Computer 3D Animation Use and Its Effect on Secondary School Students' Conceptual Understanding of Mammalian Circulatory System in Kiambu County, Kenya

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ABSTRACT

When students lack the basic information required to appreciate specific biological issues, they may believe biology is a difficult subject to learn. It may be easier to teach abstract biological processes or concepts in biology classes with the help of 3D computer animation, which may improve students' recall and retention of knowledge of the lesson being taught and increase motivation and engagement in the learning process. The main objective of this study was to determine the effect of computer 3D animation in enhancing students 'conceptual understanding of the mammalian circulatory system: structures, functions, and blood circulation in the mammalian heart. The study design was quasi-experimental. In order to gather data before and after treatment, pretests and posttests were given to students placed in the experimental and control groups. One hundred sixty students, eighty in each group, comprised the study's sample size. The performance of students in the experimental group showed that computerized 3D animation treatment was effective in improving students' conceptual understanding of the mammalian circulatory system as well as their retention of key biological terminologies as compared to students in the control group taught using conventional techniques, which resulted in no significant change in performance-conceptual understanding. Pretest and post-test items were reviewed by biology teachers and subject experts before being administered to students to validate test items. Additionally, it is advised that teachers be given the fundamental training necessary to operate or handle C3D animations and that C3D animations be made available to teachers and students in school libraries.

Keywords: Biological process, Computer 3D animation, Content, Conceptual Understanding, Teachers Attitude

INTRODUCTION

Computer animation is a subset of computer-generated imagery (CGI), which deals with producing moving digital visuals. In order to achieve the required motion effect, which is a combination of biological processes, natural occurrences, and human perception, computer-generated three-dimensional (3D) animation is used. Computer animation is in demand for science training and learning in order to aid students in conceptualizing abstract subjects better (Thalmann & Thalmann, 2002). Mudangha et al. (2018) noted that simulation grew more significant in several academic subjects following World War II. Two mathematicians, J.V. Neumann and Stanislaw Ulam, used simulations to show how the nervous system functions during World War II. A game called Business Game was created in 1968 by a group of students from the English Student Simulation Organization (ESSO) for use in the classroom. The movement began with innovations in teacher education, but it swiftly moved to secondary and postsecondary levels.

The use of models and simulations in training and military environments has a long history. The first models were made by drawing lines in the sand to represent topographic characteristics using materials like stones and twigs. Despite the complexity of modern battle models, the aims of the early models were the same:

preparing, researching, and practicing the mission (Kos, 2013).The primary goal of employing simulation in science education, according to pedagogical research, is to increase students' conceptual understanding and learning outcomes. Although the simulation-based pedagogical design might improve curricula, it is crucial to keep in mind that its main objective is still effective teaching, not the development of technical materials for the sake of technology (Fayzullayeva & Ergasheva 2021).Simulation enhances human performance by connecting thought to activity. The ability of the student to visualize or readily conceive the processes required to accomplish a goal is the most crucial component of a successful mental simulation. (Fanning, 1994).

Teaching and learning techniques have transcended conventional educational methods in the modern technological era. The use of 3D animation content is thought to significantly benefit and, to a considerable extent, be necessary for biology instruction and learning (Bhatti et al., 2017). Using computer-mediated simulations (CMS) to teach secondary school students about cell division and cell theory, Kiboss et al., (2004) investigated the learning outcomes of computer simulations used in the classroom to teach biology. The goal of the study was to determine how effective simulations are as a tool for teaching biology. The outcomes showed that computer animation has a positive impact because, in the treatment group, students' comprehensions were significantly higher than those of their peers in the control group who were taught conventionally. In terms of the mean difference between the two groups, the results also showed that the intervention or treatment group had a statistically (quantitatively) relevant and significant advantage over the control group. Further, the participants in the study under consideration were chosen at random from three separate schools, rather than the researcher using a particular class for the study.

With the aid of multimedia learning, a variety of complex biological processes can be simply and successfully explained and taught. According to Cakiroglu and Yilmaz (2020), 3D animation can be useful and effective in the following areas if teachers have the necessary ICT skills and content knowledge: enhancing visual elements that are pleasing to the eye and quickly convey a powerful and clear message; enabling teachers and students to view biological processes amusingly. Reddy and Mint, (2017)conducted a study to look into the impact of employing simulations in the classroom on students' overall academic performance in biology. The key teaching technique for the researchers' lessons on DNA replication and transcription was simulation. According to their findings, the students in the intervention group who were taught using computer animation outperformed the students in the control group who were taught using the conventional or traditional method in terms of academic performance (getting better grades).

Eighty-one pupils in grade 10 participated in a study carried out by Efe et al., (2011) the purpose of the project is to determine the precise effects of teaching photosynthesis through computer animation on students' achievement levels and biological concepts. The researchers' findings showed that students who were taught via computer simulation outperformed students in the control group who were taught using traditional methods on the post-test, demonstrating an improvement in conceptual knowledge of photosynthesis. In order to evaluate students' conceptual understanding of biology and to ascertain whether performance would differ by gender when instructed via computer simulation, Gambari et al. (2013)employed computer simulation to teach the digestive system. There were 60 senior students involved in the investigation. The researchers found that students in the intervention group (who performed better) and the non-intervention group had significantly different mean test scores. The results also showed that there was no appreciable difference between boys' and girls' mean performance scores for students instructed in the experimental group utilizing computer 3D simulation.

However, as evidenced by its exclusion from the core competency for modeling and simulation in the Vision and Change report, few biologists teach sketching as a teachable science process skill (Quillin & Thomas, 2015).During a semester-long course on animal physiology. The performance on an exam with the same multiple-choice questions did not differ statistically between the control and experimental classes, despite the fact that both received the same in-person lectures and online materials. However, when one group was additionally granted unrestricted online access to narrated video clips, these students statistically outperformed the control group on a second exam with the same multiple-choice questions. The video clips were utilized as an introduction to the interactive animations and simulations as well as independent mini-lectures by the students, who reported that watching the films was the best and most effective approach to acquiring physiological principles, according to an attitude poll (Stephens, 2017).

Objective of the Study

To determine the effect of computer 3D animation in enhancing students' understanding of blood circulation within the mammalian heart.

METHODOLOGY

The research was conducted using a quasi-experimental design. In order to determine the effects of a particular treatment, a quasi-experimental design compares a treatment group to a control group via pre-post intervention(Gopalan et al., 2020).

The participants of the study was divided into two groups: the experimental group, which received instruction using computer-generated 3D animations of mammalian hearts and the control group, which received instruction using traditional teaching methods. One hundred sixty Form 2 (which is grade 10) students were selected using simple random sampling from two public secondary schools that were both boys' and girls' schools (mixed schools). Table 1 below shows the age range of students who participated in the study.

Table 1: Age in years of Students who participate in the Study.

Age in years	Frequency
11-12	3
13-14	16
15-16	79
17-18	62
Total	160

The students were divided equally into experimental and control groups. Both the control group and the experimental group took pre-tests with the same test items at the beginning of the study. The process of gathering data consisted of three steps: pre-testing to gauge students' prior knowledge, experimental treatment (C3D intervention application) following the pretest being administered, and post-testing to gauge students' knowledge (conceptual understanding) after treatment-application. The pre and post-tests consisted of questions on the following: outlining the flow of blood in the heart, naming and outlining the functions of major blood vessels and chambers of the mammalian circulatory system, and diseases of the circulatory system. Additionally, when evaluating students' papers, proper usage and spelling of important biological terms were taken into account.

The mammalian circulatory system topic was chosen from the Form Two syllabus to examine the impact of computer 3D (C3D) animation on students' conceptual understanding of the mammalian circulatory system. The computer-generated 3D animations of the mammalian circulatory system were used to demonstrate the following: the flow of blood in the heart, structures and functions of major blood vessels, valves, chambers, and diseases of the circulatory system such as varicose veins and how plaque (fats or cholesterol) builds up

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within blood vessels. The investigation was conducted over a period of four weeks. Three weeks were used for demonstrations and teaching, and the fourth week was for evaluation.

DISCUSSION of FINDINGS

Pre-test

Before using computer 3D animation, a pre-test was given to both the experimental and control groups to gauge knowledge of the mammalian circulatory system. Table 2 below displays the results of the pretest.

Table 2: Control and Experimental Groups Pre-Test Means and Standard Deviation

Groups	N	Mean	SD	
Pre-Tes	Experimental Group	80	6.060	4.490
	Control Group	80	6.690	4.350

In Table 2 above, the pre-test scores for the experimental and control groups are presented together with their means and standard deviations. The control group's mean pre-test score was 6.69%, while the experimental group's was 6.06%. The mean difference between the mean scores of the two groups was 0.63. The mean pre-test scores of the control and experimental groups were compared using a t-test to see if there was a significant difference. The final result showed that the p-value was 0.373. The experimental and control groups' mean scores did not significantly differ, according to the p-value, which was more than It was concluded that students' conceptual understanding was on par with one another, necessitating the continuation of the study. Additionally, it was shown that both experimental and control group students had trouble spelling and using important biological terminologies while responding to pre-test questions. Students considered the following biological terminologies in Figure 1 below to be difficult to spell and use correctly.

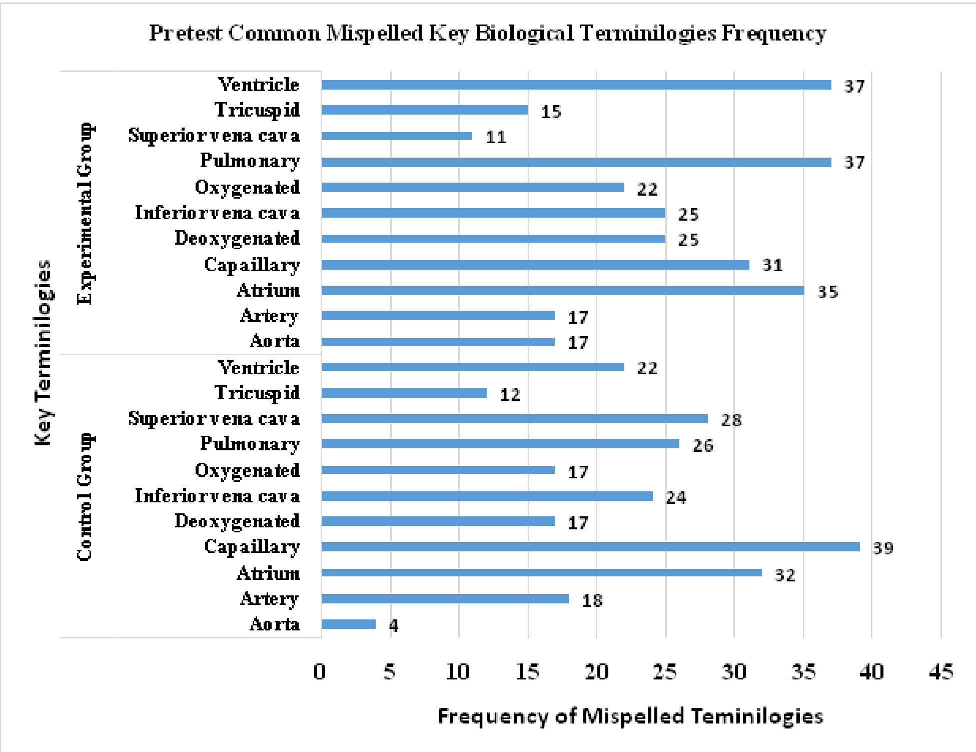

Figure 1: Control and Experimental Groups Key Biological Terminologies Misspelled in Pre-test.

Key biological terms that were often misspelled by the control and experimental groups during pre-test marking are shown in Figure 2 above. This further demonstrated that their conceptual understanding is negatively impacted by their inability to accurately spell and use biological terms as well as understand them. For the control and experimental groups, respectively, there were 239 and 252 misspelled instances of important biological terms.

Post-test

Following the administration of the pre-test, the experimental group's students were given computer 3D animation (C3D) instruction; in contrast, the control group's students were given traditional or conventional instruction, which consisted of lectures and a teacher-centered approach for four weeks, respectively. When marking students' post-tests, the use of acceptable biological terminologies, correct spelling, labeling, and concise phrases was taken into consideration. The same students were given a post-test to assess whether their conceptual knowledge and understanding had improved and been retained after the intervention period. The results are shown in Table 3 below.

Table 3: Experimental and Control Groups Post-test Mean Scores and Standard Deviation

Groups	N	Mean	Std. Deviation	
Post-Test	Experimental	80	27.7	9.119
	Control	80	13.32	5.694

The post-test findings given to the experimental and control groups are shown in Table 3, together with their respective means and standard deviations. The experimental group's mean score was 27.70%, while the control group's was 13.32%. Both the control and experimental groups' post-test means increased from their prior pre-test averages, as indicated in Table 2. The experimental group improved as a result of the intervention, whereas students in the control group might have improved as a result of their awareness that they were a part of a study and their teachers' advice to prepare for the post-test beforehand.

Table 4: Pre and Post Test Mean Comparison and Mean Means Deviation

Groups	Pre-test Mean	Post-test Mean	Mean Deviation
Experimental	6.06	27.7	7.18
Control	6.69	13.32	4.357

Based on the data in Table 4 and taking into account the two mean deviations, it can be said that students in the experimental group outperformed those in the control group as a result of the C3D animation intervention. Additionally, each animation used throughout the study for the experimental group incorporated crucial biological terminology and was accompanied by a C3D animation form which improved students' retention and conceptual understanding of key biological terminologies, resulting in a significantly higher experimental group mean score, whereas students in the control group were taught key biological terminologies using the chalk and blackboard method (traditional or conventional), which did not significantly improve students' retention and understanding of key biological terminologies. The frequencies of key misspelled biological terminologies in the post-test are represented in Figure 2 below.

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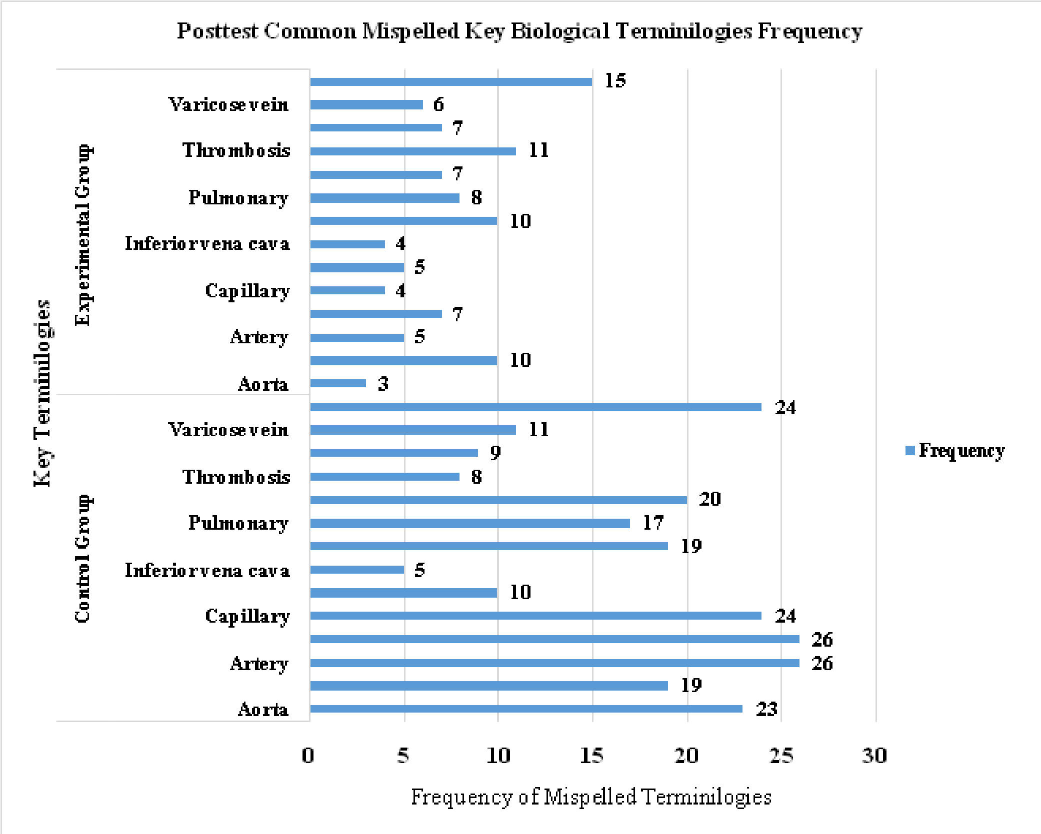

Figure 2:Comparison of Experimental and Control Groups Key Biological Terminologies Misspelled in Post-tests

Figure 2 shows that C3D animation combined with essential biological terminologies greatly improved students' recall and conceptual understanding of biological terminologies in the experimental group. The combined frequency of misspelled key biological terminologies decreased from 272 misspelled terminologies in the pretest in Figure 1 to 107 misspelled terminologies in the post-test in Figure 2 (indicating a more than 50% decrease) for the experimental group. Furthermore, the memory of key biological terminologies among students in the control group did not improve. The number of key biological terms misspelled combined in the pre-test was 239 in Figure 1 and 241 in Figure 2 for students in the control group.

A paired sample t-test was carried out to compare the means of the pretest and post-test scores of students in the experimental group in order to establish whether computer 3D animation had an effect on improving conceptual understanding. The obtained p-value was 0.00, which is lower than 0.05. The p-value found revealed that there was a significant difference between the experimental group's pretest and post-test mean scores. Table 5 compares the experimental group's pre-test and post-test scores only.

Table 5: Pre-test and Post-test Mean Comparisons for Experimental Group

N	Mean	Std. Deviation		
Experimental	Pre-test	80	6.06	4.490
Group	Post-test	80	27.7	9.119

In Table 5, students in the experimental group performed better than those in the control group who received conventional mode of biology instruction because the computerized 3D animation intervention was more effective in improving students' conceptual understanding of the mammalian circulatory system.

The results of this study are in line with earlier investigations into the application of computer-based 3D animation in the teaching of biology and other science-related subjects that involve abstract concepts at the high school level in order to enhance high school students' conceptual understanding. The experimental group performed better than the control group in this study. In a comparable study, Efe et al. (2011) employed computer animation to examine how teaching photosynthesis using computer animation affects students' accomplishment levels and biological conceptual knowledge. According to the findings, the experimental group's students outperformed those in the control group following the intervention period. In addition, Reddy and Mint (2017) ascertain from their research that computer animations, when used to teach abstract concepts like DNA replication and transcription, effectively improved students' overall academic performance in the intervention group in biology and increased students' motivation due to the interactive nature of computer animation. However, teachers must learn the fundamentals of using computer animation for instruction rather than teacher-centered instruction in order for computer simulation instruction and learning or 3D animation to be successful in enhancing students' conceptual understanding of biology's abstract concepts for secondary school students Vikki et al.(2018). Computer 3D animation should be suggested for use as a teaching and learning resource, especially in remote school settings where laboratory demonstration is difficult, in order to improve students' mental comprehension of abstract biological ideas and academic accomplishments.

CONCLUSION

The major conclusions drawn in light of the study's data and findings are: starting off, it can be said that C3D animation, as opposed to the traditional mode (teacher-centered), is an effective way for teaching and learning abstract concepts with ease, improving students' conceptual understandings of challenging concepts in biology. The post-test mean scores of the control and experimental groups indicate that computer 3D animation has the potential to improve students' conceptual understanding of the mammalian circulatory system and thereby improving students' academic success in learning biology. In addition to the research question, C3D animations significantly improve students' conceptual understanding of abstract biological processes, ability to recall biological terms quickly, and proficiency with the appropriate usage of biological terms.

RECCOMMENDATIONS

The following suggestions were made in light of the findings and conclusions of the study:

1. A similar study at the junior high level should be conducted to further explore the effectiveness of using computer 3D animation to improve students' conceptual understanding when teaching the sciences, given that this study was restricted to biology and was conducted at the secondary level in public schools.
2. The use of electronic devices like smartphones and tablets should be introduced to both teachers and students. These devices are lightweight and inexpensive to maintain. Studies should be done to use these tools for 3D animation lessons in order to expand the scope of biology teaching and learning utilizing C3D animation. Students can participate in their lessons wherever they are by using this technique.
3. All science teachers should be able to create animations or models out of materials that are readily available in their communities as teaching and learning aids (this can be accomplished by setting up courses on arts and crafts). A study should be done to find out how science teachers, especially in rural school settings, could be inspired to learn and apply improvisational abilities in science teaching and learning.

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