Chemistry 'Covalent and Ionic Compounds' using Traditional Instruction (TI) and 5E Model of Constructivist Approach (MCA) on students' achievement in Chemistry. A total of 60 tenth-grade students participated in this pretest-posttest control group quasi-experimental study. Control Group (n = 30) was taught by TI, whereas the two Experimental Groups EG (n = 30) was subjected to MCA. An analysis of covariance on Chemistry achievement posttest scores with students' pretest scores as the covariate showed that MCA was more effective in enhancing the students' achievement in Chemistry than TI. It is, therefore, suggested 5E model is a good supplementary method of teaching Chemistry.

KEYWORDS : Chemistry, Covalent and Ionic Compounds, Traditional Instruction, Constructivist Approach, 5E Model, Achievement.

INTRODUCTION
In Chemistry curriculum at secondary school level in India, 'Covalent and Ionic Compounds' occupy a central place. It is considered to be one of the most difficult topics, owing to its abstract character, its demand of a mastery of a large number of subordinate concepts and the essential role in developing an understanding in other areas of Chemistry. Several instructional approaches based on constructivism may help students learn such abstract concepts. Constructivism is the teaching philosophy that proposes learners need to build their own understanding of new ideas and scientific knowledge. Teaching via the 5E model of constructivist approach originated with the Science Curriculum Improvement Study (Trowbridge, Bybee & Powell, 2004). Its five phases which capture the essence of the students' actions are:

Engagement: The activities in this section captures the students' attention, stimulates their thinking, and helps them access prior knowledge.

Exploration: Students are given time to think, plan, investigate, and organize collected information.

Explanation: Students are now involved in an analysis of their explorations. Their understanding is clarified and modified because of reflective activities.

Elaboration: This section gives students the opportunity to expand and solidify their understanding of the concept and/or apply it to a real world situation.

Evaluation: Evaluation occurs throughout the lesson. The teacher should observe students' knowledge and skills along with their application of new concepts and a change in thinking.

The use of 5E model of constructivist approach to teach abstract and difficult concepts is not new in Chemistry education all over the world. Although there have been many studies conducted in other countries for investigating the effect of this model on students' achievement in Chemistry, there is a lack of such studies conducted in India. Therefore, the researcher felt the need of carrying out the investigation in this regard.

PURPOSE OF THE STUDY
The main purpose of this study was to investigate the comparative effects of Traditional Instruction (TI) and 5E Model of Constructivist Approach (MCA) respectively on tenth-grade students' understanding of Covalent and Ionic Compounds.

In order to suitably address the above mentioned purpose, the following null hypotheses were formulated:

H_0 1: There is no significant difference between the mean pre test and posttest Chemistry achievement scores for students in the Control Group (CG) subjected to Tradi tional Instruction.

H_0 2: There is no significant difference between the mean pre test and posttest Chemistry achievement scores for students in the Experimental Group (EG) subjected to 5E Model of Constructivist Approach.

H_0 3: There is no significant difference between the mean posttest Chemistry achievement scores for students in the Control Group and Experimental Group (CGnd EG), after controlling for the effect of pretest scores.

METHOD

Research Design and Participants
In this study, a pretest-posttest control group quasi-experimental design (Campbell and Stanley, 1966) was used. The participants included 60 students, who were enrolled in tenth-grade and belonged to two different sections during the session 2014-15, in a secondary school in Kishanganj, Bihar, India. These two sections were randomly assigned to Traditional Instruction (TI) and 5E Model of Constructivist Approach (MCA) respectively. In other words, one section, subjected to TI, was considered as Control Group, namely CG (n = 30) and the other section, subjected to MCA, was considered as Experimental Group, namely EG (n = 30). The two B.Ed. trainees 'A' and 'B' (who were enrolled in B.Ed. course during the session 2014-15, at Department of Education, A.M.U. Centre, Kishanganj, Bihar) also participated in this study. Both of them were male, held an equivalent Bachelor's degree in Chemistry and had no experience of teaching Chemistry at secondary school level. The trainees were also randomly assigned to these two groups. Trainees 'A' and 'B' taught CG and EG respectively.

Measuring Instrument
Students' achievement in Chemistry was measured using the Chemistry Achievement Test (CAT) based on 'Covalent and Ionic Compounds'. The test, containing 30 four-option, multiple-choice questions, was developed by the author. The test was intended to determine the knowledge, comprehension and application levels of students related to the fundamental concepts. Its content validity was established by subject experts. Cronbach's alpha reliability coefficient of the test was 0.90.

Instructional Materials and Methods
The topics covered in the instructional materials were:
- Definition of Covalent and Ionic Compounds
- Formation of Covalent and Ionic Compounds
- Properties of Covalent and Ionic Compounds (such as, physical state, melting and boiling points, solubility in water and organic solvents, electrical conductivity)
- Examples of Covalent and Ionic Compounds
- Differences between Covalent and Ionic Compounds

The experimental activities were performed in order to study the properties of Covalent and Ionic Compounds.

The Control Group was subjected to Traditional Instruction. This instructional approach emphasized direct lectures given by teachers, interactive discussions between the teacher and students, use of textbook materials, charts, animations and ball-and-stick models, and clear explanation of important concepts to students. After explaining the concepts, the teacher demonstrated experimental activities related with 'Properties of Covalent and Ionic Compounds' given in the textbook. The teacher's demonstrations exactly followed the procedure given in the Chemistry textbook. The students did not actively participate in demonstrations. They observed the teacher silently and asked questions. At the end of the lesson, the teacher asked several questions related to the demonstrations, received students' responses, and explained the observations and the corresponding results.

The Experimental Group was subjected to 5E Model of Constructivist Approach. In the Engagement phase, the teacher used "brain storming technique" in order to explore students' existing conceptions about Covalent and Ionic Compounds by asking questions (such as: Why do elements chemically combine together to form compounds?; Name the constituent metallic and non-metallic elements of Carbon chloride and Calcium chloride.; Write down their chemical formulae.). The teacher used animations and ball-and-stick models to illustrate the formation of Covalent and Ionic Compounds. During the Exploration phase, the students performed the experimental activities in order to explore the properties of Covalent and Ionic Compounds, wrote down their observations and discussed their results to reach a joint decision. In the Explanation phase, the students shared and discussed the results with one another. The teacher helped students connect their explanations to experiences and observations they had in the engagement and exploration phases so as to enable them derive the conclusions regarding the properties of suspensions. Then, the teacher gave new examples of Covalent and Ionic Compounds to students from their daily life. During the Elaboration phase, the students tried to identify the type of compounds and explain the reasons for their choice. In the Evaluation phase, the questions were asked to determine whether or not the students learned the concepts related to Covalent and Ionic Compounds and their respective properties.

Both the groups were subjected to their respective instructional method for one week. They attended six periods per week. Each period was of 35 minutes duration. These groups followed the same instructional sequence and had the same learning objectives. Thus, care was taken to ensure that an appropriate comparison was attained among these instructional approaches. The content validity of all the lesson plans was established by the author and subject experts. The author supervised the lesson plans of both the B.Ed. trainees throughout the length of all the periods consumed for teaching the concepts. CAT was given as pre- and post-tests to students in both the groups at the beginning and end of the instructional period to measure students' achievement in Chemistry.

DATA ANALYSIS

The data from the Chemistry Achievement Test (CAT) were analyzed using SPSS 16.0. Means (M) and standard deviations (SD) were calculated. A paired samples t-test was used to determine if there was a statistically significant difference between the pre- and posttest achievement scores in Chemistry for each of the three groups. Analysis of Covariance (ANCOVA) was used to determine whether there was a significant difference between group means of achievement in Chemistry for the Control and Experimental groups when differences in pretest scores were controlled. An alpha level of 0.05 was used for all statistical tests.

RESULTS

The Pretest and Posttest means and standard deviations for the Control Group are reported in Table 1.

Table 1: *Descriptive Statistics of Chemistry Achievement Scores for the Control Group (CG)*

Achievement in Chemistry	N	Mean	SD
Pretest	30	8.47	4.07
Posttest	30	25.93	2.43

In order to test null hypothesis H0 1, a paired-samples t-test was conducted. The results in Table 2 indicate that there was a significant difference between the Pretest and Posttest scores, t (29) = - 38.04, p < .05. The Control Group scored significantly greater on the Posttest (M = 25.93, SD = 2.43) than on the Pretest (M = 8.47, SD = 4.07). Therefore, the hypothesis H0 1 was rejected at 0.05 level of significance.

Table 2: *Paired-Samples t-test for Chemistry Achievement for the Control Group (CG)*

	Paired Differences					t	df	**Sig. (*p*)**
	Mean	SD	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest – Posttest	- 17.46	2.51	0.46	- 18.40	- 16.53	- 38.04*	29	.000

$*p < .05$

The Pretest and Posttest means and standard deviations for the Experimental Group (EG) are reported in Table 3.

Table 3: *Descriptive Statistics of Chemistry Achievement Scores for the Experimental Group (EG)*

Achievement in Chemistry	N	Mean	SD
Pretest	30	9.13	3.79
Posttest	30	29.13	1.11

In order to test null hypothesis H_0 2, a paired-samples *t*-test was conducted. The results in Table 4 indicate that there was a significant difference between the Pretest and Posttest scores, *t* (29) = - 28.51, p < .05. The Experimental Group (EG) scored significantly greater on the Posttest (M = 29.13, SD = 1.11) than on the Pretest (M = 9.13, SD = 3.79). Therefore, the hypothesis H_0 2 was rejected at 0.05 level of significance.

Table 4: *Paired-Samples t-test for Chemistry Achievement for the Experimental Group (EG)*

	Paired Differences					t	df	**Sig. (*p*)**
	Mean	SD	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest – Posttest	- 20.00	3.84	0.70	- 21.43	- 18.56	- 28.51*	29	.000

$*p < .05$

In order to test hypothesis H_0 3, a one-way analysis of covariance was conducted to evaluate the effects of instructional methods on secondary school students' achievement in Chemistry. The independent variable was instructional method (TI and MCA). The dependent variable was scores on CAT, administered at posttest stage after the completion of the instructional period. Pretest scores on the CAT administered prior to the commencement of the instructional period were used as a covariate to control for individual differences. The means and standard deviations for the pretest, posttest and adjusted posttest scores are presented in Table 5.

Table 5: *Descriptive Statistics for Achievement Scores on CAT by Instructional Group*

Instructional Group	N	Pretest		Posttest		Adjusted Posttest[a]	
		Mean	SD	Mean	SD	Mean	SE
CG	30	8.47	4.07	25.93	2.43	26.02	0.28
EG	30	9.13	3.79	29.13	1.11	29.04	0.28

a. Adjustments based on the mean of Pretest (covariate) = 8.80

Results in Table 6 show that the ANCOVA yielded a significant effect for the covariate, $F (1, 57) = 27.90$, $p < .05$, partial $\eta 2 = 0.328$ and a significant main effect for the instructional method, $F (1, 57) = 55.52$, $p < .05$, partial $\eta 2 = 0.493$; this latter effect accounted for 49.3 % of the total variance in posttest scores on CAT, after controlling for the effect of pretest scores used as a covariate. The covariate (Pretest) accounted for 32.8 % of the total variance in achievement on CAT. Since the results of ANCOVA indicate that there was a statistically significant difference for the adjusted Posttest means between the groups and the adjusted Posttest mean of the experimental group was significantly higher than that of the control group indicating the superiority of 5E model over traditional instruction, therefore the null hypothesis H0 3 was rejected at 0.05 level of significance.

Table 6: ***ANCOVA Summary for Posttest Achievement Scores on CAT by Instructional Group***

Source	Sum of Squares	df	Mean Square	F	**Sig. (*p*)**	**Partial Eta Squared, η^2**
Pretest	68.08	1	68.08	27.90*	.000	.328
Group	135.48	1	135.48	55.52*	.000	.493
Error	139.24	57	2.44			
Total	45846.00	60				

$*p < .05$

Note. Pretest (used as covariate) represents pretest scores on CAT.

DISCUSSION

ANCOVA results indicate that 5E Model of Constructivist Approach had a better impact on ninth-grade students' conceptual understanding of solutions than TT. Consistent with the results of many studies on the positive effects of 5E Instructional Model on achievement in Chemistry (Adams, Bevevino, & Dengel, 1999; Boddy, Watson, & Aubusson, 2003; Caprio, 1994; Cho, 2002; Demircioğlu, Özmen, & Demircioğlu, 2004; Diakidoy & Kendeou, 2001; Ebenezer & Erickson, 1996; Lord, 1997, 1999; Marek, Eubanks, & Gallaher, 1990; Niaz 2002; Panizzon, 2003; Seyhan & Morgil, 2007; Sungur, Tekkaya & Geban, 2001; Treagust, Duit, & Fraser, 1996; Tural, Akdeniz, & Alev, 2010; Yadigaroğlu & Demircioğlu, 2012), this study confirms the effectiveness of this model in teaching-learning process.

5E model seemed to be successful not only in relieving students from a monotonous traditional classroom environment especially but also in providing them with an enriched world of hands-on learning experiences. This model provided a repertoire of instructional strategies as well as a variety of interesting learning experiences which might be a better model to serve diverse learners. It also involved an integrated approach to laboratory instruction in which context, process and reflection with respect to content are used jointly. For instance, the laboratory activities were designed to develop students' conceptual understanding through examination of everyday phenomena, which makes learning more meaningful and relevant. The effectiveness of this model appeared to depend considerably on the extent and the nature of student-teacher and peer interactions.

CONCLUSION AND RECOMMENDATIONS

The results of the present study showed positive outcomes on the tenth-grade students' achievement in Chemistry. This study suggests that 5E Model of Constructivist Approach is a good supplementary method for traditional instruction in Chemistry at secondary school level in India. Based on the findings revealed from the study, it is recommended that such studies should be carried out for different grade levels, topics, subjects and school types to investigate the effectiveness of 5E Model of Constructivist Approach. Further research studies should be conducted to investigate teacher's readiness for, attitudes toward and knowledge about constructivist teaching in India.

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