Research Paper EDUCATION

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

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ABSTRACT

This paper investigated the effects of teaching one of the most fundamental concepts of Chemistry 'Colloids' 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, Colloids, Traditional Instruction, Constructivist Approach, 5E Learning Cycle Model, Achievement.

INTRODUCTION

Teaching approach is important in science for promoting meaningful learning and eliminating misconceptions. One such approach is the use of learning cycle which is an instructional model based on the constructivist approach (Stepans, Dyche, & Beiswenger, 1988). It is a hands-on, minds-on teaching strategy based on Piaget's developmental model of intelligence that makes students aware of their own reasoning by helping them reflect on their activities. Once students become aware of their own reasoning and apply new knowledge successfully, they are more effective in searching for new patterns. As the learning cycle has been used, researched, and refined over the years, some practitioners have extended the three stages into five, known as the 5E learning cycle: Engagement, Exploration, Explanation, Extension, and Evaluation (Trowbridge, Bybee & Powell, 2004).

In this study, the 5E learning cycle has been chosen as an instructional tool. Regardless of the quantity of phases, every learning cycle has at its core the same inductive instructional sequence. Briefly, the learning cycle begins with the active engagement of students in investigating the natural phenomena. During exploration, the teacher acts as a facilitator, providing materials and directions, guiding the physical process of the experiment. After the exploration, the teacher promotes a discussion period in which students share their observations with classmates. This is the time in which the teacher connects student experiences to the target science concept including the identification of scientific vocabulary. Once the concept has been labeled, students engage in additional activities in which they apply their recently formed understandings to new situations (Settlagh, 2000).

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 'Colloids'.

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 'Colloids'. 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 0.87.

Instructional Materials and Methods

The following concepts were covered in the instructional materials:

Definition and properties of a Colloid (such as, nature, stability, size of solute particles, separation of solute particles by filtration, scattering of light by solute particles)
Types of Colloids (Sol, Solid Sol, Aerosol, Emulsion, Foam, Solid Foam, Gel) and their respective examples
Differences between 'Solutions' and 'Colloids'
The following experimental activities were also included in

order to study the properties of Colloids:
Prepare colloidal soap solution in a beaker by dissolving soap in water.
Keep soap solution undisturbed for quite some time in order to check its stability (whether soap particles will separate out and settle down at the bottom of the beaker or not).
Observe a drop of soap solution under a microscope in order to check whether soap particles will be visible or not.
Allow the soap solution to pass through the filter paper to check whether the whole solution will pass through the paper without leaving any residue or not.
Put a beam of light on the soap solution kept in a beaker in a dark room in order to check whether the path of light beam will be visible inside the solution or not when seen from the side.

In the control group, the teacher-directed strategy was used as Traditional Instruction. The teacher used lecture and discussion methods to explain the target concepts. At the beginning of the instruction, the teacher explained the concepts related to 'Colloids'. After explaining the concepts, the teacher demonstrated experimental activities related with 'Colloids' 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.

Students in the first experimental group were instructed with the 5E learning cycle method. In the first phase, Engagement, students' interest and motivation were promoted by asking questions about 'Colloids' (such as: (i) Is soap solution an example of a true solution? And why? (ii) How does soap solution differ from sugar solution?). Its purpose was to capture students' imagination. The Exploration phase was designed to give students common, practical experiences, allowing them to build on their developing concepts and skills. Students performed the experimental activities, recorded observations and derived conclusions regarding the properties of 'Colloids' and differences between 'Solutions' and 'Colloids'. The Explanation phase permitted students to make sense of their explorations. They were encouraged to find patterns of similarities in their observations as well as conclusions and answers to questions. Then, the teacher gave new examples of different types of colloids to students from their daily life. The Elaboration phase gave students the opportunity to extend their knowledge of concepts to other contexts. Students tried to identify the dispersed phase and dispersion medium of different types of colloids and explain the reasons for their choice. They also made connection between their discussions and experiments as they did in the exploration phase in order to understand different types clearly. The final phase is Evaluation, in which students' understandings were assessed by asking questions.

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	4.66	2.73
Posttest	30	17.33	1.83

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) = - 46.46, p < .05. The Control Group scored significantly greater on the Posttest (M = 17.33, SD = 1.83) than on the Pretest (M = 4.66, SD = 2.73). 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	- 12.67	1.49	0.27	- 13.22	- 12.11	- 46.46*	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	4.93	2.45
Posttest	30	19.13	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) = - 28.98, p < .05. The Experimental Group (EG) scored significantly greater on the Posttest (M = 19.13, SD = 1.11) than on the Pretest (M = 4.93, SD = 2.45). 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			
Pre-test – Posttest	-14.20	2.68	0.49	-15.20	-13.20	- 8.98*	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	4.66	2.73	17.33	1.83	17.37	0.23
EG	30	4.93	2.45	19.13	1.11	19.09	0.23

a. Adjustments based on the mean of Pretest (covariate) = 4.80

Results in Table 6 show that the ANCOVA yielded a significant effect for the covariate, $F(1, 57) = 24.54$, $p < .05$, partial $\eta^2 = 0.301$ and a significant main effect for the instructional method, $F(1, 57) = 27.15$, $p < .05$, partial $\eta^2 = 0.323$; this latter effect accounted for 32.3 % 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 30.1 % 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 $H_0$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	39.75	1	39.75	24.54*	.000	.301
Group	43.99	1	43.99	27.15*	.000	.323
Error	92.38	57	1.62			
Total	20128.00	60				

*p < .05

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

DISCUSSION

ANCOVA results of this study prove that the instruction based on 5E learning cycle model caused a significantly better acquisition of scientific conceptions related to 'Colloids' than traditionally designed instruction in Chemistry. 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 the 5E Learning Cycle Model makes the abstract and theoretical concepts associated with 'Colloids' as concrete as possible for the experimental group to comprehend. By restructuring traditional learning activities into a 5E learning cycle sequence, students are motivated to find correct answers rather than convenient answers; engaged in a topic; explore that topic; are given an explanation for their experiences; elaborate on their learning and are evaluated. The main advantage of this constructivist instruction was that the students derived the scientific facts after long discussions with their peers; scientific facts were not narrated by the teacher to them as was the case in traditional instruction. Since students cannot discover all important ideas on their own, social interaction is a vital part of their educational excursion in constructivist approach. Students benefit from discussions with teachers and interactions with peers who can help them to acquire new concepts. During discussion with their peers, the students tried to make a connection between their existing knowledge and the new concept. They analyzed, interpreted, and predicted information. In this manner, they constructed knowledge actively, instead of receiving it from their teacher passively. Teaching and learning was an interactive process that engaged the learners in constructing knowledge.

However, in the control group where traditionally designed Chemistry instruction was used, the teacher transferred their personally acquired knowledge, understanding, thoughts and meanings regarding 'Colloids' to the passive students, mostly through lecture method. He provided information without considering students' prior knowledge and checked whether students have acquired it or not. Students listened to their teacher, took notes, studied their textbooks and completed the worksheets. The students in this group were not as successful as those of the experimental group because they were not given any opportunity to discover knowledge on their own and develop their thinking, reasoning and communication skills. They didn't become more confident in their understanding of 'Colloids'. Meaningful learning occurs if students construct their own knowledge and apply this new knowledge in new situations.

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 Science courses to investigate the effectiveness of 5E learning cycle model. This method can be compared with other instructional methods.

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