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Effects of Computer Animation and Inquiry Method on Chemistry Students' Critical Thinking and Achievement in Onitsha Education Zone

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Abstract: *The study investigated the effects of the use of computer animation and inquiry method on chemistry students' critical thinking achievement in Onitsha Education Zone of Anambra state. Two research questions and three null hypotheses guided the study. A quasi-experimental research was used in the study. The population of the study consisted of all the 2,469 senior secondary year two chemistry students. Sample comprised of 233 students chemistry students. The instruments used for data collection were chemistry Achievement Test (CAT) and Watson-Glazer Critical Thinking Appraisal (WCTA). The reliability coefficient of CAT and WCTA were established using Kuder Richardson formula (KR-20) to be 0.96 and 0.67 respectively. The research questions were answered using mean and standard deviation. The null hypotheses were tested at 0.05 level of significance using Analysis of Covariance. The findings revealed that computer animation and inquiry method had significant effects on critical thinking of students, academic achievement in chemistry. It indicated that computer animation was more effective than inquiry method in improving academic achievement of students in chemistry. The study concluded that both computer animation and inquiry method were effective in enhancing the critical thinking and achievement of SS2 students in chemistry. It was recommended that chemistry teachers should adopt the use of inquiry method and computer animation in teaching chemistry so as to enhance critical thinking and academic achievement of their students.*

Keywords: *Animation, critical thinking, achievement, chemistry*

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I. Introduction

In the national policy on education, Chemistry is one of the core subjects specified for students to offer at the secondary school level and even up to the tertiary level (FRN, 2013). Chemistry according to Ojokuku (2012) is the study of matter; the structure, composition and properties of matter and changes which matter undergoes. Stressing on importance of Chemistry, Abubakar and Ashiru (2010) described the subject as a physical science with immeasurable intrinsic values in all spheres of human activities. There is no area of science and technology that escapes its application. Despite the all-important role chemistry plays in national development, the objectives of teaching chemistry in secondary schools and colleges are yet to be attained. The performance of students at both internal and external examinations has also remained consistently poor.

Many variables have been identified by researchers that could be responsible for the poor performance of students in chemistry. Such related variables include teachers, students themselves, home and society, poor primary school background (Counihan, 2012; Nwankwo, 2007). Osisioma (2012) pointed out that variables that have both cognitive and sensory qualities are necessary in science teaching. It was also explained that the aim of chemistry education is not just to load the students with knowledge but to contribute to their mental development. Therefore, the content and methodology of chemistry teaching should be organized in such a way as to lead to this kind of change in students. Other weaknesses associated with candidates' performance according to WASSCE Chief Examiner's report, (2013) are non-adherence to rubrics, poor study habits, inability to properly define terms, poor knowledge of chemical concepts.

Similarly, past reports showed that electrochemistry questions were not popular choice among the chemistry students and those that attempted electrochemistry related questions performed very poor (WASSCE Chief Examiner's Report, 2012). Statistical analysis from West African Examination Council (WAEC) on the performance of students revealed that the achievement of students in chemistry over the years in SSCE is not encouraging. In 2009-2011, the WAEC chief examiner's report indicated poor performance. Similar report in 2013-2016 revealed that there has been a persistent decline in the percentage number of chemistry students who passed at credit level and above. Njoku and Ezinwa (2014) pointed out electrolysis as one of the difficult concepts in chemistry. Electrolysis according to Ojokuku (2012) is the chemical decomposition brought about by the passage of electric current through an electrolyte. The study will look into aspects of electrolysis like

terms used in electrolysis, ionic theory, electrolysis of solutions and molten substances. There is therefore the need for the students to be taught chemistry in a way that will foster creativity, critical thinking and achievement.

Favel (2005) defined critical thinking as consisting of the active construction of knowledge and the valuing of social justice, a continuing examination of things as they are and might be. According to Favel critical thinking is built into an active learning model. Astington (2009) defined critical thinking as being able to look at a situation and analyze what is going on by asking questions to enable one to get at alternatives to be able to make up one's mind by getting behind the rhetoric. Critical thinking according to Astington is equated to problem solving, scientific inquiring skills such as testing, hypothesizing, experiments, and drawing valued conclusions. It is the objective analysis of facts. Since science requires the critical use of reasoning in experimentation and theory confirmation, good critical thinking is the foundation of science. Critical thinking engages the students actively in the learning process and may result in improved achievement.

Achievement is the outcome of instruction. Good achievements are often an indication of meaningful learning. Vierra (2014) noted that meaningful learning is closely tied to improved academic achievement. Udo (2006) was of the opinion that meaningful learning requires the use multisensory approach to instruction. The students will make use of more than one sense modality in learning. Such approach to learning allows the students to acquire science process skills, which involves the sense of touch, sight, feeling, tasting and hearing. Yero (2008) opined that a critical view of science core curriculum reveals that science is an activity-oriented subject. This implies that teaching strategies and materials, which involve an active participation of learners, should be employed in teaching and learning processes. Instructional approaches like inquiry/discovery, interactive approach such as computer animations, project, are recommended (Azumi, 2007). Unfortunately, chemistry teachers still hold unto conventional methods.

The conventional method of teaching is characterized by verbalism and is a common method of instruction employed in the teaching of science in schools. The conventional method presents science as mental process where facts are memorized rather than an assessment of principles for application (Ekon & Nwosu, 2016). Since conventional method has been implicated as one of the cause of poor achievement, it is therefore pertinent to look for instructional methods that could address the problems of teaching and learning chemistry in schools such as computer animation and inquiry method as recommended earlier by Azumi (2007).

Inquiry method according to the constructivist view is the commitment to the idea that the development or understanding of science requires an active development of learners through seeking of information (Watkins, 2012). It is a strategy in which the teacher helps the students to make connections to new materials. Activity based inquiry learning according to Alberta Education (2004) does not only reduce tension and boredom in the class but provide an environment where the children can develop individual and collective skills. It engages the students' physical and could improve critical thinking. However, it may be able to engage students' sense in the same manner as computer animation.

Computer animation only refers to moving images produced by exploiting the persistence of vision to make a series of images look lively. Computer animation or computer generated imagery (CGI) is a process used for generating animated images by computer graphics in form of animated cartoons (Masson, 2006). Collaben and Clark (2007) recommended the use of moving pictures in classroom teaching. They emphasized that students tend to enjoy viewing and they understand messages from video and films much faster. This act of creating moving images with the use of computer is a sub field in computer graphics known as computer animation (Masson, 2006) and could be applied in science learning. It is therefore the wish of the researcher to use such animated images or objects in teaching chemistry to see if students' could improve achievement and critical thinking.

PURPOSE OF THE STUDY

The purpose of this study was to investigate the effects of computer animation and inquiry method on critical thinking achievement of senior secondary school students in chemistry. Specifically, the study determined:

1. The mean critical thinking scores of students taught chemistry using computer animation, inquiry method and conventional lecture method.
2. The mean achievement scores of students taught chemistry using computer animation, inquiry method and conventional lecture method.

RESEARCH QUESTIONS

The following research questions guided the study.

1. What are the mean critical thinking scores of students taught chemistry using computer animation, inquiry method and conventional lecture method?
2. What are the mean achievement scores of students taught chemistry using computer animation, inquiry method and conventional lecture method?

HYPOTHESES

The following null hypotheses were tested at 0.05 level of significance.

1. There is no significant difference in the mean critical thinking scores of students taught chemistry using computer animation, inquiry method and conventional lecture method.
2. There is no significant difference in the mean achievement scores of students taught chemistry using computer animation, inquiry method and conventional lecture method.

II. Method

The research design for the study is quasi-experimental. The population comprises of 2,469 senior secondary school year two (SS2) chemistry students in Onitsha Education Zone of Anambra state. The sample comprised 233 SS2 chemistry students from public secondary schools in Onitsha urban. Three schools were purposively selected in Onitsha urban. The schools were chosen also because they are situated miles apart to avoid subject interaction. One intact class each was selected from each of the three schools by random sampling. The intact classes were at random assigned to experimental group one and two and control group. Experimental group one had 79 students, experimental group two has 81 students while the control group had 73 students.

The instruments for data collection are Watson-Glaser Critical Thinking Appraisal (WCTA) and Chemistry Achievement Test (CAT). WCTA was adopted from Owolabi (1996) who reestablished the validity and reliability of the Watson-Glaser standardized test of critical thinking. CAT consists of 50 multiple choice test items on electrolysis. The same chemistry achievement test was used for both pretest and posttest. The items of the chemistry achievement test were constructed using a test blue print. This took into consideration the performance objectives and the content area of electrochemistry as contained in senior secondary school chemistry scheme of work. The test blue print emphasized the area highly weighed by the past GCE O/level and SSCE question papers. Lesson plans on each of the teaching methods were also developed by the researcher. CAT was validated by two of the experts were from the Department of Science Education and one other expert from the Department of Educational Foundations (Measurement and Evaluation Unit, Nnamdi Azikiwe University, Awka. The reliability of CAT was established using Kuder-Richardson formula 20 (K-R20). CAT was administered to the same students in Idemili North LGA. The generated scores were used to computer the reliability of CAT was yielded reliability coefficient of 0.96.

This study involved three groups of subjects. These include computer animation instructional method group denoted group E_1, inquiry Instructional method group denoted E_2 and the conventional method group denoted group C. Lesson notes for teaching the three groups were prepared by the researcher. In addition self developed computer animation instructional package was stored in compact disc read-only-memory (CD-ROM). Before the experiment commenced, the researcher with the help of a computer technician trained the research assistants (chemistry teachers) on how to use the package and the lesson plans for two weeks. The teachers were given lesson plans written by the researcher to ensure uniformity in teaching the three groups. This serves as a guide to teachers for a correct implementation of the treatment in their respective experimental schools.

In the computer animation group, the teacher who was assisted by the computer technician to put the computer, projector in order and also operate same did the following activities: presented an overview of the day's lesson using the CD rom, in the computer, gave an overview of the learning tasks/activities on the topic covered as in a lesson plan, went round to monitor students' activities as directed, praised students as they follow and understand the lesson and repeat illustrations where necessary. Students were guided by the teacher to: watch the animation with the aim to understand some concepts in the topics and not just to watch movies and to listen to teachers questions and directions to be able to use what they watch and answer such questions.

In the inquiry instructional method, the teacher did the following: pre assigned students to five member groups; distributed the materials they used to carry out their discoveries, gave an overview of each day's lesson using the teaching guide provided; gave an overview of the learning task/students activities on the area to be covered; went round monitoring progress, guides, asking questions and allowing students to find out themselves; used the findings made by students to establish and explain the concepts and evaluated students. The teacher informed students that their goal was to: use materials provided, ask questions to find out things for themselves and make good observations and inferences; ask questions and discuss ideas with their colleagues to be able to discover more; and learn how to manipulate materials and make observations as scientist, which they are.

At the expiration of the treatment, the items of the research instruments were rearranged and re-administered to the group in the fifth week. The scores obtained by the second administration served as post test scores of the study. The research questions were answered using means and standard deviation. The null hypotheses were tested at 0.05 level of significance using analysis of covariance (ANCOVA). The decision rule was to reject the null hypothesis were pvalue was less than or equal 0.05 and to accept where it is greater than 0.05.

III. Results

Research Question 1: What are the mean critical thinking scores of students taught chemistry using computer animation (CA), inquiry method (IM) and conventional lecture method (CLM)?

Table 1: Mean Pre-test and Posttest Critical Thinking Scores of Students taught Chemistry using CA, IM and those taught using CLM

Method	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean Gain
CA	79	45.76	9.54	52.66	9.57	6.90
IM	81	42.04	10.48	55.41	9.96	13.37
CLM	73	40.32	9.62	43.70	10.07	3.38

Table 1 shows that the group taught chemistry using computer animation has mean gain critical thinking score of 6.90, those taught using inquiry method has mean gain critical thinking score of 13.37 while those taught using conventional lecture method has mean gain critical thinking score of 3.38.

Research Question 2: What are the mean achievement scores of students taught chemistry using computer animation, inquiry method and conventional lecture method?

Table 2: Mean Pre-test and Posttest Achievement Scores of Students taught Chemistry using CA, IM and those taught using CLM

Method	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean Gain
CA	79	33.01	7.93	53.05	8.08	20.04
IM	81	33.42	8.58	47.86	7.59	14.44
CLM	73	33.78	7.48	36.58	7.12	2.80

Table 2 shows that the group taught chemistry using computer animation has mean gain achievement score of 20.04, those taught using inquiry method has mean gain achievement score of 14.44 while those taught using conventional lecture method has mean gain achievement score of 2.80.

Hypothesis 1: There is no significant difference in the mean critical thinking scores of students taught chemistry using computer animation, inquiry method and conventional lecture method.

Table 3: ANCOVA on Difference between the Mean Critical thinking Scores of Students taught using CA, IM and those taught using CLM

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	17442.054[a]	3	5814.018	128.507	.000	
Intercept	4148.293	1	4148.293	91.690	.000	
Pretest	11609.696	1	11609.696	256.609	.000	
Method	4053.346	2	2026.673	44.796	.000	S
Error	10360.581	229	45.243			
Total	630983.000	233				
Corrected Total	27802.635	232				

Table 3 shows that at 0.05 level of significance, 1df numerator and 232 df denominator, the calculated F is 44.796 with Pvalue of .000 which is less than 0.05. Thus, the null hypothesis was rejected. Therefore, there is a significant difference in the mean critical thinking scores of students taught chemistry using computer animation, inquiry method and conventional lecture method.

Table 4: Scheffe PostHoc

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Animation	Inquiry	-2.95906	1.54546	.162	-6.7667	.8486
	Lecture	8.95960*	1.58672	.000	5.0503	12.8689
Inquiry	Animation	2.95906	1.54546	.162	-.8486	6.7667
	Lecture	11.91865*	1.57729	.000	8.0326	15.8047
Lecture	Animation	-8.95960*	1.58672	.000	-12.8689	-5.0503
	Inquiry	-11.91865*	1.57729	.000	-15.8047	-8.0326

*. The mean difference is significant at the 0.05 level.

Table 4 reveals that no significant difference exists between the mean critical thinking scores of students taught using computer animation and inquiry method. Table 4 also reveals that a significant difference exists between the mean critical thinking scores of students taught using computer animation and conventional lecture method in favour of computer animation. Table 4 further shows that there is significant difference between the mean critical thinking scores of students taught using inquiry method and conventional lecture

method in favour of inquiry method. Computer animation and inquiry method significantly improved students' critical thinking more than conventional lecture method.

Hypothesis 2: There is no significant difference in the mean achievement scores of students taught chemistry using computer animation, inquiry method and conventional lecture method.

Table 5: ANCOVA on Difference between the Mean Achievement Scores of Students taught using CA, IM and those taught using CLM

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	16954.776[a]	3	5651.592	190.450	.000	
Intercept	7106.330	1	7106.330	239.473	.000	
Pretest	6216.033	1	6216.033	209.471	.000	
Method	11331.528	2	5665.764	190.928	.000	S
Error	6795.550	229	29.675			
Total	519819.000	233				
Corrected Total	23750.326	232				

Table 5 shows that at 0.05 level of significance, 1df numerator and 232 df denominator, the calculated F is 190.928 with Pvalue of .000 which is less than 0.05. Thus, the null hypothesis was rejected. Therefore, there is a significant difference in the achievement scores of students taught chemistry using computer animation, inquiry method and conventional lecture method..

Table 6: Scheffe PostHoc

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Animation	Inquiry	5.02594*	1.18934	.000	2.0957	7.9562
	Lecture	16.47529*	1.22109	.000	13.4668	19.4838
Inquiry	Animation	-5.02594*	1.18934	.000	-7.9562	-2.0957
	Lecture	11.44935*	1.21383	.000	8.4587	14.4400
Lecture	Animation	-16.47529*	1.22109	.000	-19.4838	-13.4668
	Inquiry	-11.44935*	1.21383	.000	-14.4400	-8.4587

*. The mean difference is significant at the 0.05 level.

Table 6 reveals that no significant difference exists between the mean achievement scores of students taught using computer animation and inquiry method. Table 6 also reveals that a significant difference exists between the mean achievement scores of students taught using computer animation and conventional lecture method in favour of computer animation. Table 6 further shows that there is significant difference between the mean achievement scores of students taught using inquiry method and conventional lecture method in favour of inquiry method. Computer animation, followed by inquiry method significantly improved students' achievement in chemistry more than conventional lecture method.

IV. Discussion

One of the findings of this study indicated that the critical thinking of students who were taught chemistry using computer animation instructional method was improved more than those who were taught using conventional method. This means that the use of computer animation is effective in enhancing secondary school students' critical thinking in chemistry. This is in line with the idea of Amal and Samar (2018) who pointed out that the use of computer animation via moves had a positive effect on achieving higher levels of thinking among students. The finding had support from what had been found by other researchers such as Barak et al (2010), Igboegwu (2011) and Oguz (2011). This is further confirmed by the result which indicated that the teaching approach positively affected students' critical thinking. It was shown by the rejection of null hypothesis of no significant difference in the posttest mean scores of students taught chemistry using computer animation and those taught with conventional method. From the result of this study the critical thinking posttests mean score of students taught with computer animation method was higher than the score of those taught with conventional method. This shows that this method improves the critical thinking of students. The finding of the study is in agreement with the research report of Igboegwu (2011) which opined that students taught with computer assisted package had higher post test scores in both critical thinking and achievement tests than those taught with conventional method.

The findings of this study indicated that the use of inquiry method in teaching chemistry students resulted in the enhancement of the critical thinking in students. It showed that there is a significant difference between the critical thinking posttest scores of students taught with inquiry method and those taught with conventional method. This is in agreement with Nwamaradi (2007) who maintained that constructivist approach like inquiry method promotes higher critical thinking in students. The findings of other researchers were in line with the findings of this study. Such researchers include Longo (2012), Duran and Dokme (2016). Duran et al

noted from their findings that inquiry based instructional method has significant effect on critical thinking of students. In contrast Arsal (2017) found out that pre-service teachers in the experimental group taught with inquiry method did not show statistically significant progress in terms of critical thinking dispositions than those in the control group.

There was indication of higher mean gain in achievement of students taught chemistry with computer animation than those taught using inquiry method and conventional lecture method. The academic achievement of those taught with computer animation was better than those taught with inquiry method and conventional method. This is in agreement with the finding of Abdulrasaq, Bello and Isaac (2017) who reported that students had better performance through the use of computer animation instructional method. This finding was supported by other researchers like Gambari, Oluwole and Adegbenro (2014), Falode, Sabowale, Saliu, Usman and Falode (2016) and Ikwuka and Samuel (2017).

The findings of this study showed that inquiry instructional method was effective in improving academic achievement of students in chemistry. Also the findings indicated that teaching with inquiry method affects academic achievement significantly better than conventional method. These findings are in line with Aniodo & Egbo (2013) who opined that students taught chemistry with inquiry role approach achieved higher than those taught with expository method. This finding had support from other researchers like Abdi (2014) who reported a significant difference in the achievement of students in favour of those taught using inquiry instructional method. The same is with the findings of Onanuga (2014).

The result of the study in also revealed that computer animation is more effective than inquiry method in enhancing achievement of students in chemistry. The result of the study showed that there is a significant difference in the effects of computer animation and inquiry method on the academic achievement of students in chemistry. This means that computer animation captured students' attention and as such provided for an increase in the achievement of students in chemistry. This was confirmed by the earlier findings of researchers like Oguz (2011), Ikwuka et al (2017) and Chikendu (2018).

V. Conclusion

It can be concluded from the findings of the study that computer animation and inquiry method are both effective in improving chemistry students' critical thinking. Computer animation however, positively enhances and significantly improves students' achievement in chemistry more than inquiry method and conventional method. On the other hand, inquiry method improves achievement in chemistry more than conventional method.

VI. Recommendations

In line with the findings of this study, the following recommendations are made:

1. Chemistry teachers should organize regular workshops to intimate teachers on the use of computer animation and inquiry instructional methods in teaching chemistry.
2. Computer programmers should develop and make available computer animation software for chemistry teachers.
3. Chemistry teachers should adopt inquiry and computer animation instructional methods to be able to enhance critical thinking and academic achievement of their students.

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