IOSR Journal of Research & Method in Education (IOSR-JRME)
e-ISSN: 2320–7388, p- ISSN: 2320-737x Volume 10, Issue 5 Ser. I (Sep. – Oct. 2020), PP 39-44
www.iosrjournals.org

Investigating the Effect of 7e Learning Cycle Model of Inquiry-Based Instruction on Students' Achievement in Science

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Abstract: *Understanding of scientific concepts is becoming increasingly difficult for young learners, especially those in basic schools. The difficulty is about the teaching approach adopted by the science teachers. The traditional teaching approach that is, lecturing, is often used by teachers because of its ease of use and lack of knowledge of alternative teaching approaches. This study was conducted to compare the 7E learning cycle model with the traditional lecture method. An experimental and control group approach was used, each group consisting of 20 students. The study found that students instructed using the 7E learning cycle model showed better performance and understanding of concepts than the control group, as the statistics show a significant difference in the performance of the two groups. The researchers suggest the adoption of the inquiry-based approach in teaching integrated science at the basic levels, especially the 7E learning cycle model.*

Keywords: *alternative teaching approaches, 7E learning cycle model, traditional lecture method, cognitive framework.*

Date of Submission: 02-09-2020 Date of Acceptance: 18-09-2020

I. Introduction

The teaching and learning of science at the Junior High schools (JHS) have been challenging to both teachers and students. Lack of resources to prepare for science lessons, innovative teaching strategies and the confidence to teach topics outside the expertise of the teacher are the major challenges facing teachers of integrated science. Learners are not allowed to be creative, explore and think critically because of teaching strategies used by teachers. Memorizing facts, procedures and teacher-centered approach in teaching integrated science have made science to appear abstract and a difficult subject for most students. The aims of teaching integrated science, according to Ghana's JHS curriculum are to: "instill the culture for all to acquire scientific literacy to develop and make decisions of life through curiosity and use concept, investigative principles to carry out research to solve everyday's life. In achieving scientific culture, students should be trained to develop scientific and technological literacy that portray science as a process of finding solutions to problems" [11].

However, Ghanaian students lack the skill of answering questions involving knowledge and application. This is evidential in Ghanaian grade 8 student´s performance in the 2011 Trends in International Mathematics and Science Study (TIMSS) compared to Morocco and Tunisia [6]. The TIMSS assessment takes into consideration the three domains of learning (knowing, applying, and reasoning). They suggested a new approach to teaching and learning of science and advocated for the use of inquiry-based science teaching, in that students learn better when they are placed at the center of teaching and the teacher serves as a facilitator. This will help learners to explore, manipulate, and practice what they have learnt.

Apart from concerns about students´ achievement in integrated science, many researchers are concerned with poor understanding and applications of the principles of science in our daily lives. [21], were concerned about the declining performance of the 12th-grade student in the United States of America during assessment in science from 1996 to 2010 with other international students. Many kinds of research have been done on the use of different models of inquiry learning in science including 4E and 5E on students' achievement in science [25], [1]. However, the 5E learning cycle model with the following stages engagement, explanation, elaboration, and evaluation; did not take into consideration the prior knowledge of students as well as the application of what students learned. The study, therefore, intends to investigate the effects that 7E learning model of inquiry-based instruction can have on grade eight (JHS 2) students science learning.

II. Review of literature

The teaching of science hardly sees innovation and improvement among science teachers. According to [14], the teaching of science has been in the form of a relay of knowledge by teachers to students to complete a task without given chance to actively participate in the lesson. This approach of teaching science might be good for producing test scores but inappropriate for a scientifically literate person. Adherents of the traditional or teacher-centered approach believe students should learn some set of information. The teacher-centered instruction which is also called the factory model of instruction is the method where the teacher dispenses knowledge and consumption to students within a specific time and space [17]. The method involves the teacher directing instruction to students to learn through memorization and reciting facts without creating an opportunity for critical thinking development and problem-solving skills [22]. Again (n.d), Students memorize facts which do not improve their ability to analyze, organize information for new knowledge construction to enhance their understanding and problem-solving skills. Students, therefore, need to observe, ask, and resolve problems which allow them to realize the importance of the truth [14]. To get the most value from the inquiry from students, teachers need to be knowledgeable and comfortable in using this method of instruction.

Inquiry-based teaching is the approach that uses the curiosity of learners with process skills to influence critical thinking while learning science [32]. As learners experience challenges, they start to compute how to overcome it by formulating questions, explore the challenge, observe and apply their finding to understand or over the challenge and that is how learning science must be. [19], advocated inquiry method of teaching as a method which involves investigating a problem; seeking truth or information that needs logical thinking, making observations, asking specific questions, performing experiments and providing conclusions; and considering imaginatively and thinking using instinct.

The innate passion of children for researching and discovering capabilities need to be encouragedin the classroom. [3], emphasized the importance of inquiry skills over rote learning to enhance the standard of education and making sure that every child succeeds in science. Inquiry as a learning approach enhances the promotion of students' problem-solving and critical thinking skills that are relevant for everyday activities pursuant. Through inquiry, students can ask questions most importantly relevant questions. [18], argues that teachers sometimes hesitate in their classroom to use inquiry-based approaches because they are not familiar with those techniques. To him, the way teachers teach in their classrooms needs to change to a more robust way of understanding science, learning process, students learning, and effective teaching principles.

The 7E Learning Cycle is a learning-centered model. The model consists of phases of activities arranged for students to acquire the skills to be learned in an active learning activities. These stages are elicited, engage, explore, explain, elaborate, evaluate, and extend. The 7E learning cycle has several benefits including; encouraging students to remember the subject they have learned before, inspiring students to be more successful and through students' interest, training students to learn how to improve concepts through practical exercises, training students to verbally express the concepts they have learned, allowing students the ability to think, search, locate and demonstrate the concept they have learned [24].

The seven-step Learning Cycle 7E model, developed by PISA, [23] is expected to be able to improve the scientific literacy component, which is: awareness of scientific issues can be improved at elicit and engaging stage, the recognition of the evidence required for scientific research can be improved in the exploration stage, drawing and evaluation of conclusions and the communication of relevant conclusions can be strengthened at the stage of explanation, the assessment of the accuracy of the answers can be improved at the stage of evaluation and the presentation of an interpretation of scientific principles can be improved at the stage of elaborate and expand.

Current research shows how effective the 7E learning cycle model is too pure science. [13], shows that scientific literacy skills between experimental classes increase significantly over control classes. [26], also conducted similar research, revealed a significant difference between the experimental group students and the 7E model that was more successful than the control group. Moreover, the 7E model gave participants trained in the experimental group a positive impression of reducing misconceptions and of proving that the 7E model is effective learning. Again, the 7E learning cycle model suggests that learning will require students engaging in constructive learning programs to facilitate the process of assimilation, accommodation and organization in the students ' cognitive framework. However, limited research has been done on the effects of using the 7E learning cycle on performance in science Junior High school students.

Purpose of the study

The purpose of this study was to compare the effectiveness of inquiry-based instruction 7E learning cycle model to improve conceptual understanding of Diversity of Matter as a unit and scientific process skills and didactic (traditional) approach. The objective of the study is based on the research question:

1. What effects does the use of 7E learning cycle model of inquiry-based instruction have on achievement of JHS science students in Ghana?

The research question posed a null hypothesis that was tested at an alpha .05 level of significance.

H_0: There is no significant difference in the mean achievement scores of the learners in controlled and experimental group when taught using the traditional approach as compared to 7E learning cycle inquiry-based model instruction respectively.

III. Methodology

3.1 Rationale

In designing teaching intervention, one of the cardinal principles is the insight acquired from other researchers who have investigated Inquiry-based learning with the 7E learning cycle model. We took interest in reviewing the literature on 7E learning model with special focus on its effectiveness in promoting the acquisition of, and application of knowledge. These findings occasioned the use of 7E compared to 4E and 5E learning cycle models. Again, the constructivist socio-cultural perspective by [29] also informed the choice of the teaching design. The teaching method was designed to allow students to verbalize their ideas and feedback on other people's ideas when carrying out the inquiry. Moreover, there is evidence that direct teaching or traditional methods restrict the development of student process skills and the ability to make judgments [31].

3.2 Design of the study and methodology

The research design used in this study was an action research study [8], one of the qualitative research designs with non-equivalent groups, which includes a pre-and post-test design with control and experimental groups. The pattern of the experimental design is shown in table 1. In the table below, the experimental group is assigned E1and control group assigned C1. X represents treatment with the 7E learning cycle model.

Table 1: The design experiment pattern

Groups	Pre-test	Experimental treatment	Post-test
Experimental group	E1	X	E1
Control group	C1	-	C1

3.3 Sampling

The stratified sampling technique was used at the onset to have all-female in group A and males in group B, afterwards, the simple random sampling was used to acquire groups A1, A2, B1 and B2. A1 and B1 were added to constitute the experimental group E1, and A2 and B2 made up the control group C1. Each group is made of 8 girls and 12 boys making 20 students for each group with N = 40. The experimental group were not statistically different from the control group based on their previous achievement scores.

3.4 Instrumentation and Data analysis

The research instrument used for the data collection was the Academic Achievement Test (AAT) designed by the researchers. The AAT contains 38 multiple choices questions initially, but after piloting and reliability tests, eight questions were excluded. Reliability (coefficient of Cronbach Alfa) was found as 0.87. Four options were given with one correct answer. Content validity was done by two science teachers and one university professor in science education. Before and after the intervention, students completed the same data collection tools to detect changes in their conceptual understanding, scientific process abilities and scientific attitudes. This was to check to understand the concept of diversity of matter, and an observational checklist to appraise scientific attitude and process skills of the learners were also used. In the beginning, standard deviations and mean of the tests scores were computed. It was observed that the scores were normally distributed. Hence, the paired-samples T-Test was to be conducted to find out whether there is a significant difference between the pre and post-test scores of the students involved in this study. Data obtained with this instrument were analyzed using IBM SPSS 25.0 version for the statistical computation of mean, standard deviation and one-way ANCOVA test as shown in table 2.

3.5 Procedures

Two different treatment was employed by the researchers: the experimental group were taught using 7E learning cycle model while the control group were taught using the traditional approach. The same teacher delivered the instruction to both groups. Both groups were taught by the same science teacher who was the informed about the purpose of the study and instructed in the 7E learning cycle model-based instruction before the intervention. Classroom observations were done to test the application of both control and experimental classes.

During the process of the observation, teacher-student, and student´s engagement and commitment in the learning environment; student actions and attitude and teacher's actions, and the physical and material conditions of classroom accessibility were observed. In the experimental group, students were taught with 7E learning cycle model with teaching learning activities and lessons designed to enhance students' active participation in the lesson. The lesson´s activities followed the 7E learning cycle model phases. During the elicit phase, the teacher drew the learners' attention to the prior understanding and knowledge relevant to the unit. Learners were asked to mention some of the common substances used at home. At the engagement phase, teacher-focused learners thinking on the learning outcomes and provided conversation opportunities for all students to connect their prior experience and current experiences about concepts of acids, bases, and salts. A story of everyday use and benefits of acids, bases and salt was told to initiate focused conversation among learners in pairs. Again, learners were given orange juice, vinegar, toothpaste, coca-cola, baking soda, detergents, both red and blue litmus papers, beakers and told to group the substances based on their observation with litmus papers.

The exploration phase saw learners plan their way of grouping the substances given with the help of the litmus paper. Learners observe the scientific process, record data, design, and plan experiment, develop a hypothesis, organize, and interpret the results. They were able to compare findings with other group members. The intention was to create the needed learning environment for them to explore, the teacher only provided questions, suggested strategies, feedback and assessed understanding. At the explanation phase, learners gave a written and verbal presentation of their findings, conclusions, and explanation of their results. Learners were guided toward coherent and consistent generalization; the use of scientific vocabulary and probing questions were also provided to help learners use the scientific vocabulary to explain their results in the exploration. At the elaboration phase, learners were given activities that led them to apply the knowledge acquired to the new concept, asking relevant questions and hypothesis to explore. The students were given a task on the classification of acids and bases using pH indicator, and the economic importance in the agriculture, medicine, and industry. During the evaluation phase, assessment of concept understanding was done by the students. At this stage, the teacher used these activities to evaluate the students learning. The extend phase saw learners given the occasion to apply the concept learned in a new situation. The learners were tasked to draw a future's wheel indicating how misapplication of chemical fertilizers could affect the environment.

In the control group, the traditional approach was used as an instructional strategy. The teacher used the traditional method of questioning and responding to teach basic and specific concepts. A question and answer method with specific explanations and were used in the delivery the content with students been fully passive. Teaching methods used consisted of explanations and textbooks given by the teacher. In this group, the teacher taught the concepts through lecture and discussion methods. The teacher organized the whole class as a team, wrote notes about the meaning of concepts on the chalkboard, and distributed worksheets to complete by students. The key fundamental theory was that knowledge in the form of information was passed on to the students. The teacher then asked students questions about the concepts in the form of a class discussion. Worksheets were explicitly designed with written answers that reinforced the concepts during the classroom discussion session. The correct solutions to the problems were given to the students. Typically, each lesson consisted of the teacher presenting the correct solution to problems. Most of the instructional time was dedicated to the instruction and discussion resulting from the description and questions of the teacher. The same textbook and handouts were used for both the experimental and control groups. The research took place over an 8 weeks period, 6 weeks was used to complete the instructions and 2 weeks was dedicated for administering the and post-tests.

IV. Findings

Table 2 below shows that the experimental group performed better than the control group as indicated by the mean values and standard deviations, but it is not possible to tell whether these differences are statistically significant.

Table 2: Comparison of the pre-test and post-test scores between the groups based on the achievement level

Variable	Groups	N	Mean	std. deviation	std. error mean
Pre_test	Experimental group	20	39.85	12.918	2.889
	Control group	20	37.55	8.370	1.871
Post_test	Experimental group	20	66.65	10.001	2.236
	Control group	20	47.70	7.719	1.726

The research hypothesis was evaluated using ANCOVA analysis. Table 3 shows the differences in achievement test in post-test scores between the control and experimental groups.

Table 3: ANCOVA analysis for pre-test and post-test scores between the groups based on the achievement level

Source	Type I Sum of Squares	df	Mean Squared	F	Sig. (*p*)	Partial Eta Squared
Corrected Model	4715.900a	2	2357.950	45.728	.000	.712
Intercept	130759.225	1	130759.225	2535.853	.000	.986
Pre_test	1584.212	1	1584.212	30.723	.000	.454
Group	3131.688	1	3131.688	60.734	.000	.621
Error	1907.875	37	51.564			
Total	137383.000	40				
Corrected Total	6623.775	39				

Dependent variable: Post-test, a. R Squared = .712 (Adjusted R Squared = .696)

Table 3 shows that at $p<0.000$, the F value of (60.734) was significant. This means that statistically, the mean score of students taught using 7E learning cycle model of inquiry-based instruction (experimental group) is significantly different from those taught using the traditional approach (control group).

V. Discussion and Conclusion

The findings of the study showed there was a significant difference in achievement levels between students who received instructions with the 7E Learning Cycle Model and traditional teaching methods. Students who received inquiry-based instruction assisted by the 7E learning cycle model have been more successful than students who were taught by the traditional methods of teaching. This analysis provides findings supporting studies conducted previously by other researchers [27], [28], and [5]. [15], concluded that the 7E instruction model as an inquiry method is much better since it promotes students understanding of the concept, critical thinking skills and problem-solving skills. [2], concluded that the inquiry-based approach enabled by the 7E learning cycle model has a statistically significant impact on academic performance of students over the traditional teaching method.

The 7E model enhances student's ability to become scientific literate by designing and planning experiments, recording results, and drawing conclusions [12]. Through the teachers guidance as a coach, the students goes through series of activities which enhances their prior knowledge at the engagement phase thus helping to increase their understanding of the concept [4] and [7]. The results confirm similar study by [16], who claimed the use of the 7E Model in teaching science help increase students' performance, promote retention and promotes student's ability to relate scientific content with daily lives.

Moreover, the 7E model inquiry labs promote students active learning and knowledge application abilities to related contexts as the process of the inquiry instruction helps to reduce misconceptions students may have about the content [20]. Teachers in the classroom should, therefore, consider appropriate ways of preparing a conducive learning environment that supports students' active learning. Creating teachings embedded in the 7E instructional model for different subjects will place a higher degree of importance on the model. Also, training teachers to acquire the skill of implementation can enhance students learning. By incorporating 7E model in science curriculum, students can discover knowledge by themselves and since students participate actively in the lesson, creating their own ideas can lead to solving everyday problems

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