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Effect of Computer-Assisted Instruction on Students' Performance in Selected Cell Division Topics: A Quasi-Experimental Study at Adisadel College, Ghana

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Abstract

This quasi-experimental study explored the effectiveness of CAI in a Biology classroom at Adisadel College in Ghana. The study participants were 80 second-year Biology students who were conveniently sampled from the Green Track and the Gold Track of students in the school. The experimental group consisted of 40 students and was engaged in using CAI for five consecutive weeks. The students in the control group were taught by the conventional method. Students in both groups were exposed to the same content for the same period. The same pre-test and post-test were conducted on both groups, and the responses were analyzed using a t-test. A 10-item Likert-scale questionnaire was administered to the experimental group after the treatment to assess the impact of the CAI on their learning. The study's findings revealed that students exposed to CAI performed significantly better than their counterparts taught with conventional instruction. The students also support the use of CAI in their classrooms. The Physics Education Technology (PhET) simulations used during the study improved students' understanding of the concepts and thus reflected in their performance in the post-test. Science teachers are encouraged to employ PhET simulations in their teaching.

Keywords: computer-assisted instruction, simulation, performance, concepts, quasi-experimental study, Adisadel college, Ghana.

1. Introduction

Computer Assisted Instruction (CAI) has proven to be very effective in the teaching and learning process in many classrooms. However, not much can be said about its effectiveness in the Biology classroom in Ghana. This is evidenced in a study conducted by Owusu et al. (2010) in two senior high schools in Ghana. They investigated the comparative effectiveness of CAI and conventional teaching method in Biology on students in two different senior high schools in Ghana. Findings reported by the authors show that students in the conventional or traditional classroom outperform their counterparts who were taught with CAI. This finding contrasts with results from studies conducted in different fields and geographical areas (Yakubu et al., 2022; Ahiatrogah et al., 2013). Evidence from numerous studies in other countries has shown that using CAI can improve students' performance in the classroom. For example, in their study conducted in Nigeria, Mudasiru and Adedeji (2010) reported a significant difference in performance between students exposed to CAI and their counterparts in the conventional classroom. According to Mudasiru and

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Adedeji, the students exposed to CAI either individually or cooperatively performed much better than those in the conventional classroom. Akour (2008), in a similar study about the effects of CAI on Jordanian college students' achievements in an introductory computer science course, found that students who were taught by the conventional instruction method combined with CAI performed better than those taught using only the conventional method of instruction.

According to Collier (2004), instruction supplemented by a properly designed CAI is more effective than instruction without CAI. The use of CAI helps build in students a knowledge capacity (Kareem, 2015). Thus, the integration of CAI in teaching proves to be very useful in teaching various subjects. CAI has emerged as an effective and efficient media of instruction (Nazimuddin, 2015). Simulations allow learners to observe real world experience and understand complex concepts properly (Widiyatmoko, 2018). The use of CAI proves to be significant compared to the classroom lecture method in terms of achievement in knowledge (Kausar et al., 2008).

Grounded on the findings reported in the studies mentioned previously, the authors decided to explore the effectiveness of using CAI in a senior high school Biology classroom in Ghana. Unlike the study by Owusu et al. (2010), the current study used two different classes of students from the same school. Owusu et al. used two other classes of students from two different schools. The conditions at both schools might have been different, which could have affected their study outcome. Therefore, the authors employed CAI and conventional methods to teach two groups of second-year students at Adisadel College in Ghana some topics in cell division.

Hypotheses

H_o1. There is no significant difference in the mean pre-test scores of the experimental and control groups.

H_o2. There is no significant difference in the mean pre-test and post-test scores of the experimental group.

H_o3. There is no significant difference in the mean post-test scores of the experimental and control groups.

2. Materials and methods

The study employed the quasi-experimental research design. Shuttleworth (2008) stated that quasi-experimental research design involves selecting groups upon which a variable is tested without random pre-selection processes. Quasi-experimental research design aims to demonstrate the causal effect between an intervention and an outcome. Quasi-experimental research design generates results faster and is at a lower cost than a true-experimental design (Sarfo et al., 2022). A quasi-experimental design was chosen over an experimental design because the school's curriculum by the Ghana Education Service could not permit adequate and uninterrupted experimental study. According to McMillan and Schumacher (2010), nonequivalent groups of pre-test-post-test control or comparison group design are very prevalent and useful in education because it is often impossible to assign subjects randomly. Also, in quasi-experimental, the researcher uses intact, already established groups of subjects, gives a pre-test, administers the intervention condition to one group, and provides the post-test.

The sample for the study was 80 second-year Biology students of Adisadel College, Cape Coast. The participants were categorized into two groups: 40 students from the Gold Track as the control group and 40 from the Green Track as the experimental group. The second-year students from Gold Track and Green Track were selected for the study because students from both tracks share similar characteristics. The co-author is a staff of the school and the Biology teacher of the two classes. The students were selected using a convenient sampling technique. Both classes were present in the school as the Ghana Education Service calendar for senior high schools demanded. Two tests of the comparable standard were used to collect quantitative data from the experimental and control groups. The pre-test and the post-test were conducted based on the concept of cell division. The pre-test was administered a week before the treatment. The pre-test was used to find out the strength and weaknesses of the students' level of understanding of cell division and also to review students' previous knowledge of cell division. The post-test was administered after the treatment. The pre-test and post-test of the nonequivalent group design were used to collect data to find out if there was any significant difference in academic achievement between the control and experimental groups. At the end of the treatment, a 10-item Likert-scale questionnaire was administered to the students in the experimental group. This was done to find out from students

whether the treatment had an impact on their learning. Their responses were analyzed into simple frequencies, percentages and mean score and standard deviation of each item calculated.

Treatment

The intervention was implemented for five weeks in the first semester of the 2019/2020 academic year. The experimental group (Green Track) were instructed using CAI, and the control group (Gold Track) were instructed using the conventional instruction method. Students in both groups were exposed to the same content for the same period. The experimental group was treated as described weekly below.

Week 1: The lesson began with a revision of students' previous knowledge of concepts associated with cell division. The concepts discussed were karyokinesis, cytokinesis, haploid, diploid, germ cell, somatic cell, chromosome, chromosome number, chromatid, centromere, centriole, and kinetochore.

Week 2: The downloaded Physics Education Technology (PhET) simulations were projected on a screen in the classroom for students to observe the processes that occur in the interphase stage of cell division and the main stages involved in mitosis. The main stages of mitosis are the prophase, metaphase, anaphase, and telophase.

Week 3: Students were taken through the meaning of meiosis. Simulations were projected on a screen in the classroom for students to observe the stages and processes involved in the first phase of meiosis. The stages are prophase I, metaphase I, anaphase I, and telophase I.

Week 4: Students were taught the main stages and processes involved in the second phase of meiosis with simulations. The stages are prophase II, metaphase II, anaphase II, and telophase II.

Week 5: Students were taught the importance of mitosis and meiosis, including the main differences between mitosis and meiosis.

The control group were taught the concept of cell division using the conventional instruction method of teaching and learning. The lecture method, discussion, demonstration, and brainstorming were the instructional methods employed for the study period. Students in the control group were taken through the same topics as was done to their counterparts in the experimental group.

3. Results and discussion

Independent sample t-test statistics were used for both pre-test and post-test for the two groups and to test the null hypotheses at a significant level of 0.05. Table 1 shows the t-test analysis of the pre-test scores of the control and experimental groups. The table shows that the control group's mean score is slightly higher than that of the experimental group. However, there is no significant difference in the mean scores of the two groups at a significant level of 5 % ($t = 0.11$; $p > 0.05$). This indicates that there was no significant difference in the performance between the two groups at the onset of the study.

Table 1. T-test Analysis of Pre-test Scores of Control and Experimental Groups

Group	Test	N	Mean	SD	df	t-value	p-value
Control	Pre-test	40	11.10	1.84	78	0.11	0.91
Expt.	Pre-test	40	11.05	2.40			

Table 2. T-test Analysis of Pre-test and Post-test Scores of Experimental Group

Group	Test	N	Mean	SD	df	t-value	p-value
Expt.	Pre-test	40	11.05	2.40	39	23.02	0.00
Expt.	Post-test	40	17.05	1.52			

Table 2 shows the t-test analysis of the pre-test and post-test scores of the experimental group. According to the Table, the mean score of the post-test is higher than that of the pre-test. This indicates a significant difference between the two means at a significant level of 5 % (t = 23.02; p< 0.05). This finding shows that CAI had a positive effect on the academic performance of the experimental group.

Table 3 shows the t-test analysis of the post-test scores of the control and experimental groups. From the table, the mean score of the experimental group is higher than that of the control group. The analysis revealed a significant difference between the two means at a significant level of 5 % (t = 6.82; p < 0.05). The experimental group performed better in the post-test than the control group. Thus, the post-test showed the CAI helped students learn to understand.

Table 3. T-test Analysis of Post-test Scores of Control and Experimental Groups

Group	Test	N	Mean	SD	df	*t-value*	p-value
Control	Post-test	40	14.50	1.81	78	6.82	0.00
Expt.	Post-test	40	17.05	1.52			

Students' Perceptions of CAI

Concerning students' perceptions about CAI after being exposed to computer simulations during lessons on cell division, a 10-item questionnaire was administered to the students in the experimental group. The items were measured using a 5-point Likert-type scale which ranged from Strongly Agree = 5, Agree = 4, Uncertain = 3, Disagree = 2 to Strongly Disagree = 1. Students' responses were analyzed by calculating each item's mean and standard deviation. The result from the analyses is presented in Table 4.

Table 4. Students' Perceptions of the Use of CAI

Item	**Strongly agree F (%)**	**Agree F (%)**	**Uncertain F (%)**	**Disagree F (%)**	**Strongly disagree F (%)**	**Mean**	**SD**
CAI enhanced my critical thinking skills	15 (37.5)	20 (50.0)	2 (5.0)	3 (7.5)	0 (0.0)	4.20	0.70
I think CAI improves the quality of instruction	17 (42.5)	19 (47.5)	3 (7.5)	1 (2.5)	0 (0.0)	4.30	0.52
CAI enabled me to be more active during lessons	12 (30.0)	23 (57.5)	3 (7.5)	1 (2.5)	1 (2.5)	4.10	0.74
CAI made me understand the cell division	16 (40.0)	22 (55.0)	0 (0.0)	2 (5.0)	0 (0.0)	4.30	0.52
CAI enabled me to improve my performance	16 (40.0)	20 (50.0)	3 (7.5)	1 (2.5)	0 (0.0)	4.28	0.65
CAI aroused my interest in cell division	20 (50.0)	18 (45.0)	0 (0.0)	2 (5.0)	0 (0.0)	4.40	0.55

I think other science teachers must use CAI	17 (42.5)	21 (52.5)	2 (5.0)	0 (0.0)	0 (0.0)	4.40	0.54
CAI made cell division more practical for me	20 (50.0)	15 (37.5)	2 (5.0)	3 (7.5)	0 (0.0)	4.43	0.78
I learned new computer skills with CAI	14 (35.0)	24 (60.0)	0 (0.0)	1 (2.5)	1 (2.5)	4.23	0.63
CAI enabled me to retain more information	17 (42.5)	18 (45.0)	2 (5.0)	3 (7.5)	0 (0.0)	4.43	0.80

Data clearly shows that most students support using CAI because of the enormous benefits they gain when it is used. About 87.5 % of students declared that CAI enhanced their critical thinking skills and enabled them to be more active during lessons. Almost 90 % of the students think CAI improves the quality of instructions and enables them to improve their performance. Nearly 95 % of the students believed that CAI aroused their interest in learning cell division and enabled them to understand the concept. About 87.5 % of students opined that CAI made cell division more practical and enabled them to retain more information. Approximately 95 % of the students believed that they learned new computer skills with CAI and thought other science teachers in the school must use CAI.

The extent to which the performance of the experimental and control groups differed concerning cell division before the treatment was nil. According to Table 1, the t-test analysis of the mean pre-test score shows no significant difference ($t=0.11$; $p>0.05$). This indicated that the two groups were comparable in their initial understanding of cell division. The sample was drawn from a student population similar in academic achievement before the treatment. Table 2 shows the t-test analysis of the experimental group's mean pre-test and post-test scores, indicating significant differences ($t = 23.02$; $p < 0.05$). This was a result of the exposure of the experimental group to CAI. The findings of this study also confirm that of Widiyatmoko (2018), who revealed that simulations allow learners to observe real-world experiences and understand difficult science concepts properly.

The performance of students exposed to computer-assisted instruction differs significantly from their counterparts taught with conventional instruction. According to Table 3, the t-test analysis of the mean pre-test and post-test scores shows a significant difference ($t = 6.82$; $p < 0.05$). The experimental group performed better than the control group in the post-test. This indicates that when students are taught using CAI, they perform better than the conventional method of instruction. This study finding is inconsistent with that of Owusu et al. 2010 but consistent with the results of Akour (2008). Akour reported that students taught by the conventional method combined with CAI performed significantly better than those taught using only the conventional method. The result is also in line with Mudasiru and Adedeji (2010) findings. They reported in their study that students exposed to CAI either individually or cooperatively performed significantly better than students taught with conventional instruction. The study also sought to find out from students the impact of CAI on their learning of cell division. Data from Table 4 indicates impressive responses from students. This indicates a high level of agreement about using CAI in teaching and learning cell division.

4. Conclusion

The study explored the effectiveness of using CAI in a Biology classroom at Adisadel College in Ghana. This study's findings indicated that students exposed to Computer-Assisted Instruction (CAI) performed significantly better than their counterparts taught using the conventional instruction method. The findings of this study also showed that the integration of PhET simulations in teaching and learning cell division positively impacted the experimental group. Thus, students understood the processes involved in mitosis and meiosis very well.

5. Recommendations

The interactive nature of PhET simulations positively impacts students' performance. Therefore, science teachers must be encouraged to use simulations in their lessons. Computer-assisted instruction should be used to teach science concepts that are abstract and difficult to understand. The computer-assisted instruction can transform students from passive learners to active learners.

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7. Declaration of Competing Interest

The authors of this study declare that there is no interest in conflict, and all reference materials were dully acknowledged.

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