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Impacts of Computer-Assisted Instructions on Students' Academic Performance of Biology within Secondary Schools

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Abstract

Computer-assisted instructions (CAI) not only motivate students to learn but also enable learners to learn by interacting with instructional tools that allow learners to react the way they would react in real situations. This study sought to investigate the impact of computer-assisted instruction on learners' achievement of biology with a focus on cell division topics. The study adopted a quasi-experimental design. The population of this study was all upper secondary students that have Biology in their learning subjects within the Nyagatare district. To get a sample, researchers purposively selected three schools on the condition that they are equipped with smart classrooms having connected computers. The researchers took one class at each school. Thus, we got a total of ninety (90) senior five learners. The researchers split these learners into two groups composed of 45 learners in the experimental group, and 45 students in the control group. Learners in the experimental group were subjected to computer-assisted instructions while learners in the control group went through the traditional lecturing instructions. To collect data, a biology performance test (BPT) was used. The reliability coefficient (Cronbach's coefficient Alpha) calculated for the instrument was 0.704. Pre and post-tests were given to all students in both groups. We used the inferential statistics t-test to analyze the data. The results showed [t (88) = -6.640, p = .000; p<.05] indicating that there is a statistically significant difference in mean scores between groups. The findings from the study allowed us to conclude that computer-assisted instruction enhances students' performance in biology, especially in cell division. Therefore, we recommend the integration of computer-assisted instructions into teaching and learning to enhance learners' performance in biology.

Keywords: Biology, cell division, computer-assisted instructions, impact, learners' performance

1. Introduction

Biology is a science subject that significantly contributes to the scientific and economic development of countries (Contributions, Science, & National, 2008). Biology is considered as a fundamental and central science in different working areas such as in medicine, pharmacy, biochemistry, engineering, microbiology, textile industry, agriculture, and in petroleum (Tang & Zhao, 2009). With this regard, Wibowo & Sadikin (2019) suggested that Biology education should remain on the global scientific agenda. Hence, countries emphasized biology curricular reform for quality education. For instance, in Rwanda, the biology syllabus was reviewed to make a shift from knowledge-based learning to competency-based learning ensuring also the necessary Information and Communication Technology (ICT) skills and competencies that a learner needs to acquire the required knowledge (Nsengimana, 2021). To this end, great effort was put into ICT integration. This is explained by the different facts such as smart classroom facilities provision in schools with STEM subjects by equipping them with computers and other STEM-related facilities. ICT uses help learners to enter fully into the lesson which also improve their understanding of the biological concepts by using different animated colored videos Wekesa and Amadalo (2013)

Ineffective teaching methods and insufficient instructional resources are most problematic for effective and successful biology teaching and learning. Studies confirmed different innovative instructional methods for teaching biology, among others. They include computer-assisted instruction (CAI) (Mihindo, Wachanga, & Anditi, 2017). Computer-assisted instruction is an approach that recorded the statistical evidence that learners retain more information by doing and observing phenomena rather than just reading hard copies or listening to the teachers (Basturk, 2005). Thus, the CAI is a potential tool that can help also in teaching and learning cell division.

Some topics in biology like cell division, respiration, molecular biology, photosynthesis and deoxyribonucleic acid (DNA) replication were declared by Biology teachers to be difficult topics in Biology (Endoscopy, 1999). Most especially, many teachers reported that the cell division topic is one of the most difficult topics in biology (Chattopadhyay, 2012). The learning difficulties encountered by Rwandan science students have been attributed to different factors such as lack of effective teaching methods and learning approaches focusing on memorization of abstract concepts (Musengimana, Kampire, & Ntawiha, 2021). Some of challenges encountered by students in cell division classrooms were linked to the ineffective teaching and learning methods. In this context, students were taught this concept and asked by teachers to only reproduce or recall abstract concepts that they have memorized (Ozcan, Yildirim, & Ozgur, 2012a). In addition, the student's failure in cell division was found to result from inadequate teaching methods and unqualified teachers with low learner-centered implementation skills (Zeki & Güneyli, 2014).

Thus, the CAI is viewed as an effective teaching and learning method to be used while teaching and learning cell division, since this method recorded the statistical pieces of evidence asserting that learners retain more information by interacting with the computer rather than by just reading or listening to the instructor (Basturk, 2005). Through CAI, learners are not only encouraged by using ICT tools like computers, but they also learn by interacting with computer software like the way they would react in real situations (Noushad, 2010). Through CAI, students understand and are able to describe the phenomenon, master the way they can control them, and they are aware of the right reaction they can come up with when facing the different situations. CAIs are the controlled representations of real-world phenomena (Noushad, 2010). These instructional methods are used when real-world experiences are either unavailable or undesirable displayed in a multimedia manner. Thus, the CAI used in this study is multimedia instruction to effectively teach cell division in secondary school where multimedia computer-assisted instructions are presented as animation, videos, and static pictures or photos (Mayer & Moreno, 2002). The researcher investigated the impacts of computer-assisted instructions on students' academic performance within secondary schools of Nyagatare district since this learning method is newly introduced in this district compared to the traditional lecture teaching method which was already used. Therefore, to achieve the objective of the study the following research questions were formulated.

1). Is there any statistical variation in post-test average scores between students taught cell division by using computer-assisted instruction and those learned through lecture traditional

teaching methods?

2). Is there any statistical variation effect of traditional lecture teaching methods and computer-assisted instructions on students' performance in cell division?

2. Research Problem

Instructional methods that require students to memorize the concepts cause misconceptions and a lack of understanding about cell division (Ozcan, Yildirim, & Ozgur, 2012). With this regard, it is difficult to reduce students' misconceptions when traditional teaching methods are applied alone during the instruction process cell division (Elangovan & Ismail, 2013).

In the Rwandan context, cell division is one of the biology concepts that students learn from senior five of secondary school in Rwanda (REB, 2019). However, students' poor performance in the biology national examination was noticed whereby learners fail to answer questions provided on the cell division concepts (Bizimana, Mutangana, & Mwesigye, 2022). Although different methods were employed to increase student's performance in subject of biology, still, learners have big problem in comprehending biology abstract concept and are confused with the terms and processes related to the cell division (Ozcan, Yildirim, & Ozgur, 2012c). Studies that investigated the effect of CAI on students' performance in biology, focused on other biology concepts rather than cell division (Elangovan & Ismail, 2014; Kareem (2018). Besides, a scarcity of studies that tested the effect of CAI on Rwandan students' performance in biology was released in literature. Therefore, the presents study fills in the gap by testing the impact that computer-assisted instruction has on Rwandan secondary school learners' achievement in biology.

3. Literature Review

For decades, different studies have been conducted to the impact of computer-assisted instruction on learners' performance in different learning subjects (Adams & Onwadi, 2020; Elangovan & Ismail, 2014; Julius, Twoli, & Maundu, 2018).

The computer assisted instruction (CAI) utilize computers to facilitate in the transfer content in instruction activities, therefore, the content is kept in the computer and made accessible for the students that can be used in instruction activities through the computer-assisted instructions. CAI has a significant important to the learners since it provide a quick self-managed learning opportunity that empowers students to learn new content compared to traditional teaching strategy (Usun, 2003).

Computer-assisted instructions are the one education method that helps students understand abstract concepts in an assimilated concrete manner (Nur et al., 2006). In general, computer-assisted instructions reproduce some aspects of the real-world situations. It makes abstract concepts become visible phenomena easy to understand, even when they are not visible in natural settings. Computer-assisted instructions are used in teaching and learning activities to support students of different visual, auditory, and kinesthetic (Laurillard, 2002). Computer-assisted instructions help in playing videos, animations, pictures, or photos designed to convey a realistic experience. It is also an instruction lesson that provide the

chance to learn the reality of surrounding habitat and critical thinking skills (Landon-Hays, Peterson-Ahmad, & Frazier, 2020).

While Elangovan and Ismail (2014) discussing the educational advantages of computer-assisted instructions (CAI), authors used a quasi-experimental study design to compare the results of learners involved in study entitled introductory statistics subject that incorporated CAI to participants versus a lecture introductory in a statistics subject by using traditional teaching method. The pre and posttest marks described that the learners taught by utilizing CAI performed acquired higher means scores on the posttest marks than learners taught by using the lecture traditional method group only. On the other hand, Julius, Twoli and Maundu (2018) investigated the effects of CAI on the presentation of technical college students. The instruments used were tested by using statistical analysis measures and the analysis of variance (ANOVA) and they found that CAI had positive impact to the academic performance.

Adams and Onwadi (2020) tested the effect of CAI on junior helper school understudies' performance. The mean scores and inferential statistic tests like analysis of covariance (ANCOVA) were utilized at an α=0.05. The findings showed that CAI is a technique upgrading students' higher performance than a regular way. Within the same line, Yusuf (2010) did an investigation on impact of computer-based instruction in optional school understudies' presentation in biology with a sample size of 120 senior one (S1) students. By using 3 x 2 factorial models, the results analysis showed that learners' achievement of the students that went through the CAI achieved higher than their counterparts exposed to the traditional lecture teaching method.

The research conducted by (Yusuf & Afolabi, 2010) on the effect of CAI on students' performance on secondary school students' performance in biology, the results revealed that the performance of students exposed to CAI either individually or cooperatively were better compared to the traditional method. This was also supported by the study conducted by (Khan, 2019) found students use CAI in circulatory system perform better than students that use conventional method, in addition CAI helps teachers to organize meaningful teaching learning experiences and thereby motivates them to adopt more innovative methods and approaches in their teaching. The investigation on impact of computer-assisted instruction (CAI) on learners' achievement in biology subject of secondary school in Ghana showed that learners that were delivered teaching by CAI accomplished better than those who are being learned by traditional lecture teaching approach (Palacio, Negret, Velásquez-Tibatá, & Jacobson, 2017). The use of computer-assisted instruction in instruction activities will help students to understand the process of cell division clearly through visualization and repetition of scenarios (Pribicevic, 2013).

Concerning to Wekesa and Amadalo (2013), CAIs would show us how the cell division process will take place by using different animated colored videos, which will help learners to enter fully into the lesson which also improves their understanding of the biological concepts, especially in cell division topic.

4. Theoretical Underpinnings

This study was underpinned by the cognitive learning theory that deals with the learners to recall and be able to apply what they have acquired. This theory deals with structuring, organizing and sequencing information in the mind to facilitate optimal processing and processes explaining the network of oral and visual demonstrations (Ibrahim, 2011). Based on this theory, human cognition deals with oral and nonverbal contents and events since there is a referential connection linking the verbal and nonverbal clues (Ibrahim, 2011; Mayer & Moreno, 2002). The content delivered by using verbal and visual presentation reinforced the learners to remember and apply their knowledge (Wigham, 2012).

This theory is fitting in this study, since the use of CAI in the teaching and learning of cell division, learners interact with computer devices through the provision of audio contents, videos, photos, texts, and animations. In addition, CAI provides a wider range of learning process and tasks within the concept which also gives learners with the choice to collaborate more overtly among instructional materials and therefore, generate more active processing of information (Mihindo, Wachanga, & Anditi, 2017).

5. Methodology

5.1 Research Design

This study used a quasi-experimental design aiming at explaining and explaining the variation of information under conditions that are hypothesized (Cohen et al., 2007; Cresswell, 2014). Thus, this study used pre-and post-test to measure the impact of computer-assisted instructions on senior five students' performance in cell division.

5.2 Population and Sampling

During sampling, researchers purposively selected three secondary schools on the condition that these schools have smart classrooms and are well equipped with computer labs. Since the topic of cell division is taught for senior five students, the researchers used the senior five classes. The target population of this study was all upper secondary students that have Biology in their learning subjects within Nyagatare district. To get sample, we purposively selected three schools on condition that they are equipped with smart classrooms having connected computers. We took one class at each school. Thus, we got a total of ninety (90) senior five learners. We spilt these learners into two groups composed of 45 learners in the experimental group, and 45 students in the control group. All the so-called investigational groups were learned through computer-assisted instructions, while those in the control group, experienced traditional lecture teaching methods.

5.3 Instruments

Self-constructed biology tests were utilized to examine students' familiarity of subject and their performance in biology for the topic of cell division for both learners within the investigational and control group. The content of the test was about mitosis and meiosis. Thus, closed-ended questions (multiple choice) consisting of 14 items were prepared, given to students, and scored at 20 marks. After the intervention of teaching the experimental group

through CAI during a period of a month, the same test was given as a post-test to both students in the experimental and control group.

5.4 Validity and Reliability

For the instrument validity and reliability, two experts in biology education and two others in measurement and valuation validated the instrument before its use. This was done to ensure the content and face validity of the test. The test items engendered were compared with the same group of experts to confirm their appropriateness in terms of suitability of language and relevance for the level of the learners. A final instrument to use was thus created. Besides, the research instrument was measured and calculated for reliability by utilizing a test-retest method. Thus, Cronbach's coefficient alpha determined how items correlate each other to provide a measure of the internal consistency of test items. The Cronbach's coefficient alpha is expressed as a number between 0 and 1(Tavakol & Dennick, 2011).

While conducting test-retest, the data obtained through a re-administration of the instrument after two weeks were correlated with the data obtained earlier using the Pearson product-moment correlation method. The criteria of Cronbach's alpha coefficient for establishing the internal reliability is categorized as follows: Excellent ($\alpha>0.9$), Good ($0.7<\alpha<0.9$), Acceptable ($0.6<\alpha<0.7$), Poor ($0.5<\alpha<0.6$), Unacceptable ($\alpha<0.5$). The Pearson product-moment correlation is symbolized by the letter r. $r = \frac{N\sum XY-(\sum X)(\sum Y)}{\sqrt{[N\sum X^2-(\sum X)^2][N\sum Y^2-(\sum Y)^2]}}$

where N stands for a number of respondents, X is the first administration of test scores, and Y is the second administration retest scores. The reliability coefficient calculated for this study's instruments was 0.704, which is a good coefficient. This ensured that the instruments are worthy to collect reliable data.

5.5 *Ethical Considerations*

Before data collection, the researchers obtained a recommendation letter to conduct this study, from the University of Rwanda, College of Education (UR-CE). Afterward, we received a research approval letter from the Nyagatare district to research within the district. This letter was presented to the school head teachers to collect data within schools. The participants of this study have explained the purpose of the study and then, given a consent form to sign for their acceptance to participate voluntarily in the study.

5.6 Statistical Treatment of Data

Descriptive statistics was utilized to analyze the data of this study where the standard deviation and mean was involved and an inferential statistics utilized t-test to analyze data to reply research hypothesis and research question. T-test was utilized to examine the variation of two means scores and helped to confirm if there is a big variation for the control and experimental group or not. A t-test was used after ensuring that scores in pre-and post-test are normally distributed. The t-test was pre-determined at $\alpha=0.05$ significance level to reject or accept the null hypotheses that postulate equally or no-significant differences between the two groups. The data from the study were analyzed with the aid of the statistical package for

social sciences (SPSS) version 23.

6. Results Presentation

The results presentation and analysis is guided by research questions.

Q1: Is there any statistical variation in post-test average scores between students taught cell division by using computer-assisted instruction and those learned through lecture traditional teaching methods?

To measure the most effective approach between students learned cell division using lecture traditional teaching method and CAI method, a pre-test was administered as the researchers sought to establish how much knowledge the learners in control and those in the experimental group had on the topic of cell division before the intervention. Thus, students were given a pre-test. The results for the pre-test are presented in Table 1.

Table 1. Descriptive and inferential statistical analysis of the pre-test scores

	Group	N	Mean	Std. Deviation	T	Df	*Sig. (2-tailed)*
Pre-test Score	Experimental	45	8.8889	2.20765	-0.086	88	0.931
	Control	45	8.8444	2.65395			

T-value significant at $p < 0.05$.

The results in Table 1 show the achievement of the experimental group and control group previous to the discussion is administered. The results in Table 1 presented the pre-test mean scores of control group (C) and experimental group (E), with, [t (88) = -0.086, p = 0.931; p>.05 informing that in the pretest, the mean scores are not statistically variation. This indicates that the two groups had comparably nearby means scores. It means that students are with similar understanding and suitable characteristics for the study. Therefore, the academic performance in biology before the integration of CAI into teaching and learning was quite the same for both experimental and control groups.

Q2: **Is there any statistical variation effect of traditional lecture teaching methods and computer-assisted instructions on students' performance in cell division?**

The learners in the experimental group were taught by computer-assisted instructions, while those in the control group were taught by traditional lecture methods while learning cell division both during a period of one month. After instructions students in both groups were given a post-test to examine whether there is a statistical variation in students' achievement about cell division. The results from the control and experimental groups are shown in the following table (see Table 2).

Table 2. Descriptive and inferential statistical analysis of the post-test scores

	Group	N	Mean=$\bar{x}$	SD	t	Df	*Sig. (2-tailed)*
Post-test	Experimental	45	15.4667	2.63561	-6.640	88	.000*
	Control	45	11.6889	2.76011			

*T-value significant at $p < 0.05$.

The findings from Table 2 indicate that students in control and those in experimental groups performed differently with [t (88) = -6.640, p = .000; p<.05] indicating that the CAI method has a significant effect on learners' performance than the traditional lecture teaching method. Similarly, these findings explain that learners in the experimental group who went through computer-assisted instruction methods increased their performance level and understood more the concepts related to cell division topic.

Since the p-value was found to be .000 and was less than .05 significance level, we, therefore, reject the null hypothesis (H0) which states that there is no statistically high variation difference in post-test scores between learners learned cell division by utilizing computer-assisted instructions and those learned through traditional lecture teaching methods. Similarly, we reject the second null hypothesis (H1) which states that traditional lecturer teaching method and computer-assisted instruction have no statistically significant different effect on students' performance in cell division. This means that there is a statistically significant variation in learner academic performance when learned by utilizing computer-assisted instructions compared to those students learned with the traditional lecture teaching method. Thus, the result from the statistical analysis revealed that CAI significantly influences students' academic performance in learning biology, especially in cell division.

7. Discussion and Conclusion

The researchers investigated whether there is an impact of CAI on students' performance in learning biology. Our focus was put on the cell division topic. Although our sample size was not enough to generalize our findings, in addition to a limited intervention period of one month, we found that there is a big variation between learners who learn through CAI compared to those who learn using the traditional lecture teaching method.

This study did not deeply investigate whether the students' outperformance over the control group is linked and limited to the text, movie, aural, sound, cartoon, image, and collaborative content provided through computer use only. However, we argue that this performance is linked to other factors, such as students' curiosity which stimulate their interest to interact with the computer and learn, the quality of the content exposed to learners in the experimental group, and the learners' chance to repeat anytime and anywhere the content stored on the different electronic devices.

When students are exposed to ICT learning tools, they can easily interact with them (Ghavifekr & Rosdy, 2015). This is also supported by cognitive learning theory guiding this study, whereby students cooperate more overtly using tangible resources and therefore, making learners more participating in learning process (Mihindo, Wachanga, & Anditi, 2017). In addition, students are likely to capture and retain what was exposed to more than one sensory organ. The content prepared through CAI is much clearer than those prepared using hand, pen, and notebook. Furthermore, showing videos is more helpful for a learner to assimilate the content than describing abstract scenarios.

In their study on applications and problems of computer-assisted education, Usun et al. (2006) showed that CAI was proved to move result-oriented than traditional instruction in the Turkish National Education System. When comparing CAI and traditional lecture teaching, CAI was found as more interesting; better to enhance students' understanding, and more motivating to produce higher learners' performance than traditional instruction alone. For instance, Özmen (2008) argued that teaching-learning of topics in chemistry related to chemical bonding can be improved by the use of computer-assisted teaching materials. The outcome from the study indicated that teaching-learning of chemical bond topic in chemistry can be made better by utilizing CAI method. Therefore, based on the findings, CAI may enhance the teaching and learning of science, thus, improves the students' performance in biology and chemistry subjects.

The findings are also in line with Serin's (2011), who carried out a study on the effects of computer-based instruction on the achievement and problem-solving skills of science and technology students. The consequence of his research showed that statistically rise in the achievement and finding solutions of the experimental group using CAI versus the control group that received traditional teaching method. In addition, Kareem (2018) argued that the use of multimedia in teaching biology impact positively on learners performance in biology. The content delivered through multimedia in which texts, audio visual content (movies), audios, cartoons, images, and interactive contents, are grasped better by students. Hence, multimedia is considered as a way of transmitting messages which entails various kinds of communication as also supported by cognitive learning theory (Mohamed Ibrahim, 2011).

Computer-assisted instruction is expected to be a useful approach for presenting visual features and concepts, hard to be grasped by students and engaging them to learn actively through observing and repeating much time the processes of cell division to deeply understand the concepts, leading to students' higher-order thinking ability development (Rogayan Jr., Padrique, & Costales, 2021). Computer-assisted instructions are easy to be accessed and free to use by anyone when a computer is available and connected. Using computer-assisted instruction in teaching and learning activities will help students to understand the process of cell division clearly through visualization and repetition of scenarios (Pribicevic, 2013). Thus, computer-assisted instruction will be one of the responsive tools that also promote active teaching and learning methods expected to help learners understand biology easily during the teaching and learning process. Therefore, it is concluded that computer-assisted instruction is expected to improve student performance in biology, especially in cell division topics.

In this study, our area of interest was investigating whether there is a difference in mean score on students' performance between students taught through the computer-assisted instructions and those taught through the traditional lecture teaching method in cell division topic, in biology subject. This study showed that the students' academic performance in biology before the integration of CAI into teaching and learning was quite the same for both students in experimental and control groups. However, the result from the statistical analysis revealed that CAI significantly influences students' academic performance in learning biology, especially in learning cell division.

8. Recommendations and Further Studies

Teachers are called to use CAI while learning Biology as this teaching approach is still at the early stage. Since this study was carried out only on senior five students, further study can be done on other educational levels to investigate the impact of computer-assisted instruction on learners' performance in biology.

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Conflict of Interest

Authors declare no conflict of interest

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