Research Paper EDUCATION

Effectiveness of 5E Learning Cycle Model of Constructivist Approach on Ninth-Grade Students' Understanding of Suspensions

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ABSTRACT *This paper investigated the effects of teaching one of the most fundamental concepts of Chemistry 'Suspensions' using Traditional Instruction (TI) and 5E Learning Cycle Model of Constructivist Approach (LCMCA) on students' achievement in Chemistry. A total of 60 ninth-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 LCMCA. An analysis of covariance on Chemistry achievement posttest scores with students' pretest scores as the covariate showed that LCMCA was more effective in enhancing the students' achievement in Chemistry than TI. It is, therefore, suggested 5E model is a good method of teaching Chemistry.*

KEYWORDS : Chemistry, Suspensions, Traditional Instruction, Constructivist Approach, 5E Learning Cycle Model, Achievement

INTRODUCTION

There are a number of concepts in Chemistry curriculum at secondary school level in India which the students fail to understand and consider them to be similar with one another, owing to their overlapping nature. The concepts of 'Solutions, Colloids and Suspensions' are one of them. Several instructional approaches such as 5E learning cycle model, based on constructivism, were developed to overcome such students' difficulties and remediate their alternative conceptions in Chemistry (Boylan, 1988). This model involves the use of coordinated and coherent sequencing lessons and activities. Each phase in the 5E learning cycle model contributes learners to better understand scientific knowledge. Each phase has a different function. In engagement phase, the students are exposed to an object, problem, situation or events which are prepared to activate students' minds and misconceptions before the instruction and motivate them towards learning activities. In exploration phase, the students are required to investigate objects, materials or situations. They have a chance to establish relationships, observe patterns, identify variables and question events as a result of mental and physical involvement in activities. They try to find out the rationale behind their ideas to overcome and remedy misconceptions and reach to clear and final conclusions. In explanation phase, the concepts, processes and skills are presented simply, clearly and directly by attracting students' attention to specific aspects of engagement and exploration experiences. The reasons and correct scientific explanation for the misconceptions are also presented in this phase. In elaboration phase, the students are involved in further new experiences to elaborate their concepts, processes and skills so that those who still have doubts and confusions find a chance to overcome them and enhance their comprehension level. In evaluation phase, educational outcomes that are identified at the beginning of the lesson are evaluated through formative evaluation to give students feedback about their knowledge and comprehension levels (Bybee, 1993).

The use of 5E learning cycle model of constructivist approach to teach the concepts of 'Solutions, Colloids and Suspensions' 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 Learning Cycle Model of Constructivist Approach (LCMCA) respectively on ninth-grade students' understanding of suspensions.

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 pretest and posttest Chemistry achievement scores for students in the Control Group (CG) subjected to Traditional Instruction.

H_0 2: There is no significant difference between the mean pretest and posttest Chemistry achievement scores for students in the Experimental Group (EG) subjected to 5E Learning Cycle 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 (CG and 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 ninth-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 Learning Cycle Model of Constructivist Approach (LCMCA) respectively. In other words, one section, subjected to TI, was considered as Control Group, namely CG (n = 30) and the other section, subjected to LCMCA, 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 'Suspensions'. The test, containing 20 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 0.88.

Instructional Materials and Methods

The topics covered in the instructional materials were:

- Definition and properties of a suspension (such as, nature, stability, size of solute particles, separation of solute particles by filtration, scattering of light by solute particles)
- Examples of suspensions from daily life
- Differences among 'Solutions', 'Colloids' and 'Suspensions'
- The following experimental activities were also included in order to study the properties of suspensions:
- Prepare a milky suspension in a beaker by shaking chalk powder

in water.

- Keep this suspension undisturbed for quite some time in order to check its stability (whether chalk particles will separate out and settle down at the bottom of the beaker or not).
- Observe this suspension in order to check whether chalk particles will be visible or not.
- Allow this suspension to pass through the filter paper to check whether the whole suspension will pass through the paper without leaving any residue or not.
- Put a beam of light on this suspension kept in a beaker in a dark room in order to check whether the path of light beam will be visible inside the suspension or not when seen from the side.

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 and charts, and clear explanation of important concepts to students. After explaining the concepts, the teacher demonstrated experimental activities related with 'Suspensions' 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 Learning Cycle Model of Constructivist Approach. In the Engagement phase, the teacher used "brain storming technique" in order to explore students' existing conceptions about solutions by asking questions (such as: Is muddy water an example of a suspension? Give a suitable reason for your answer.). During the Exploration phase, the students performed the experimental activities in order to explore the properties of solutions, 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 suspensions (such as: Milk of Magnesia, Sand particles suspended in Water, Flour in Water) to students from their daily life. During the Elaboration phase, the students tried to identify the components (solute and solvent) of different types of suspensions 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 suspensions and their 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	3.40	2.94
Posttest	30	15.40	1.89

In order to test null hypothesis H_0 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) = - 30.35, p < .05. The Control Group scored significantly greater on the Posttest (M = 15.40, SD = 1.89) than on the Pretest (M = 3.40, SD = 2.94). Therefore, the hypothesis H_0 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	- 12.00	2.16	0.39	- 12.81	- 11.19	- 30.35*	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	4.00	2.74
Posttest	30	17.80	1.69

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) = - 24.55, p < .05. The Experimental Group (EG) scored significantly greater on the Posttest (M = 17.80, SD = 1.69) than on the Pretest (M = 4.00, SD = 2.74). 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	- 13.80	3.08	0.56	- 14.94	- 12.65	- 24.55*	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 LCMCA). 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	3.40	2.94	15.40	1.89	15.48	0.30
EG	30	4.00	2.74	17.80	1.69	17.72	0.30

a. Adjustments based on the mean of Pretest (covariate) = 3.70

Results in Table 6 show that the ANCOVA yielded a significant effect for the covariate, F (1, 57) = 11.78, p < .05, partial η2 = 0.171 and a significant main effect for the instructional method, F (1, 57) = 27.65, p < .05, partial η2 = 0.326; this latter effect accounted for 32.6 % 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 17.1 % 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	31.83	1	31.83	11.78*	.000	.171
Group	74.65	1	74.65	27.65*	.000	.326
Error	154.17	57	2.70			
Total	16806.00	60				

*$p < .05$
Note. Pretest (used as covariate) represents pretest scores on CAT.

DISCUSSION

The findings of the present study show that the instruction based on 5E learning cycle model caused a significantly better acquisition of scientific concepts and elimination of alternative conceptions than the traditionally designed instruction. There is a consistency between the findings of this study and the previous studies as far as the positive effects of 5E model are concerned on achievement (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 may be because 5E model view learning as dynamic and interactive process which shows students inadequacies in their knowledge and comprehension levels and challenges them to gain correct scientific conceptions. The superiority of instruction based on 5E model is due to its activities and their sequence of presentation in each phase. The use of the learning cycle can clarify students' thought processes and correct their misconceptions. When students explore a new concept through an exploration, their new experiences cause them reevaluate their past experiences. This produces disequilibrium in the student, and s/he needs to accommodate the concept to reach equilibration. The students in the learning cycle group have the opportunity to explain, to argue, and to debate their ideas, which allows them to accommodate the concept. Such a discussion environment provides opportunities for greater involvement, thereby giving students more chances to gain insights, intrinsic interest, and self-efficacy, and students are allowed to focus on learning, understanding, and mastering the task. In the elaboration phase, students gain familiarity with the introduced concept and either assimilate or accommodate the new concept into their schemata. The persistence of inadequate cognitive structures is attacked by applying new concepts to a broad range of new examples. Moreover, students actively participate in activities and get opportunities to discover knowledge. On the other hand, in traditional instruction, the teacher actively provides knowledge to passive students through lectures.

CONCLUSION AND RECOMMENDATIONS

The results of the present study showed positive outcomes on the ninth-grade students' achievement in Chemistry. This study suggests that 5E Learning Cycle Model of Constructivist Approach is a good supplementary method for traditional instruction in Chemistry at secondary school level in India. Based on the results, the researcher recommends that this study can be carried out with bigger groups to obtain more accurate results. Similar research studies should be carried out for different grade levels, different schools and different courses to investigate the effectiveness of 5E model in schools across India.

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