EFFECTS OF COMPUTER SIMULATION INSTRUCTIONAL STRATEGY ON BIOLOGY STUDENTS' ACADEMIC ACHIEVEMENT IN DNA REPLICATION AND TRANSCRIPTION

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ABSTRACT

This study investigated the effects of Computer Simulation Instructional Strategy on Biology Students' Academic Achievement in DNA replication and transcription. The effects on retention ability and gender were also examined. The pretest-posttest, post posttest, quasi-experimental control group design was used for the study. DNA Replication and Transcription Achievement Test (DRTAT) was developed and administered on fifty undergraduate 300 level Biology Education students from Ekiti State University (affiliated with Michael Otedola College of Primary Education, Epe) selected as the participants. The reliability coefficient of DRTAT was established at 0.70 using Kuder-Richardson (KR 20). Experimental group was taught using computer simulation instructional strategy while the control group was taught using lecture method. Null hypotheses were verified at $p \leq 0.05$ levels using t-tests. Result showed that there is a significant main effect of computer simulation on students' mean achievement score in DNA replication and transcription. There was also a significant effect on the retention ability of students but no significant effect on gender was observed. The computer simulation was effective in enhancing students' achievement scores and retention ability therefore, computer simulation is recommended as a means of teaching Undergraduate Biology students in Nigerian university other tertiary institution.

Keywords: DNA, Replication, Transcription, Computer Simulation, Lecture Method.

INTRODUCTION

Genetics is not only considered an important topic in biology education, but it has also become very relevant in everyday life. Genetic science is rapidly evolving, and the media inform us almost on a daily basis of new ideas and results in biological research with respect to genetics, for instance the Human Genome project. In our knowledge-base society, it is important that the majority of people have at least some knowledge and understanding of genetics. First and foremost it is up to scientists themselves to inform society in a clear and understandable way about the state of affairs in genetics research. Besides, schools play an important role in educating society (Knippels, 2002). The study of genetics can offer insights into the way the living world works. The impact of recent genetics research on medicine, food production, health and lifestyles is considerable and it can be argued that every citizen must have some understanding of the issues involved. However, any review of the literature about school and university students in learning genetics leads to the inescapable conclusion that students consider genetics difficult to learn and many misconceptions and misunderstandings can arise. Overall, genetics is an important theme for all learners but it is an area where there are major difficulties in understanding (Chu, 2008). Many students and teachers considered genetics as one of the most difficult topics (Bahar, Johnstone and Hansell, 1999; Knippel, Waarlo and Boersma, 2005). Other studies have shown that the difficulty of learning genetics is a common phenomenon, because the topic is abstract and the processes involved are not physically observable (for example cell division, fertilization, and germination). (Abimbola, 1998; Locke and McDermid, 2005; Richards and Ponder, 1996; Ruiyong, 2004; Turney, 1995). Much science education literature of the past two decades has dealt with learning and teaching genetics. The review study on genetics education identified five major difficulties: a) the domain-specific vocabulary and terminology, b) the mathematical content of Mendelian genetics tasks, c) the cytological processes, d) the abstract nature of the subject in the biology curriculum and e) the complex nature of genetics: a macro-micro problem (Knippels, 2002). The processes of DNA replication and transcription consist of a number of sequential steps together with some limitations imposed by the enzymes involved. Besides finding the sequences of events difficult to master, students find the significance and relationships of the different components of the processes very difficult (Fossey and Hancock, 2005).

Naturally, the complexity of these processes and their interrelation is often difficult for the novice student to understand. For example, students learn that an essential process such as RNA transcription involves RNA polymerase, but the fact that RNA polymerase itself is actually a multimeric protein complex is often not understood. Students also may not realize that RNA polymerase does not act alone, but rather that it is one component of the transcription process that involves several multiprotein complexes, and that each complex plays an essential role in the production of RNA (McClean, Johnson, Rogers, Daniels, Reber, Slator, Terpstra, and White, 2005). This one example exposes a shortcoming in curricular delivery: students struggle to visualize the complexities underlying the most essential molecular and cellular processes. A major challenge to biology educators is to teach these processes so that students can comprehend and understand their complexity. Because of this challenge, many instructors no longer simply lecture in class and assign readings from principal textbooks. Most are looking for new approaches that enhance student learning of biological processes. The use of visualization is significant among these approaches (McClean *et al*., 2005).

Student learning research has shown that visual perception is the most developed sense in humans and is an important way by which we learn. Vision allows us to collect and process information from our environment and to make decisions or form concepts from that information. From an educational perspective, visualization aids student understanding of complex processes because it assists in the conversion of an abstract concept into a specific visual object that can be mentally manipulated. Further research has shown that by using well-designed visual tools, students can digest large amounts of information in a relatively short time and construct their own personal visualization of a process (Kraidy, 2002; Linn, Songer, and Eylon, 1996). Graphical representations are visualizations that augment the information presented in text by providing a focus for the learner (Mayer, 1989). They are most effective when they support content for which the learner has little prior knowledge (Mayer and Gallini, 1990). Computer animation, in particular, is a new educational tool that fosters long-term learning by calling attention to objects during the early steps of instruction (Rieber, 1994). Rieber (1994) demonstrated that using animations to communicate ideas and processes that change over time reduces the abstractions associated with the temporal transitions of the process. The value of graphics appears to be associated with the dual-coding theory (Paivio, 1991), which suggests that long-term memory retention is facilitated by a combination of verbal and visual cues. As such, animations are valuable aids in supporting the visual aspects of long-term memory. Furthermore, by combining narration and animation, dual-coding is further supported (Mayer and Anderson, 1991). Chou (1998) and Serpell (2002) also noted the significantly greater effectiveness of computer simulation instruction as compared to traditional instruction. Slack and Stewart (1990), Johnson and Stewart (1989), and Collins and Morrison (1992) reported that by using genetics construction kits as part of a strategic computer simulation, undergraduate and high school students learned to "solve" genetics programs and to build accurate and rich mental models of genetic knowledge. Animations have been used in science teaching to help students' understanding of complicated science topics (Akpinar and Ergin, 2008; Ardac and Akaygün, 2004; Ebenezer, 2001; Weiss, Knowlton, and Morrison, 2002). Animations stimulate more than one sense at a time and therefore make them more attention-getting and attention-holding (Akpinar & Ergin, 2008). There is fairly extensive literature arguing that animations are more effective than static sequential images for teaching dynamic events (Pollock, Chandler, and Sweller, 2002; Tversky and Morrison, 2002). In spite of an increasing availability of animation, particularly as part of textbook packages, there has been little or no use of such materials in Nigerian schools. Where they have been used sparingly, no investigations have been done into the integration of such animations for teaching and learning and no research has been carried out on the effects of these animations in science teaching, especially where they are most applicable.

It is therefore pertinent to provide tools that can make teaching and learning difficult concepts such as genetics easier and concrete. One such tool may be Computer Simulation Instruction strategy, the basis of this research in which computer simulation was used in teaching some undergraduate students DNA replication and transcription concepts.

STATEMENT OF PROBLEM

Genetics is an important and fundamental area in biology education. The study of genetics offers insights into the way the living world works. However, as important as it is, it is also one of the most difficult topics. For example, students find the sequences of events in DNA replication and transcription and the components of the processes difficult to understand. Various research studies have identified different difficulties associated with teaching and learning Genetics. One of the problems is the abstract nature of the topic. Due to the abstract nature of genetics, many students have difficulties in visualizing the concept because the processes involved are not physically observable. It has been observed that teachers in Nigeria constantly used lecture method in teaching the concept and ignore computer animations, a gap in the application of media technology to improve students' learning. From an educational perspective, visualization aids student understanding of complex processes because it assists in the conversion of an abstract concept into a specific visual object that can be mentally manipulated. This research therefore seeks to investigate the effect of computer animation instruction strategy on the academic achievement of undergraduate biology students.

RESEARCH HYPOTHESES

Ho1: There is no significant difference in the mean achievement scores of undergraduate Biology Education students taught DNA replication and transcription concepts using Computer Simulation instructional strategy and those taught the same concept using lecture method.
Ho2: There is no significant difference in the retention of biology students taught DNA replication and transcription concepts using Computer simulation instructional strategy and those taught using lecture method.
Ho3: There is no significant difference in the mean scores of male and female undergraduate biology students in DNA replication and transcription concepts exposed to Computer simulation instructional strategy only.

METHODOLOGY

This study employ pretest posttest quasi-experimental control group design. A total of fifty undergraduate 300 level biology education students (25 students each for experimental and control) were involved in this study from Ekiti State University (Affiliated with Michael Otedola College of Primary Education, Epe, Lagos State). Fifty students were randomly selected for the research. All the selected students were assigned numbers from 1 to 50 and divided into 2 group using even and odd numbers. The even numbers make up the experimental group while the odd numbers make up the control group. The sample includes 14 males and 36 females. All students have the same background in genetics. Experimental group are group exposed to experimental treatment, that is, teaching using computer simulation instructional strategy, while control group are group taught using lecture method. This design have been prescribed by Kerlinger (1973) and used by Thomas and Israel (2014).

Students were taught DNA Replication and Transcription Concept. The experimental group used the computer simulation using the DNA replication and transcription animation videos downloaded from
www.wapwon.com/video/category/dna_replication,wapspot.mobi/tube/download/dna-r/FBmO_rmXxlw and content.dnalc.org/c15/15510/transcription_basic.mp4
The control group were exposed to the content through conventional teaching methods, using a teacher centred strategy or lecture method.

Instruments

DNA Replication and Transcription Achievement Test (DRTAT)

This instrument was developed based on the important points in DNA replication and transcription. Based on the learning objectives and content of the topic, 25 multiple-choice items were developed with four possible answers for each question (A-D). The DNA Replication and Transcription Achievement Test (DRTAT) was trial tested on 20 students who are not participating in the research. From the students' responses a reliability coefficient of 0.70 was established using the Kuder-Richardson (KR 20) formula. The DRTAT was used as the pre-test, post-test as well as the post post-test. DNA Replication and Transcription Concept Achievement Test (DRTAT) were administered to both experimental and control groups.

Data Analysis

Data collected from the DNA Replication and Transcription Achievement Test (DRTAT) were analyzed using t-test (independent) statistic at 0.05 level of significance using data of Post test and post-post test academic achievement score of students in Computer Simulation instruction and lecture method groups. SPSS 22 (Statistic Package for Social Sciences) was used for data analysis.

RESULTS

Three research hypotheses raised in this research were tested and verified using inferential statistic and presented in Tables 1, 2, and 3 respectively. Computer statistic software, SPSS 22, was used in the analysis. All tests were verified at $p \leq 0.05$ levels of significance.

Testing Null Hypothesis One

Ho1**:** There is no significant difference in the mean achievement scores of undergraduate Biology Education students taught DNA replication and transcription concepts using Computer Simulation instructional strategy and those taught the same concept using lecture method.

Table 1: Results of t-test Analysis of Achievement Scores of the students in the Lecture method and Computer simulation method

Variable	N	Mean	S.D	Df	t-value	t-crit	p.	Alpha	decision
Lecture method	25	15.96	2.49	48	4.20	2.02	0.002	0.05	Sig
Computer simulation	25	18.44	1.58						

*Significant at $p \leq 0.05$ level of significant

Table 1 showed that the t-value computed is 4.20 and the p-value of 0.002 is observed at degree of freedom of 48. Since the critical p-value of 0.002 is less than the alpha value of 0.05, there is a significant difference in the academic achievement of the students in lecture method and computer simulation method group. A significant difference implies rejection of null hypothesis and retaining alternate hypothesis. The significant difference is in favour of computer simulation group as revealed in their mean scores.

Testing Null Hypothesis Two

Ho2: There is no significant difference in the retention of biology students taught DNA replication and transcription concepts using Computer simulation instructional Strategy and those taught using lecture method.

Table 2: t-test analysis of the retention ability of biology students taught using lecture method and computer simulation method

Variable	N	Mean	S.D	Df	t-value	t-crit	p.	Alpha	decision
Lecture method	25	16.24	2.30	48	4.94	2.02	0.00	0.05	Sig
Computer simulation	25	18.44	1.36						

*Significant at $p \leq 0.05$ level of significant

From the result obtained in Table 2 above, it is observed that the t-value of 4.94 is obtained and the p-value observed is 0.00 at the degree of freedom of 48. The critical p-value of 0.00 is less than the alpha value of 0.05. This shows that there was a significant difference. A significant difference implies rejection of null hypothesis and retaining alternate hypothesis. Therefore, null hypothesis that stated, there is no significant difference in the retention ability of biology students exposed to Computer simulation instruction strategy in DNA replication and transcription concept is rejected. The significant difference is in favour of biology students exposed to DNA replication and transcription concepts using Computer Simulation instruction Strategy as revealed in their mean score.

Testing Null Hypothesis Three

Ho3**:** There is no significant difference in the mean scores of male and female undergraduate biology students in DNA replication and transcription concepts exposed to Computer simulation instructional strategy only.

Table 3: t-test Analysis of Academic Achievement Scores of the Male and Female Students in the computer simulation instructional strategy group

Variable	N	Mean	S.D	Df	t-value	t-crit	p.	Alpha	decision
Computer simulation: Female	19	18.26	1.66	23	1.15	2.2	0.2	0.05	Not Sig
Male	6	19	1.27						

*Significant at $p \leq 0.05$ level of significant

From the result in table 3 above, it is observed that in the Computer simulation instruction strategy group, the t-value of 1.15 is obtained and the p-value observed is 0.20 at the degree of freedom of 23. The critical p-value of 0.20 is greater than the alpha value of 0.05. This shows that there is no significant difference. A no significant difference implies retaining of null hypothesis and rejecting alternate hypothesis. Accordingly, null hypothesis that stated that there is no significant difference in the academic achievement of male and female students exposed to Computer Simulation Instruction Strategy in DNA replication and transcription concept was not rejected.

DISCUSSION

Students taught DNA replication and transcription using computer simulation instruction strategy had higher achievement (posttest) scores, indicating that they understood the concept more than those taught using lecture method. From the findings in Table 1 and 2 the study revealed that the group of students taught DNA replication and transcription using Computer simulation instruction strategy recorded the higher mean score than those taught using lecture method, which showed that there is a significant difference in the academic achievement of the two groups. A significant difference implied rejection of null hypothesis and retaining alternate hypothesis. From the result it can be averred that the computer simulation instructional strategy was more effective than the lecture method. The effectiveness of computer simulation instructional strategy could be due to the ability of the students to visualize and understand the complexities underlying the concept since it helps in the adaptation of an abstract concept into a precise visual object that can be mentally manipulated.This result is in conformity with the findings of Liao (1999) who suggested that, as a whole, student learning is greater when a multimedia learning tool is included during instruction relative to a control group without such tools. Also, Tayo, (2012)'s finding reveals that Students exposed to developed animated agricultural package performed significantly better than those exposed to the conventional lecture method. There was also a significant difference in the retention ability of the two groups. The significant difference is revealed in Table 2 as shown in their mean achievement score and the t-value. This is because motion leads to long term memory therefore students exposed to computer simulation instructional strategy retained more knowledge than those taught using lecture method. This finding is in accordance with that of Lin, (2011) who in his study reveals that animations lead to greater long – term memory retention of learned materials. The value of graphics appears to be associated with the dual-coding theory, which suggests that long-term memory retention is facilitated by a combination of verbal and visual cues. As such, animations are valuable aids in supporting the visual aspects of long-term memory. Furthermore, by combining narration and animation, dual-coding is further supported (Mayer and Anderson, 1991).

Table 3 presents the mean achievement scores of male and female students for computer simulation instruction strategy. Comparison of the means, using independent sample t-test, showed that there was no significant difference in the performance of male and female students exposed to computer simulation instruction strategy in DNA replication concept ($p > .05$). The non-significant of gender could be as a result computer simulation instructional strategy, which improved the performance of both the male and female students. Other researchers have found no significant difference in the academic achievement of male and female students. Aremu and Sangodoyin (2010) found no significant main effect for gender with regards to student academic achievement mean scores in biology.

CONCLUSIONS

The result of this study showed that computer simulation instruction strategy improves students' academic achievement and retention ability. Computer simulation instruction strategy is an effective tool for teaching complex and abstract concept and topics that have hitherto proved difficult for both teaching and learning. Computer simulation instruction is a valuable instrument for lecture delivery as it aid visualization of abstract concept therefore helps learners with important conceptual relationships.

RECOMMENDATION

University Management and management of other tertiary institutions in Nigeria are advised to provide Computers and Projectors for lecturers to assist in the smooth and effective delivery of lectures using computer animation instructional strategy which has been proven by this research to be more effective than the widely used lecture method. National University Commission (NUC), National Commission for Colleges of Education (NCCE), federal and states ministry of education should organize a special re-training, workshops, and seminars for lecturers and teachers on developing animated software for teaching and learning.

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