



Effect of Computer Animations on Senior High School Students' Academic Achievements in Rate of Reactions

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Abstract

The significance of computer animations in a senior high chemistry classroom is investigated in this chemistry education research study. This study investigated the effect of computer animations on the academic achievements of senior high school students in terms of rate of reactions. The study was conducted in two public Senior High Schools in Ablekuma West Municipal in Greater Accra Region of Ghana. This study was anchored on the positivist paradigm and adopted the quantitative approach as well as a quasi-experimental design to achieve its objectives. The study used purposive sampling to select 85 students for the study. Two intact classes were engaged in the study with 45 students in the experimental group and 40 students in the control group. The instrument used for the collection of data was the 'Rate of Reaction Achievement Test' (RoRAT), in the form of a pre-test and a post-test. The pre-test was used to check if the two groups were at the same level of achievement in rate of reactions or not before the treatment. A post-test was administered after the treatment to find out whether the treatment activities assisted to enhance students' academic achievement in the rate of reactions or not. The results showed that there was no significant difference between the means of the pre-test scores of the experimental group and the control group before the treatment, which indicated that the two groups were the same in terms of their understanding and achievements in the rate of reaction concepts. However, there was a statistically significant difference between the means of the post-test scores of the experimental group and the control group after the treatment. The effect size in the post-test scores between the two groups was large. The study concluded that computer animations assisted senior high school students to better understand rate of reactions resulting in enhanced academic achievement.

Subject Areas

Chemistry

Keywords

Computer Animations, Rate of Reaction, Senior High, Chemistry, Academic Achievement

1. Introduction

Chemistry is often regarded as a difficult subject, an observation which sometimes repels learners from learning this subject. This is because Chemistry includes many complicated and abstract concepts [1]. According to [2] understanding many concepts in chemistry is difficult for most students because of its abstract nature. The topic, rate of reactions is one of the abstract chemical topics which students find difficult to learn [3]. According to [4], rate of reactions is the change in the concentration of a reactant or product with time while chemical kinetics refers to the rate of reactions or the reaction rate. Rate of reactions in the Senior High School syllabus looks at the following areas: definition of rate of reactions, factors that influence the rate of chemical reactions, deductions from experimental data and graphs on rate of reactions, collision theory of reaction rate, transition state and chemical reactions, the rate law as well as zero, first and second order reactions [5].

Rate of reactions as a highly structured topic is a central part of the chemistry curriculum [2]. The rate of reactions concept is an essential prerequisite for some chemistry concepts such as solubility of substances, acids, bases and salts among others and especially chemical equilibrium [2]. According to [6], students perceive rate of reactions and related concepts difficult to learn. Research on students' understanding of rate of reactions has clearly indicated that students have difficulties in understanding concepts that underlie this topic. Some of the findings were students' inability to define rate of reactions (and defining reaction rate as reaction time) and difficulties in explaining how reaction rate changes as the action progresses [7] [8]. Other findings were misunderstanding of the relationship between temperature change and the rate of reactions [8] and misunderstandings of the relationship between concentration change and the rate of reactions [7] [9]. Some researchers also had these findings that students show misunderstanding of the effect of catalyst on the rate of reactions and on the mechanism of their action [10] [11] and having conceptual difficulties in interpreting empirical data and graphical representation [7]. Students' misconceptions affect their understanding of chemistry concepts since they become obstacles in integrating new concepts into existing concepts [2].

Chemistry teachers, notwithstanding the difficulties encountered by students are making frantic efforts in making rate of reactions less difficult and interesting

to learn [6]. If we teach today as we taught yesterday, we rob our children of tomorrow [12]. According to [2], teachers should design and use conceptual change-oriented instruction which is an effective way to help students to understand chemical concepts meaningfully in their chemistry classes. Students are required to conceptualize descriptive, particulate and mathematical modeling regarding chemical kinetics and the interrelationship between them in order to improve their understanding of rate of reactions concepts [13].

[14] stated that to make chemistry 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 information and communication technology (ICT) comes in. [15] also said that it is time to engage students with interactive learning systems so that they can improve their learning and memorizing capabilities. [16] argued that ICT and computer assisted instruction (CAI) as computer-based tools should be used by teachers to make teaching more meaningful. Computer animation is a useful tool for instruction and making information meaningful. When computer animation is used in teaching, students view animated pictures as real objects which help to improve their understanding of complex concepts [14]. According to [17], a strong scientific education is a prerequisite for any nation's technological advancement.

[18] has shown that learners are motivated when their learning is supported by technology, which in turn leads to increased understanding. According to Wright as cited in [19] cartoons can be successful in integrating cognitive domain with psychomotor domain because they have the power of integrating visual, auditory and kinesthetic learning abilities. Cartoons can be used effectively in teaching because they do not only provide information, they also capture the students' attention and stimulate the active involvement of students in the learning process [20]. Animation makes the subject more visually appealing than text-based teaching materials, according to [21] but it has no discernible impact on understanding. Computer models permit students to link their microscopic explanations of chemical phenomena with their macroscopic observations and students can visualize microscopic processes in chemistry and they have better understanding of chemical knowledge [22].

Mayer's cognitive theory supports the use of computer animation in teaching and learning. [23] explained that people learn more deeply from words and pictures than from words alone. Mayer's cognitive theory of multimedia learning proposed that the two channels for processing information are audio and visuals and humans can only process a finite amount of information in a channel at a time and they make sense of the information by actively creating mental representations. If animations use visual and auditory channels effectively, working memory is increased [24].

According to [25], students' persistent mass failure in chemistry at West African Senior Secondary Certificate Examination (WASSCE) has been attributed to many factors among which are the chemistry topics which research has identified to be difficult for students to learn. This could be because teaching strategies such

as the use of ICT in computer-assisted modes of teaching, cartoons and other innovative and interactive approaches have not been applied by teachers in their lesson executions. Some of the topics which have persistently proved to be difficult at senior high school level include rate of reactions, chemical equilibrium, periodic chemistry, mole concept, organic chemistry, redox reactions, chemical bonding and solubility of substances, among others [26] [27]. The inability of students to fully understand rate of reactions, which is one of the identified difficult topics [10], makes it difficult for them to understand related concepts like chemical equilibrium [28].

This study looked at the effect of computer animations, an interactive teaching mode, on Senior High School students' academic achievements in rate of reactions. The outcome of this study will add up to the existing instructional strategies used in the teaching and learning of rate of reactions. There was also the need to conduct this study because it could help chemistry teachers to use computer animation as an alternate instructional strategy in teaching rate of reactions and this could make their lessons more interesting. In addition, this study could help curriculum developers to consider the use of computer animations in teaching other topics in chemistry.

1.1. Research Question

What is the effect of computer animations on students' academic achievements in learning rate of reactions?

1.2. Hypotheses

H₀₁ and H₀₂ were used to address the stated research question. The null hypotheses were tested at the 0.05 significance level.

H₀₁: There is no statistically significant difference between the means of the pre-test scores of students in the experimental group and the control group before they were taught using computer animations and traditional method respectively.

H₀₂: There is no statistically significant difference between the means of the post-test scores of students in the experimental group and the control group after they were taught using computer animations and traditional method respectively.

2. Research Methodology

The philosophical foundation of this study was positivism. Therefore, a quantitative research approach was used in order to achieve its objective. This approach was adopted as the study compared the influence of a treatment between two groups. The research design for this study was the quasi-experimental research design. Nonequivalent (pre-test and post-test) control group design was used for the quasi-experiment. Two intact science classes of the two public schools in Ablekuma West Municipal in Greater region of Ghana were engaged. One science class of one school was the experimental group and one science class of the other school was the control group. The experimental group was taught rate of reactions

using computer animations and the control group was taught rate of reactions using the traditional method.

2.1. Research Population

The target population comprised about 350 general science students. The estimated accessible population of the study was 180 Form three (3) general science students. The sample size was 85 Form Three general science students. The consent of the participants was sought before they participated in the study. Participation was solely voluntary. No participant was coerced to participate in the study. The sampling technique that the researchers used was purposive sampling. This was done to collect in depth data from the right respondents, who studied general science for about three years in senior high school. The instrument used for data collection was the “Rate of Reaction Achievement Test” (RoRAT), which was in the form of a pre-test and a post-test. Both the pre-test and the post-test comprised 20 multiple-choice questions and 10 closed-ended questions for students to answer. Each item in the multiple-choice questions had four options from which students were to select the correct answers. The post-test was a modified version of the pre-test.

2.2. Validity and Reliability

Face validity of test items was done by experts in chemistry education. Testing for reliability is important as it refers to the consistency across the parts of a measuring instrument [29]. To ensure there was no ambiguity in the questions and to enhance the reliability of the instrument, it was trial tested using a small sample of the students who were not involved in the study. Test-retest reliability was used to assess the degree to which the test scores are consistent from one test administration to the next. Pearson’s correlation coefficient was used to find out if the first test scores correlated with the second test scores or not. The statistic found for Pearson’s correlation coefficient was $r = 0.81$. This means that the two test scores were consistent and highly reliable for the study. The purpose of the trial testing was to identify any difficulties in responding to the questions in the pre-test and post-test.

2.3. Data Collected

The data were collected from the pre-test and post-test written by the control group and the experimental group. This study was conducted within four weeks. The same pre-test was administered to both students in the experimental group and control group before employing computer animations for the experimental group. A two-week instruction was conducted for the experimental group using computer animations and the control group using the traditional approach by the same teacher. Both the computer animation-based instruction and the traditional approach instruction were divided into three sessions within a week. Each session lasted for 40 minutes. While the experimental group received their lessons

through computer animated visualizations on projected screen, the control group received their lesson through the traditional method. **Figure 1** and **Figure 2** shows some screenshots of the animated visualization that was used to teach the experimental group. **Figure 1** was used to explain the types of collisions and the orientations of the colliding molecules that can bring about chemical reactions.

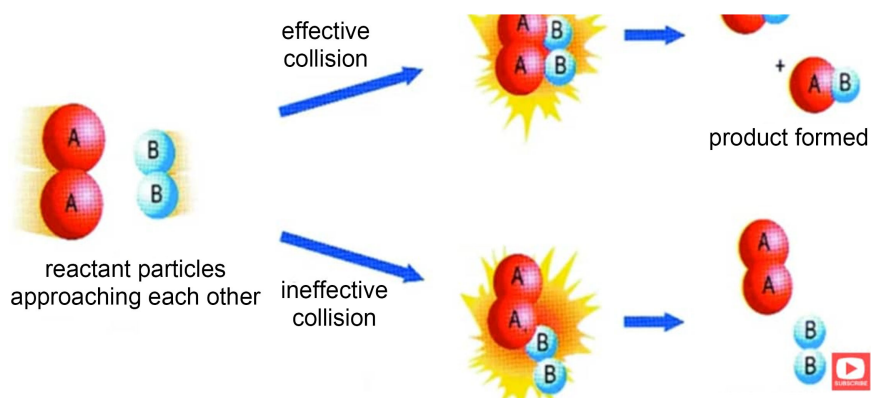


Figure 1. Screenshot of animated visualization showing the orientation of colliding molecules that can bring about effective collision and ineffective collision.

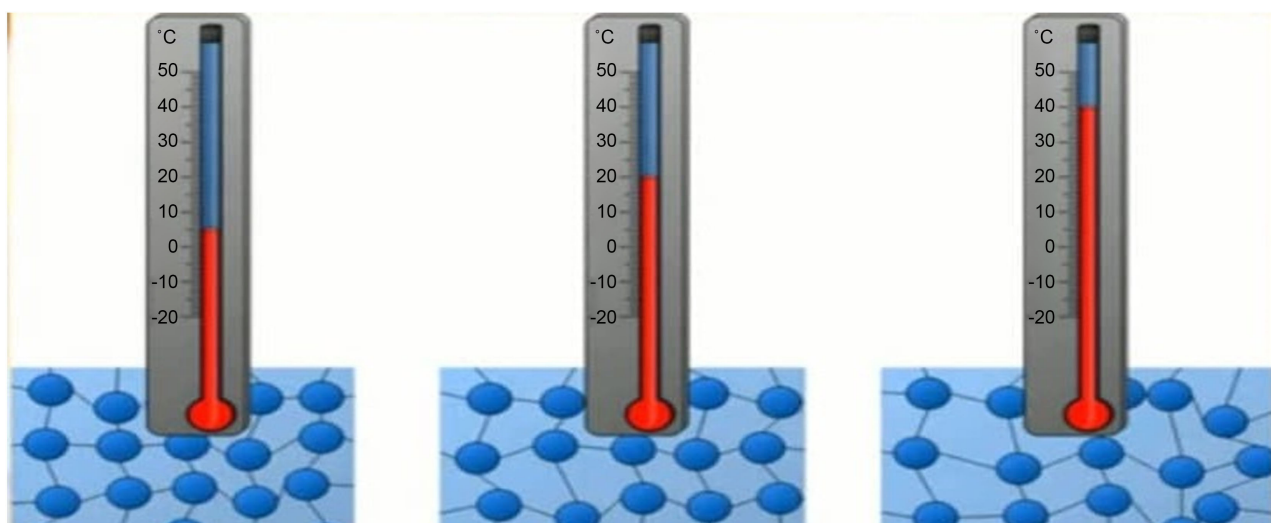


Figure 2. Screenshot of animated visualization showing how change in temperature affect the rate of reactions.

Figure 2 was used to explain the effect of change in temperature on the rate of reactions.

The post-test, which was a modified form of the pre-test was administered to both the experimental group and the control group in the fourth week to check for any difference in the performance of the two groups after the implementation of the treatment. [30] indicated that the period between the pre-test and post-test should not be made too long, since the situational factors may change, and also not too short that the participants will remember the first test. In view of this, the post-test was administered a week after the treatment.

3. Data Analysis

The data were analysed with the help of SPSS version 26. The unpaired t-test was used to compare the difference in the means of both the pre-test scores and the post-test scores of the experimental group and the control group. Cohen's D was calculated to determine the effect size due to the implementation of the computer animations as the treatment in the experimental group.

4. Findings

An unpaired t-test was applied to the pre-test results of the experimental group and control group before the treatment to see whether a statistically significant difference existed between the mean scores. **Table 1** shows the outcome of the t-test results between the experimental group and the control group before the treatment was employed.

Table 1. Unpaired t-test results of the experimental and control groups' Pre-test scores.

Groups	N	M	SD	T	P
Experimental group	45	36.51	15.43	-0.050	0.960
Control group	40	36.68	12.18		

Significant at $p < 0.05$.

Table 1 presents the results of the unpaired t-test for the overall mean scores for the experimental group and the control group. The standard deviations of the pre-test scores for the experimental and control groups were 15.43 and 12.18 respectively. The mean of the pre-test scores for the experimental group was 36.51 and the mean for the control group was 36.68. The mean of the control group was slightly higher than the mean of the experimental group, but this small difference is not statistically significant.

An unpaired t-test analysis was further applied to compare the means of the post-test scores for the experimental group and control group. The t-test results are shown in **Table 2**.

Table 2. Unpaired t-test results of the experimental and control groups' post-test scores.

Groups	N	M	SD	Cohen's D	T	P
Experimental group	45	70.87	10.58	2.176	13.960	0.000
Control group	40	47.33	11.09			

Significant at $p < 0.05$.

Table 2 shows statistically significant difference in the means of the post-test scores of the experimental group and control group. The means of the post-test scores for experimental group and control group were 70.87 and 47.33 respectively. The mean of the experimental group was higher than the mean of the control group in the post-test scores.

5. Discussions

Analysis of results from **Table 1** shows that the t-statistic was -0.050 and the p-value was 0.960 . The results indicated that the p-value was greater than the alpha value, 0.05 ($p > 0.05$). There was, therefore, no statistically significant difference between the pre-test scores of the experimental and control groups. Therefore, we fail to reject the null hypothesis. This indicates that the students in the experimental group and control group were at the same level of understanding of the rate of reactions at the beginning before the treatment was employed.

From the analysis of **Table 2**, it was found that the t-statistic was 13.96 and the p-value was 0.000 . The p-value was less than the 0.05 alpha value and this shows that there was a statistically significant difference in the post-test scores between the experimental group and the control group after the treatment. Therefore, the null hypothesis was rejected. Based on the results provided in **Table 2**, it was concluded that the treatment used in teaching the experimental group enhanced learners' understanding of rate of reactions and they performed better than those in the control group that were taught using the traditional method. Additionally, the calculated Cohen's D value of 2.176 showed a large effect size that buttressed the effectiveness of the computer simulations in improving senior high school students' academic achievement in rate of reactions than the traditional teaching method.

In congruence to these results of this study, [31] pointed out that video animations enhanced students' imagination and visualizations and assisted students in understanding difficult topics. The results of this study are also in agreement with the findings of [32] that suggested that utilising technology in the classroom could help students to have more conducive environment to learning because it improves their attitudes, thus allowing educators to teach more effectively. They added that implementation of technology helps students to become more engaged with school work and it benefits teachers in the sense of keeping current with research and new teaching methods. This is also consistent with [33] findings, which showed that students exposed to computer animation scored differently on mean interest than students taught expository methods, with the experimental group scoring higher.

[34] also investigated the effect of animation on the academic achievement of students in the human and environment unit lectured as part of the science and technology course of seventh grade in primary education. The findings of the study indicated that the animation technique was more effective than the traditional teaching methods in terms of enhancing students' achievement. Also, similar to the results of this study, [14] revealed that computer animation chemistry instructions had significant effect on students' academic achievement in chemistry. They suggested that the use of animations in teaching adds real value to chemistry concepts and concluded that the use of computer animations in teaching abstract chemistry concepts enhanced the efficiency of teaching and learning and assimilation of information. [35] reported that the use of animations in teaching

is significant in increasing the attitudes and academic achievement of students. The usage of animation created using multimedia design concepts in instructional materials makes it easier to teach challenging subjects [36].

6. Conclusions and Recommendations

Based on the findings, it was concluded that the use of computer animations assisted Form Three general science students of the experimental group to better understand concepts relating to rate of reactions. This explains why the academic achievement of the experimental group improved more than the control group in rate of reactions. The study also concluded that computer animations stimulate mental model building abilities of students. This explains why the Form three general science students in the experimental group were able to explain the collision theory and used this theory to explain how temperature, concentration, nature of particles and catalyst affected the rate of reactions. They were also able to calculate the order of reactions and interpret graphs representing the zero order, first order and second order as indicated in their post-test.

The representational models in animation allowed students to realize their existing conceptions, became dissatisfied with these conceptions and accepted better explanations. Computer animation provided better understanding of abstract concepts by serving as a bridge between the real-life examples and misunderstood concepts.

Science teachers, especially chemistry teachers in the schools selected for the study should incorporate computer animation in teaching abstract concepts for easy conceptual changes and for better understanding. Heads of Senior High Schools assisted by the Ghana Education Service (GES) in the selected schools should make projectors and other equipment needed for computer animated instructions available for teachers to use to make teaching of subjects and topics perceived to be in abstract especially chemistry be made easier and real.

7. Suggestions

- Curriculum designers for Senior High Schools should include the use of computer animation as an instructional approach for teaching complicated topics in the science curriculum.
- Education Service directorate should also make computers, projectors and other equipment needed for computer animated instructions available in Senior High Schools in Ghana.

8. Limitations

This article was limited to the effect of computer animations on senior high school students' academic achievements in rate of reactions. It only involved two Form Three general science classes from two public senior high schools in Ablekuma West Municipal in Greater Accra region of Ghana.

Conflicts of Interest

The authors declare no conflicts of interest.

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