

Effectiveness of Computer-Assisted Instruction and Conventional Instructional Approaches on High School Student Performance in Cellular Respiration

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ABSTRACT

This study examined the effects of computer-aided instruction (CAI) and conventional teaching methods on high school biology performance. He was randomly selected from each of his two schools to take two science courses. An unequal, quasi-experimental, pre-test, and post-test design were used. Students in the experimental group used their CAI to learn cellular respiration (a biological concept), while the control group learned the same cellular respiration using a conventional approach. Independent and paired-samples t-tests were used to analyze pre-and post-test results for both experimental and control groups. Results showed that students taught using the traditional approach performed better on the post-test than those taught using the CAI. However, students in the experimental group performed better after being instructed to use the CAI. The results also showed that underperforming students performed better after being tutored at CAI. This indicates that CAI is more effective in teaching underperforming students.

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1. INTRODUCTION

Throughout education, science has occupied a leading position among school subjects as it is seen as an essential tool for developing educated people [1]. Ofuebe [1] defined science as the dynamic human activity involved in understanding how our world works. Ambuno, Egunifomi, and Osakwe [2] said that without science, there would be no world today. Biology is still the most popular science subject in Ghana's high school system. However, the biggest challenge in secondary school biology classes seems to be better understanding certain concepts, such as cellular respiration.

Cellular respiration includes the metabolic reactions and processes by which cells of an organism convert food nutrients into energy. Cellular respiration involves two basic

and essential concepts. Glycolysis and the Krebs cycle release energy for physical activity. Students usually have trouble understanding these two concepts because of chemical processes [3], [4]. High school students struggle to understand the Enzymatic reactions and phenomena that control two concepts leading to the release of energy from food and the position of cellular respiration in the human body [5]. Among other concepts, teachers and students see cellular respiration as a challenging and complex area of biology that requires memorizing facts for exams [4]. The West African Examinations Council (WAEC) Chief examiners report that students have difficulty answering biological questions, including cell division, genetics, and cell respiration, and perform poorly in biology academically. The perceived complexity of cellular respiration may be due to the inappropriate, irrelevant, and abstract teaching methods some teachers use in teaching and learning cellular respiration [5].

From our observation as biology teachers and the statistics available, students in the senior high schools within Gomoa East Educational District are not exceptions to the difficulty students face in grasping the concept of Cellular respiration. This situation is a source of worry for educators and researchers. Students find it challenging to understand cellular respiration because teachers rely on traditional teaching methods, which encourage the memorization of facts without understanding the processes involved [5], [6]. Mwanda, Mwanda, Midigo, and Maundu [7] Claim that combining educational and learning tools, such as ICT as a media platform, can successfully communicate abstract scientific topics. Duyilemi, Olagunju, and Olumide [8] Most studies on the effectiveness of ICT in the classroom reported that it was found to be more effective than lecture-based approaches in biology teaching and learning. Research conducted by Moos and Marroquin [9], different types of computer-based instruction, including interactivity, hypermedia, and hypertext, influence students' intrinsic and extrinsic motivation to achieve life goals, academic success, and self-efficacy. According to Ameyaw and Sarpong [10], computer-based teaching can change student misconceptions and enable and encourage independent learning. Elliot, Wilson, and Boyle [11], and Ezeaghasi and Obochi [12] All shared similar findings about the positive effects of computer-based instruction on student academic performance, contrary to the researchers' views such as Owusu, Monney, Appiah, and Wilmot [13] and Ahiatrogah, Madjoub, and Bavel [14].

For instance, Ezeaghasi and Obochi [12] investigate the efficacy of a computer-simulation on students' cell division learning outcome and retention in Nigerian institutes of education. A total of 176 students from colleges of education were sampled for the study. These learners were selected at random and placed into two groups. Cell division was taught to one group via computer simulation, whereas the other was taught the traditional/ conventional way. According to the scores obtained for both the pretest and posttest, students taught via ICT performed better than those taught using the lecture method. The same posttest questions were given to both groups a few days later to determine their retentiveness, and the scores once again demonstrated that learners who were instructed using ICT retained more knowledge about cell division than students who were taught using the lecture technique.

As a result, they argued that the computer simulation model, one type of computer teaching approach, had a good/positive impact on learners learning outcomes in cell division in biology compared to the lecture technique. However, Ahiatrogah, Madjoub, and Bervel [14] No significant performance differences were found between students in computer-assisted classrooms and traditional groups. A comparative study was conducted on the effectiveness of computer-assisted and conventional teaching methods for early dropouts by Owusu, Monney, Appiah, and Wilmot [13]. They found that students taught using traditional methods performed better on post-tests than those taught using computers. There are three different perspectives on the effect of computer-assisted education on student learning success in biology classes.

One school of thought claims that computer-assisted instruction (CAI) Improves student academic performance. In contrast, the second school of thought argues that there is no significant difference in student performance between CAI-based and non-CAI-based learning, and the third school argues that traditional approaches are likely to improve student performance. Claimed to be more effective—as biology CAI. Therefore, there is an urgent need for sophisticated and more acceptable teaching methods to enable students to conceptualize and process cellular respiration [3], [5].

This study aims to compare the effects of computer-assisted instruction and conventional strategy on students' academic achievement in the cellular respiration concept at a senior high school in Ghana. This would assist teachers in planning instructional strategies to improve students' understanding and achievement in cellular respiration.

The study has significance for policy formulation and implementation in Ghana concerning teaching concepts related to cellular respiration. By gaining insights into the effects of Computer Assisted Instruction and the conventional teaching strategy, the study contributes to knowledge in the following ways: First, it brings to the fore the effect of the selected instructional approaches concerning students' achievement in cellular respiration. This might give the Ghana Education Service (GES) and the Ministry of Education (MOE) information on how biology teachers could teach cellular respiration to pupils with difficulty understanding it.

Finally, the information gained from the study would provide insights into what other instructional strategies have the potential to improve senior high school students' achievement in cellular respiration. This would provide valuable information on how the curriculum could be restructured and teacher preparation programs could better fulfill the needs and aspirations of schools.

2. METHOD

2.1 Research design

This study used an unequal pretest-posttest quasi-experimental design because participants were not randomly assigned to the two groups [15]. We used this design to collect quantitative data to determine whether there were significant differences between students taught using computers and those taught using conventional approaches. Selected classes have been assigned test and control schools.

2.2 Research questions

1. Is there a statistically significant difference between the mean posttest performance scores of students taught using computer-assisted instruction and those taught using conventional strategies?
2. Is there an impact of computer-assisted instruction on student performance in cellular respiration?
3. Is there a statistically significant difference between low-performing and high-performing students' performance when taught using computers?

In order to answer research questions 1 and 3, two null hypotheses were formulated.

H₀₁: There is no statistically considerable distinction between the expected overall performance of college students taught the use of computer-primarily based totally preparation and the standard overall performance of college students taught the use of traditional coaching methods.

H₀₂: There is no statistically significant difference between the average results of low and high cellular respiration performers when taught with computer-based instruction

2.3 Sampling technique and Sample size

This research employed a multi-stage sampling technique [16]. When more than one sampling technique is used in one study, it is called a stepwise technique. Of the four public high schools offering biology as an elective in the Gomoa East Education District, one high school was specifically selected to participate in the study because it was the only one with a computer laboratory with enough computers to support the computer-assisted instructional approach. One other school was chosen randomly from the remaining three using computer-generated random numbers. This was done to ensure that all the schools had an equal chance of being chosen for the study. Two intact elective biology classes were randomly chosen from the schools used for the study. This was done through simple random selection using computer-generated random numbers. The treatment and control groups were then randomly assigned to the classrooms. The study participants included 78 second-year students in the chosen biology classrooms.

2.4 Instrumentation

The instruments used to gather data were an achievement test designed as P1 and P2 (pretest and posttest) on students' comprehension of concepts in cellular respiration. The posttest and pretest questions were created using the biology syllabus, table of specifications, and instructional objectives on cellular respiration. This acts as a guide for developing valuable and trustworthy items to meet the researcher's objectives or to serve the intended purpose. The pretest and posttest consisted of twenty (20) multiple-choice items with four alternative options (A-D). The goal of the pretest was to assess students' prior knowledge of cellular respiration and the homogeneity of the study groups. After the intervention, all the participants were given a posttest to ascertain their performance or achievement in the concept. For content validity, the pretest-posttest items were created based on the West Africa Examination Council's biology syllabus and instructional objectives. The items were then given to two other

experienced biology tutors from senior high school, all senior biology examiners, for assessment and input.

The items were pilot-tested to obtain the final version of the instruments used for collecting the data based on the inputs of the two biology teachers. The instruments were administered to students in a school in the Gomoa West Educational District of the Central region of Ghana. Thus, the district had a similar characteristic to those selected for the main study. The pilot testing of the instruments facilitated the determination of their validity and reliability. Hence, the main study did not use the Gomoa West educational district. The KR-20 formula was then used to estimate the reliability of the test items because they were dichotomously scored (right or wrong) [15]. The reliability coefficients for the pretest and posttest were 0.70 and 0.72, respectively. According to Ampiah [17], these values surpassed the reliability coefficient threshold of 0.60, which is acceptable for research purposes.

2.5 Data Collection Procedure

2.5.1 Pre-intervention

A pretest was performed in both classes based on respiration. A pretest was conducted to determine whether the experimental and control groups performed comparably. The pre-and post-test consisted of 20 items with multiple-choice options, including options A through D. These multiple-choice questions were intended to determine students' academic performance before and after the intervention. To ensure the adequacy of the content, a specification table was used to develop pretest-posttests based on the specific objectives of the lesson plan. Two senior biology instructors also reviewed exam items. Item confidence was calculated using Kuder-Richardson 20, as items were rated dichotomously and had a confidence coefficient of 0.70. In addition, researchers used pretest results to compare with posttest results.

2.5.2 Intervention stage

In the intervention phase, glycolysis and the Krebs cycle were taught in one class using computer-based teaching methods and in the other class using conventional teaching methods. CAI lessons were developed using Microsoft PowerPoint 2017 and other applications such as graphics, text, animations, and hyperlinks. His two lessons of the conventional approach and his CAI were designed. The computer tutorial format emulates a conversation between a student and a computer. Concepts are presented based on the student's response to the question, allowing the student to move on to the next concept or review the material learned by Kausar, Choudhry, and Gujjar [18]. Lesson plans for traditional teaching methods were also developed using lectures, discussions, and occasional question-and-answer sessions. The course, including exams, lasted him two weeks.

2.5.3 Post-intervention stage

Posttests were administered in two classes, and results were recorded. Both groups had the same content but different teaching methods. Controls were taught by a biology teacher using a conventional lesson plan, while the experimental group was taught computers at their own pace using a computer lesson plan.

2.6 Data Analysis

The t-test was used to analyze the pretest and post-test results. Statistically, the assumptions underlying the t-test were met. Histograms and standard Q-Q plots of the items before and after the test show the normal distribution of the data. The Kolmogorov-Smirnov normality test also shows that the data were generally distributed using sig. The pretest and posttest values are 0.91 and 0.28, respectively, which are greater than the significance confidence level of 0.05. Levine's test for equal variances for both the pretest and posttest return 0.661 and 0.063, respectively, which are more significant than 0.05. Therefore, the two groups had equal or uniform variances in this study. A t-test was used to determine whether the two groups had a statistically significant difference in study performance. A t-test was also used to determine whether there was a statistically significant difference between low- and low-performing students after the intervention.

3. RESULTS AND DISCUSSION

3.1. Results

Table 1. Results of independent-sample t-tests for pre-and post-test results for experimental and control groups

Groups		N	Mean	P-value
Pretest scores of the groups	Control	38	52.11	.001
	Experimental	42	40.95	
Posttest scores of the groups	Control	38	66.18	.000
	Experimental	42	57.26	

Significance *P < 0.05.

The first null hypothesis states that there was no significant difference in the post-test results between the control and experimental groups at the significance level of 0.05. Table 1 shows a statistically significant difference in pre-test scores for both groups, indicating that students did not perform at the same level before the intervention. There was also a statistically significant difference in academic performance according to test scores between the experimental and control groups. Therefore, the null hypothesis was rejected at the 0.05 level. The experimental group (CAI) performed poorly on the posttest, with a mean score of 57.26 Compared with the conventional group, mean of 66.18, P value <1.000 (<0.05).

The results of paired sample t-test on students' pretest and posttest of the experimental group are represented in table w below.

Table 2. Results of pretest and posttest paired sample t-tests for students in the experimental group

Groups		N	Mean	P-value
Pretest	Experimental group	42	40.95	.000
Posttest	Experimental Group	42	57.26	

Significance *P < 0.05.

A second research question aims to determine whether computer-assisted teaching affects student performance. Table 2 shows that CAI had a significant impact on student academic performance. Student performance on the posttest after CAI instruction was significantly increased, with a mean of 57.26 p-values of 0.000, compared to performance on the pre-intervention pretest of 40.95. This indicates that CAI has the potential to improve academic performance in biology students.

Table 3. Results of independent-samples t-tests for pre-and posttests of low- and high-performing students in the experimental group

Groups		N	Mean	P-value
Pretest	Low achievers	25	31.60	.000
	High achievers	17	53.82	
Posttest	Low achievers	25	55.60	.293
	High achievers	17	58.53	

Significance *P < 0.05.

Independent t-tests are used to answer research questions that determine whether there is a significant difference in post-test scores between low-performing and high-performing students. We analyzed the scores before and after. Table 3 shows a statistically significant difference in the performance of students who perform well and those who do poorly on the pretest. High-performing students on the pretest had a mean score of 53.82 p-values of 0.000, significantly higher than the low-performing students' mean of 31.60. However, the two groups found no statistically significant difference in the post-test results. After being taught concepts using the CAI, the poor performers' performance improved dramatically in post-test results, averaging 55.60. This indicates that CAI is more effective in low-performing students, but there was no statistically significant difference between low- and low-performing students when taught at a CAI of 0.05.

3.2. Discussion

The results of this study showed that students taught with traditional teaching approaches outperformed those in computer-based teaching groups. This finding is similar to previous work by Owusu, Monney, Appiah, and Wilmot [13], Conventional approaches to improve student academic performance in biology are more effective than computer-based instruction. However, the results of this study suggest that CAI may improve student academic performance in cellular respiration. Indicates that there is Moos and Marroquin [9] that Computer-Assisted Instruction Influences students' intrinsic and extrinsic motivation to help them achieve life goals and self-efficacy and improve academic success.

This study also showed that using computer-based instruction to teach students improved the performance of underperforming students and that both groups performed better at the end of class. Compared to other results, this study is inconsistent [12], [19], [20]; CAI is more successful in teaching high-performing students than low-performing students. While the conventional approach group performs better than her CAI group, the underperforming students in the CAI group perform significantly better when taught using

CAI. Therefore, this suggests that CAI may help poorly performing students improve their academic performance in biology.

4. CONCLUSION

From the results of this study, it can be concluded that CAI is less effective than traditional methods. However, CAI has been shown to have the potential to improve academic performance in students who perform poorly in the classroom. In addition, it can be concluded that CAI positively impacts student performance as it can stimulate and stimulate interest and excitement in students.

5. IMPLICATION FOR TEACHING BIOLOGY

The introduction of ICT in primary and secondary schools in Ghana's education system should be reformed to teach ICT as a subject and include ICT as a teaching method in the biology curriculum. Nevertheless, ICT should complement traditional educational approaches rather than take over the educational process because this study shows that the traditional approach to biology education is perfect.

6. RECOMMENDATION

Because this study only used two schools, we recommend conducting a similar study in at least five different schools. Once completed, the effectiveness of these educational approaches can be assessed appropriately.

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