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EFFECTS OF ANIMATION ON SELF-EFFICACY AND ACHIEVEMENT IN CHEMISTRY AMONG CONCRETE AND FORMAL THINKERS IN SECONDARY SCHOOLS IN JOS - NIGERIA

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ABSTRACT: In this study animation instructional strategy (AIS) was used to find its effect on the self-efficacy and achievement of concrete and formal chemistry students in secondary schools in Jos – Nigeria. The pre-test, post-test non-equivalent control group design was used. A sample of 136 chemistry students randomly assigned into experimental group (65) and control group (71) participated. Three instruments; a test of logical thinking (TOLT), chemical bond test (CBT, r = 0.87) and chemistry students' self-efficacy questionnaire (CSSEQ, r = 0.82) were employed. The experimental group was treated with AIS while the control group was taught using the traditional lecture method (LM). T-test statistic was used to analyze the data at P≤0.05 level of significance. Results revealed a significant difference in the achievement of chemistry students taught using AIS and those taught using LM, and a significant difference between the self-efficacy of students taught chemical bondingusing AIS and those taught using LM. There was no significance difference between the achievement mean scores of formal and concrete learners in the AIS class, and no significant difference between the self-efficacy of formal and concrete thinkers in the same AIS class.The study recommended the use of animation instructional strategy along with other student-centered strategies to chemistry teachers to enhance the achievement of formal and concrete learners.AIS should also be used to improve students' self-efficacy.
Key words: animation, self-efficacy, achievement, formal, concrete, thinkers

I. INTRODUCTION

Science, technology, engineering and mathematics (STEM) have so much influence our daily lives such that it is now difficult to imagine what the world would be without the tremendous benefits we derive from them. The influences in our daily lives can be seen in the areas of communication, health, agriculture, transportation, housing, and industrial operations amongst others [1]. Governance at almost all levels has been made easier with the use of information and communication technology. It has been documented that STEM areas have greater job opportunities and salaries than the non-STEM fields [2]. These same areas have been very influential in promoting the economic growth of nations [3]. It is clear that everybody needs STEM and in every aspect of human endeavor. This may account for the giant steps nations are taking and the huge expenditure in the areas of STEM.

Chemistry occupies a pivotal position in science and technology and is concerned with the study of the composition, properties, structures and uses of matter. It is considered as the hub of science and it is considered as a service subject [2]. Chemistry plays the role of being the catalyst for sustainable national growth and development. The knowledge of chemistry comes to bear in the manufacture of many valuable products for human use such as soap, oils, drugs, hydrogenated oil, kerosene, foams, petrol, plastic, lubricants, vaseline, insecticides, ceramics and detergents [4]. Chemical activities take place daily in the environment such as combustion (burning), rusting, cooking and breathing amongst others.

However, in spite of the central and pivotal role of chemistry in STEM and importance in sustaining sustainable economic growth and development, the performance of Nigerian students in the School Certificate Chemistry over the years has not been not been encouraging [5], [6]. The deterioration of the chemistry students' achievement amongst students has sparked numerous studies to investigate the causes of the issue [2]. According to [7], the contributing causes include the abstract nature of chemistry concepts, attitude, interest, students' perception (self efficacy), student anxiety, motivation for chemistry learning, use of ineffective teaching strategies, teachers' professional and academic qualifications, etc.

Researches have shown that the continued use of the traditional lecture method for teaching all topics in chemistry has been ineffective. This has resulted to poor achievement in chemistry external examinations such as the Senior School Certificate Examination (SSCE) normally conducted by the West African Examination Council (WAEC) and the National Examination Council, NECO [8], [7]. A variety of teaching strategies have been advocated for use in science and mathematics classroom, ranging from teacher-centered approach to more students-centered ones. These include the use of concept maps and advanced organizers, computer animations, use of analogies, cooperative learning, hands-on activities, conceptual change, problem solving, inquiry-oriented approaches, experiential learning, role playing, etc.

According to [9], chemistry is an abstract subject that is difficult to understand. This is so because the basic concepts have to be mentally visualized by the students to understand the chemical phenomena. More so, understanding Chemistry is based on assigning meaning to the unseen and the intangible. Therefore in order that the subject may be more relevant, enjoyable, easy and meaningful to students, adequate instructional materials need to be provided and properly utilized as the teaching and learning situation may demand. This is where animation instructional strategies become necessary.

Computer animation is a product of modern technologies. It is a computer-generated animation is a series of still computer-generated pictures that are presented in succession to create the illusion of motion, much like a picture. Computer animation produces special effects and stimulates images that would be impossible to show with non-animation techniques. The instructional effectiveness of computer animations may be explained using Paivio's dual-coding theory, which assumes that learners store information, received in their working memory as either verbal or visual (pictorial) mental representations [10]; [11].Studies have suggested that students who receive instruction including computer animations or visualizations of chemical processes at the molecular level are better able to answer conceptual questions about particulate phenomena [11]; [12]; [13]. [9] found out that computer animation instruction had significant effect on students' academic achievement in Chemistry. Similarly, [7] in a study, established that there is a significant difference between the achievements mean scores of chemistry students taught chemical bonding using animation instructional strategy and those taught using lecture method. The students taught using animation instructional strategy achieved higher in a chemistry achievement test involving chemical bonding. These studies show that the use of visualization is important for teaching chemistry concepts. Animation can be used to give an accurate and rich picture of the dynamic nature of molecules and molecular interaction, which are often very hard to grasp from text-based presentations of information. This is particularly important for a topic such as chemical bonding that involves the movement of electrons.

One of the social characteristics of a learner is the belief he holds in his ability to accomplish a task or activity successfully [14]; [15]. This belief in one's ability is called self-efficacy and it affects one's achievement in school tasks. Research has repeatedly indicated that individual students' levels of self-efficacy affect the effort they spend on an activity, the persistence they put forth when confronting obstacles, the resilience they show in the face of adverse situations, the level of academic achievement they attain, and the enrolment choices they make [16]. Many students have difficulty in school not because they are incapable of performing successfully but because they are incapable of believing that they can perform successfully- they have learned to see themselves as incapable of handling academic work or to see in the work as irrelevant to their perceptual world [15]. Self-efficacy is an important construct in education because it influences both teachers' and students' behavior. It is one aspect of the social cognitive theory defined as someone's belief in his or her own ability to achieve a certain level of achievement or performance [2]. Self-efficacy is also influenced by the psychological situation and emotional state of an individual. Positive emotional states can enhance one's self-efficacy whilst negative emotions can lower one's self-confidence [2]. This means that it is one of the learner's emotional input behavior with which he enters the learning environment. For students to be successful in school chemistry, they need to have a positive sense of self-efficacy. Quite a number of studies have reported a significant relationship between self-efficacy and academic achievement [2]; [17]; [18]. Highly self-efficacious students had more academic achievement compared to those with low self-efficacy beliefs [14].

[19] noted that the classroom environment is characterized with students of varying pattern of thought due to variation in the individuals' information processing mechanism. Some students process information through logical operation with concrete object. Students in this category are classified as concrete thinkers [20]. Other children are classified as formal thinkers who differ from the concrete thinkers in their ability to carry out operations among symbols and think in abstraction [15]. In a typical secondary school chemistry class, there are both concrete and formal learners. While the chemistry teachers can do nothing to increase student's mental capacity, they can make use of instructional strategies that help to make concepts easier to comprehend to both sets of students.

One of the important concepts of chemistry is chemical bonding. However, studies have revealed that chemistry students encounter difficulties in understanding the concept, hence a lot of researches [7]; [21]; [22].

Literatures available reveal that the abstract concept of chemical bonding is considered by teachers, students, and chemical educators to be very difficult and complicated. The atoms, molecule, and the chemical bond are considered abstract concepts and this makes it a topic that students commonly find problematic. They therefore tend to develop a wide range of alternative conceptions [21]. Yet a proper understanding of such concept is of paramount importance for understanding almost every other areas of chemistry such as electrolysis, oxidation and reduction reaction, acid and bases, carbon compounds and balancing of chemical reactions.

1.1 Statement of the Problem

Many studies have been conducted on self-efficacy and academic achievement but adequate research has not yet established a firm connection between self-efficacy and chemistry students' achievement in chemical bonding. There are very few, if at all, works that have been carried out showing the effects of the use of animation on self-efficacy and academic achievement among formal and concrete learners in chemistry classrooms. Therefore, considering the issues from the related literature, the problem of this study is the investigation of the relationship between the self-efficacy and achievement of concrete and formal thinkers (students) when taught chemical bonding using animation instructional strategy.

1.2 Purpose of the Study

The aim of this study was to determine theeffect of computer animation strategy on senior secondary one-chemistry students' achievement in chemical bonding. Specifically, the study sought to:

i. The difference in achievement between students taught chemical bonding using animation instructional strategy and those taught using lecture method.
ii. The difference in self-efficacy between students taught chemical bonding using animation instructional strategy and those taught using lecture method.
iii. The difference in achievement between formal and concrete learners that were taught chemical bonding using animation instructional strategy
iv. The difference in self-efficacy between formal and concrete learners that were taught chemical bonding using animation instructional strategy

1.3 Research Questions

The following research questions were formulated to guide the study:

i. What is the difference in the achievement of students taught chemical bonding using animation instructional strategy and those taught using lecture method?
ii. How does the self-efficacy of students taught chemical bonding using animation instructional strategy different from that of those taught using lecture method?
iii. What is the difference in the achievement of formal and concrete learners taught chemical bonding using animation instructional strategy?
iv. What is the difference in the self-efficacy of formal and concrete learners taught chemical bonding using animation instructional strategy?

1.4 Research Hypotheses

Ho_1: There is no significant difference between the achievement mean scores of chemistry students taught chemical bonding using animation instructional strategy and those taught using lecture method.

Ho_2: There is no significant difference between the self-efficacy of chemistry students taught chemical bonding using animation instructional strategy and those taught using lecture method.

Ho_3: There is no significance difference between the achievement mean scores of formal and concrete learners taught chemical bonding using animation instructional strategy.

Ho_4: There is no significance difference between the self-efficacy of formal and concrete learners taught chemical bonding using animation instructional strategy.

II. MATERIALS AND METHOD

A quasi-experimental design was used for this study. It involved pre-test, post-test non-equivalent control groups.A total of one hundred and thirty six (136) chemistry students participated in the study. These were drawn from four secondary schools. An intact class was randomly selected from each of the schools (where there are more than one) giving a total of four intact classes. The four classes (schools) were randomly assigned into control and experimental groups with two classes in each group. The experimental group had 65 students while the control had 71 students. In the experimental group (two classes), a test of logical thinking (TOLT) was used to classify the subjects in to concrete and formal learners. Among the 65 students In the experimental class, 26 students fell in the concrete learners category while 39 were in the formal category.

Three research instruments were used for the study. The first one was a test of logical thinking (TOLT) used to categorize the students into formal and concrete thinkers. The second instrument was a chemical bond test (CBT). The researcher developed the CBT based on standard examinations such as WAEC and NECO to ensure that questions are from the topics covered by the study. The CBT was made up of 30 multiple choice questions based on Chemical Bonding.

The third instrument was a chemistry students' self-efficacy questionnaire (CSSEQ) adapted from the Electronic Supplementary Material (ESI) for Chemistry Education Research and Practice (The Royal Society of Chemistry) and slightly modified to consist of items drawn from chemical bonding and related topics. The items investigated the confidence which students had in undertaking different tasks in chemical bonding. The CSSEQ contained fifteen items that required the responses of students. The responses were: Very well (VW), Well (W), Average (A), Poor (P) and Very poor (VP), and were scored 5, 4, 3, 2, and 1 respectively. Two lecturers in the Department of Science and Technology Education, University of Jos, Nigeria, and a secondary school chemistry teacher validated the questionnaire. Ilorin, Nigeria for item structure and language clarity. The reliability of the CBT and CSSEQ were found to be 0.87 and 0.82 respectively.

A pretest (CBT and CSSEQ) was administered to both control and experimental groups. Thereafter the students were taught the concept chemical bonding using animation instructional strategy in the experimental group. The researcher used animated software in a laptop and projected on the wall to teach the experimental class. The software shows how electrons are transferred from one atom to the other. It also shows how electrons are shared between atoms in covalent bonding. The control class was taught using the conventional lecture method while the experimental group was taught using a combination of lecture and animated instructional strategy. The teaching lasted a period of three weeks. Thereafter, the items in the CBT and CSSEQ were reshuffled to make them appear different at a glance and were administered to both control and experimental groups as posttest at the end of the treatment. The pretest and posttest scores of the groups were used for analyses.

Both the CBT and CSSEQ were administered directly to the students in each of the schools and retrieved on same day of visitation. The data obtained were subjected to statistical analysis using mean, standard deviation, and t-test statistics employed to test the research hypotheses at 0.05 level of significance.

III. RESULTS AND DISCUSSION

The data obtained using the CBT and CSSEQ were analyzed and used to answer the research questions. The same data were also used to test the hypotheses and the results presented. Here, only the posttest results are presented.

Research Question One: What is the difference in the achievement of students taught chemical bonding using animation instructional strategy and those taught using lecture method?

Table 1: T-test on academic achievement of control and experimental groups (posttest)

Group	N	Mean	SD	SE	t-value	df	p
Control	71	16.82	3.29	0.39	-9.017	134	0.000
Expt	65	21.54	3.77	0.34			

Table 1 reveals that chemistry students that were taught chemical bonding using animation instructional strategy had a mean score of 21.54 while those in the control group had a mean achievement score of 16.82. The difference in the mean achievement was 4.72 in favor of students taught with animation instructional strategy. This shows that animation instructional strategy improves the academic achievement of chemistry students in tasks involving chemical bonding.

Hypothesis One: There is no significant difference between the achievement mean scores of chemistry students taught chemical bonding using animation instructional strategy and those taught using lecture method.

From the analyses presented in Table 1, the p-value is less than 0.05 ($p < 0.05$). This means that the difference between the mean achievements of the students taught using lecture method and those taught using animation instructional strategy was significant. Therefore the null hypothesis was rejected. There is a significant difference between the achievement of chemistry students taught chemical bonding using animation instructional strategy and those taught using lecture method.

The result here agrees with those of [7] and [21], who in their different researches reported the effectiveness of animation instructional strategies over jigsaw and lecture methods respectively in teaching chemical bonding. It also agrees with that of [9] who found out that computer animation Chemistry instruction had significant effect on students' academic achievement in Chemistry. The result is also consistent with that of [13] and that of [23]who found out that the use of computer animation resulted to significantly higher conceptual understanding in tests involving particulate nature of matter evaluation. It however differs from that of [24], who reported that students taught electrochemistry with lecture method supplemented with music had higher achievement scores than those taught with animation instructional strategy.

Research question two: How does the self-efficacy of students taught chemical bonding using animation instructional strategy different from that of those taught using lecture method?

Table 2: T-test on self-efficacy of control and experimental groups (posttest)

Group	N	Mean	SD	SE	t-value	df	p
Control	71	3.02	0.28	0.03	-6.927	113.706	0.000
Expt	65	3.43	0.40	0.05			

From the mean scores of the groups in self-efficacy test in Table 2, the control group had a score of 3.02 while the experimental group had a score of 3.43. The difference is 0.42. It was observed that students in the experiment group had a higher self-efficacy score than those taught in the control. This implies that the use of animation strategy improves students' self-efficacy (belief) in chemistry.

Hypothesis two: There is no significant difference between the self-efficacy of chemistry students taught chemical bonding using animation instructional strategy and those taught using lecture method.

Hypothesis two tested for significant difference between self-efficacy of students in the experimental group and those in the control group. The result of the test in Table 2 has $p < 0.05$, revealing that there is a significant difference between the two groups of students involved in the study. The null hypothesis was rejected. Therefore there is a significant difference between the self-efficacy of chemistry students taught chemical bonding using animation strategy and those taught using lecture method. This shows that self-efficacy is associated with learning strategies.

The findings in Tables 1 and 2 agree with that of [25] who reported that self-efficacy is significantly associated with learning strategies, and that of [18] who found out that self-efficacy is one of the affective factors often associated with academic achievement. The finding is however, at variance with those of [26] whose study showed that no significant relationship existed between the self-efficacy and academic achievement of chemistry students. [27] also reported that self-efficacy had no relationship between generation status and academic achievement.

Research question three: What is the difference in the achievement of formal and concrete learners taught chemical bonding using animation instructional strategy?

Table3: T-test on academic achievement of formal and concrete learners exposed to animation strategy

Group	N	Mean	SD	SE	t-value	df	p
Concrete	26	21.54	3.04	0.59	0.000	63	1.000
Formal	39	21.54	2.61	0.42			

Results presented in Table 3 shows that both formal and concrete thinkers had a mean achievement score of 21.54 each when both were exposed to animation instructional strategy. This implies that the use of animation instructional strategy influenced both formal and concrete thinkers' achievement equally.

Hypothesis three: There is no significance difference between the achievement mean scores of formal and concrete learners taught chemical bonding using animation instructional strategy.

The test revealed in Table 3 that the two groups were not significantly different in their academic achievements as $p > 0.05$. The null hypothesis was not rejected. Therefore there is no significance difference between the achievement mean scores of formal and concrete learners taught chemical bonding using animation instructional strategy.

This finding disagrees with the findings of [15] who reported a significant difference in the academic achievements of students in concrete and formal operational stages of learning in favor of those at the formal stage. Students in the formal operational stage had higher academic performance than those in concrete operational stage when both were exposed to the cooperative learning strategy. [19] observed earlier that the difference between formal and concrete learners was associated with the variation in the individuals' information processing mechanism.

Research question four: What is the difference in the self-efficacy of formal and concrete learners taught chemical bonding using animation instructional strategy?

Table 4: T-test on self-efficacy of formal and concrete learners after exposed to animation strategy

Group	N	Mean	SD	SE	t-value	df	p
Concrete	26	3.51	0.388	0.062	-1.228	63	0.229
Formal	39	3.38	0.421	0.082			

In Table 4, the concrete students' self-efficacy mean score after exposure to animation strategy was 3.51 while that of formal students was 3.38. There was a mean difference of 0.13 in favor of the concrete group.

Hypothesis four: There is no significance difference between the self-efficacy of formal and concrete learners taught chemical bonding using animation instructional strategy.

Hypothesis four tested for significant difference between self-efficacy of students at concrete operational stage and those at formal operational stage when exposed to animation strategy. From results presented in Table 4, p (0.229) > 0.05. The test revealed that students who are formal thinkers did not significantly differ in their self-efficacy from students who were concrete thinkers when both groups were taught using animation instructional strategy. The null hypothesis was therefore retained.

This is in tandem with reports of [15] who found out that there is no significant difference in self-efficacy of students at concrete operational stage and those at formal operational stage when exposed to cooperative learning strategy. The findings of hypotheses three and four where there is no significant difference between the achievement and self-efficacy of students at concrete operational stage and those at formal operational stage can be attributed to the computer animation strategy. This strategy produces special effects and stimulates images that would be impossible to show with non-animation techniques. In chemical bonding computer animation makes the visualization of the movement of electrons (which are invisible to the naked eyes) possible such that both formal and concrete thinkers find easy to understand.

IV. CONCLUSION AND RECOMMENDATIONS

This study was on the effects of animation on self-efficacy and achievement in chemistry among concrete and formal thinkers in secondary schools. The findings indicate that animation could be an alternative method of teaching chemistry, especially topics like particulate nature of matter, chemical bonding and electrolysis that involves movement of particles. It has the potentials to enhance academic achievement of formal and concrete learners equally in chemistry. The strategy significantly affects the self-efficacy of formal and concrete learners as revealed by the result of the study.

Chemistry teachers should use animation instructional strategy along with other student-centered strategies to enhance the achievement of students in chemistry especially in a class that consists of formal and concrete learners. Since the strategy is associated with improvement in self-efficacy, there is need for science teachers to employ its use in chemistry classes. This will not only boast their confidence in chemistry but in other subjects. Finally, chemistry teachers should be trained in the production of computer animations for chemistry lessons.

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