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## Technology Use in Science

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# Computer Animation and the Academic Achievement of Nigerian Senior Secondary School Students in Biology

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**Abstract**

This study investigated the effects of computer animation on the academic achievement of Nigerian senior secondary school students in biology. The moderating effects of mental ability and gender were also investigated. The pretest-posttest, control group, quasi-experimental design with a 2x2x2 factorial matrix was adopted for the study. One hundred and eighty-nine senior secondary school Year II biology students from two randomly selected Federal Government Colleges in two states in Southwestern Nigeria were the participants. Findings show that there is a significant main effect of treatment on students' achievement in biology. The computer animation was effective in improving students' achievement therefore, computer animation is recommended as a means of teaching biology to students in Nigerian secondary schools.

**Keywords**

Computer Animation; Academic Achievement in Biology

## Introduction

The dynamics of technology have created a complete new world of learning in recent times. According to Willis and Raines (2001), every country of the world is embracing new technology in order to stay current and be relevant in professional fields like medicine, transportation, manufacturing, entertainment, and education. In a relatively short period of time, computer technology has increasingly changed the ways in which we teach and learn. Newly developed instructional software that integrates text, sound, and computer animation can now present material to students in a multimedia form that may maximize its effectiveness.

Multimedia refers to computer-based applications where users are provided with information through different types of media (Kommers, Grabinger, & Dunlap, 1996). It also refers to the presentation of learning media using both pictorial and verbal forms such as spoken and printed text (Mayer, 2000). One important contribution of multimedia is animation, which, simply defined, is images in motion (Dwyer & Dwyer, 2003). It is the use of drawings, cartoons, and other graphic materials to create motion pictures. Computer animations work as rapid changes of a picture on the computer screen. (Dasdemir, Doymus, Simsek, & Karacop, 2008). According to the latter, there are three main features of animations, and they are picture, indication of certain movements, and simulation. The flexibility of learning through animation allows for a wider range of stimuli, thus increasing students' engagement in learning. This can be one way of bringing about a change of emphasis in teaching from a teacher-directed approach to a teacher-facilitated approach. With this, both teachers and students may control the pace of lessons according to their abilities.

Animations have been used in science teaching to help students' understanding of complicated science topics (Akpinar and Ergin,2008; Ardac & Akaygün, 2004; Ebenezer, 2001; Sancar & Greenbowe, 2000; Weiss, Knowlton, & Morrison, 2002, Williamson & Abraham, 1995). Animation has a lot of advantages; it has been shown that students who learn from animation have greater self-esteem and motivation (Kearsley, 2002). Animations stimulate more than one sense at a time and therefore make them more attention-getting and attention-holding (Akpinar & Ergin, 2008; Ching, Ke, Lin, & Dwyer, 2005). There is fairly extensive literature arguing that animations are more effective than static sequential images for teaching dynamic events (Pollock, Chandler, & Sweller, 2002; Tversky & 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 don 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.

Biology, which is an integral part of science and focuses on living things (plants and animals), is a highly popular subject amongst senior secondary students in Nigeria. In the Nigerian educational system, it is compulsory that every student in the senior secondary school study at least one science subject. Over the years, the trend has been that most students choose biology over the other science subjects such as chemistry, physics, and so on. The performance of students in the subject has, however, been very poor (Bilesanmi 1998, Ige, 2001). Investigations have revealed quite a number of reasons; one is that some concepts are very difficult for teachers to teach as well as for students to learn (Ige, 2001; Nzewi & Osisioma 1994; Okebukola 1990, Orukotan 1999). Some of these topics include genetics, ecology, and nervous coordination. Further investigations have shown that many of these topics are taught mostly with only textbooks. This presents difficulties in understanding for students and many of these topics, particularly genetics which is difficult to teach, end up being neglected by teachers (Orukotan, 1999). 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 & McDermid, 2005; Richards & Ponder, 1996; Ruiyong, 2004; Snowden & Green, 1994; Turney, 1995).

There is a need, therefore, to provide tools that can make learning a concept such as genetics easier and concrete. One such tool may be animation, the basis of this research in which an animation package was designed to teach senior secondary school students some concepts in genetics.

## Related Literature

The theoretical framework of this study is anchored in the Dual Coding Theory of Visualization. According to the theoretical assumptions of dual coding theory, words and external pictures activate the coding system in an additive way (Paivio, 1986). In addition, when information is dual-coded, the probability of retrieval is increased. Dual coding theory further assumes that words and pictures activate mental processing in different ways. In the computer-based, multimedia learning environment, dual coding theory has been extensively applied in guiding research with computer-generated static or animated displays (Mayer & Anderson, 1992; Mayer & Sims, 1994). Therefore, exposing students through computers to genetics with diagrams and texts will enable them to take greater advantage of their capability to process information on two levels, of stimulating the visual system, and by reducing the load placed on the verbal processing system, hence enhancing performance. This theory provided the basis for our research.

Not much work has been done in the past on design of and research into the use of animation in Nigeria, because the skills and equipment required were scarce in the early days of computers (Onansanya, Shehu, Iwokwagh, & Soetan, 2010). Fortunately, nowadays animation can be created more easily as inexpensive user-friendly software is available for this purpose. Some examples of such software applications are the Macromedia Creative Suite, and Cinema 4D. These are software applications that could be used to design graphics and animate processes even in three dimensions. This has resulted in the development of animation for teaching and learning and has come with a lot of encouraging results. Recent studies carried out on the integration of animation have shown positive effects on learning; a reduction in students' cognitive load in learning tasks due to the use of animations; the potential for increased learning when there is a need for external visualization and when content depends on motion; and opportunities for the classification of complex information (Akpinar & Ergin 2008; Dancy & Beichner, 2006; Dasdemir et al., 2008; Iskander, 2005, Li, Santhanam, & Carswell, 2009; Onansanya et al., 2010; Rieber, 1994; Rieber & Boyce, 1990). On the effect of animations, Park (1998) concluded that series of empirical studies demonstrated that animations serve several instructional roles: attracting and directing attention; representing domain knowledge about dynamic processes; and explaining complex phenomena. Stith (2004), McClean et al. (2005) and O'Day (2006) emphasized that animation provides a valuable way to communicate dynamic, complex sequences of biological events more effectively than text or static graphics. Using animations may also increase conceptual understanding by promoting the formation of dynamic mental models of the phenomenon under consideration (Akpinar & Ergin 2008). The peculiar characteristics of animation, the complexity of the systems involved in biology generally, and the spatial and temporary nature of many biological processes makes computer animation a viable tool for teaching biology topics in particular.

Furthermore, it has been found that just using static images may not be that effective, and there is fairly extensive body of literature arguing that animations are more effective than static sequential images for teaching dynamic events (Pollock et al., 2002; Poohkay 1994; Tversky & Morrison, 2002). In a study by Rieber and Boyce (1990), comparing animation-based instruction with carefully designed verbal presentations, results show that the animation did not result in a greater quantity learnt, but did result in less time required to retrieve information learned.

However, animations have been found to be most effective when text is adjacent to important structures and is spoken simultaneously to reinforce the learning process (O'Day, 2006; Ustuner & Sancar, 1999). The latter of the two studies concluded this based on an extensive review of the literature covering all educational disciplines. This effect is often called the contiguity effect. There is also evidence that suggests that students may need help attending to the relevant parts of an animation; that is, they may need to be trained in the use of animations for them to be effective (Mayer & Anderson, 1992). However, although animation seems to attract learners' attention and increase their motivation to learn, whether or not instructions using animation can facilitate student-learning achievement still remains a question. With all of these available resources, there is an opportunity for researchers to carry out further studies on the value of animations in life science teaching.

In addition to the possible influence of computer animation on students' achievement, some other factors inherent in students can also affect academic achievement. Two of such factors are investigated in this research: mental ability and gender of the learner. The consideration of mental ability in this study is predicated on the fact that most concepts in genetics are complex and abstract in nature and thus they may require levels of abstract thinking and critical reasoning. Investigating mental ability, therefore, as a construct would provide insight into whether the use of a computer animation would remove differentiation in achievement based on this ability.

Mental ability to some extent determines the imagination, language perception, concept formation, and problem-solving ability of learners. The ability of a learner is a construct that many researchers have found to affect their achievement, especially in science and mathematics (Dreary, 2010; Rohde & Thompson 2007). It has also been discovered that students of varying ability levels often perform differently depending on the types of methods and materials used for instruction. Reyes (1984) emphasized that students with low mental ability need special attention in their work. This is because usually their level of motivation towards learning is very low and their attitude toward learning may be negative. Based on this, there is the need to investigate strategies and tools that may impact the motivation and improve the attitude of such learners.

Gender may be another very important moderating factor in this research, especially since it involves the use of computers and a science subject, two areas that usually are stereotyped as male domains. Gender, according to various studies, could be a factor when computers are used for teaching. The usual assertion is that since boys are more predisposed to the use of technology, they may benefit more from the integration of technology for teaching and learning. Girls, on the other hand, may be limited in their learning when it involves technology. Investigating gender in this study could help clarify these issues.

The matter of gender in learning spans quite a number of other issues as well. These include differences in perception of visual information by females and males, differences in learning scientific knowledge through computer-based learning materials, differences in academic achievement in science subjects, differences in perceptions of and attitudes towards the computer, and differences in level of anxiety towards the use of computers (Aremu, 2008; Butler, 2000; Enochsson, 2005; Isman & Celikli, 2009; Madell & Muncer, 2004; Wong & Hanafi, 2007). It is therefore beneficial to investigate whether gender of students involved in using animations would have an effect on academic achievement.

**Statement of the Problem**

Various research studies have revealed that student performance in biology in Nigerian secondary schools is on the decline. Coupled with the difficulty that the teachers experience in teaching some of the concepts such as genetics, it becomes imperative that solutions in terms of strategies and tools are found. Against this background the current study investigated the effects of computer animation on students' academic achievement in senior secondary school biology (genetics). It also investigated the moderating effects of mental ability and gender on academic achievement.

**Hypotheses**

The following null hypotheses were tested at $p = 0.05$:

$Ho_{1:}$ There is no significant main effect of computer animation on student achievement in biology.
$Ho_{2:}$ There is no significant main effect of mental ability on students' achievement in biology using computer animation.
$Ho_{3:}$ There is no significant main effect of gender on students' achievement in biology using computer animation.
$Ho_{4:}$ There is no interaction effect of treatment, mental ability and gender on students' achievement in biology using computer animation.

**Methodology**

This study adopted a pre-test posttest control group quasi-experimental design. The independent variables are the teaching strategy at two levels, (use of computer animation and conventional teaching method), mental ability at two levels (high and low), and gender at two levels (male and female). A biology content pre-test was used as a covariate. The design is structurally shown as follows

Experimental Group $O_1 X_1 O_2$

Control Group $O_1 X_2 O_2$

Where

$O_1$ = Pre-test Assessment for experimental and control groups (covariate)

$X_1$= Treatment, i.e. computer animation presentation

$O_2$ = Post-test assessment for experimental and control groups

$X_2$ = Conventional teaching method.

Topics on genetics were divided into a six-week learning package. The experimental group used the computer and animations, following the instructions in the package. The teacher was a facilitator, clarifying concepts, answering questions and initiating feedback from students. The control group (at a different school) went through the same content during this period based on the six-week learning package. They were exposed to the content through conventional teaching methods, using a teacher-centered strategy or lecture method involving 'chalk and talk'.

*Participants*

A total of 189 Secondary School II biology students were involved in this study from Federal Government Colleges in South Western Nigeria using intact classes. Their age range was 14-16 years; 115 males and 74 females were involved in the study (Table 1). All students were experienced computer users with the same background in genetics (from Junior Secondary School III). Computer studies, as a subject has been mandatory since 1988 in Federal Government Schools in Nigeria. Students take this subject starting in their first year of Junior Secondary School. All schools have at least one computer laboratory with 10-15 functional computers.

*Table 1*: Grouping of Study Participants

| **Group** | **Gender** | **Mental Ability** |
|---|---|---|
| Experimental<br>(n = 109) | Male (n =65 )<br>Female (n =44 ) | Low (n =63 )<br>High (n =46 ) |
| Control<br>(n = 80) | Male (n =50 )<br>Female (n =30 ) | Low (n =21 )<br>High (n =59 ) |

The teachers were all certified professionals having earned their undergraduate degrees in education and in some cases post-graduate diplomas). Those who handled the experimental group where trained to use the learning package and those in the control group were trained to deliver the instruction through the conventional lecture method. This was necessary so that the teachers where competent to teach the topics. The teachers in each school were trained separately, thus there was no interaction between them.

*Intervention*

The Computer Animation Learning Packages in Genetics (CALPG) was the intervention used in this study. This computer package consists of a series of interactive slides with animations and graphics. The use of hyperlinks enables flexibility in choosing what content to learn and /or revise. The colored animations make learning real and authentic. The development of the package followed the design steps as shown in Appendix A. Some of the slides are shown in Figures 1-4.

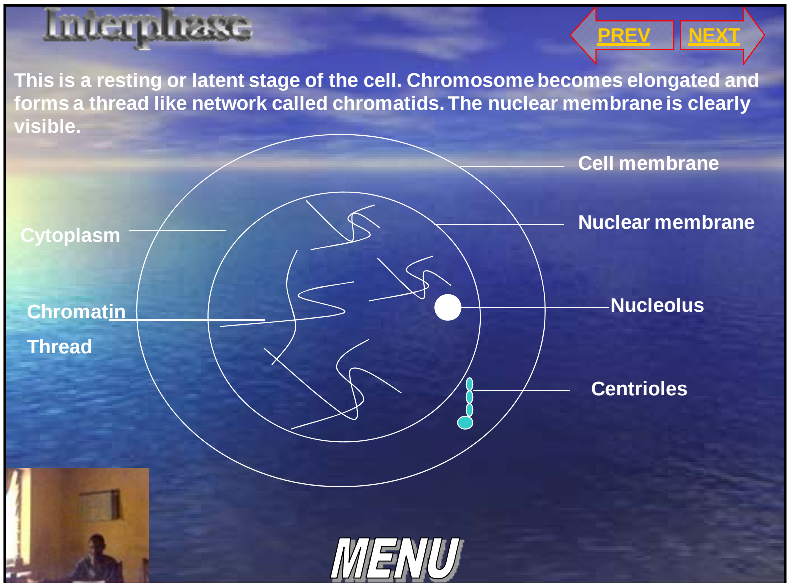


*Figure 1:* Animation 1

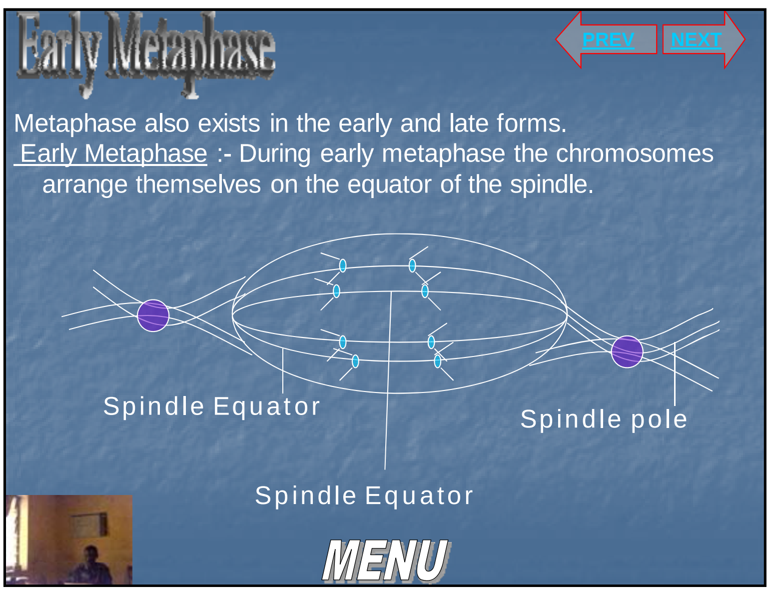


*Figure 2*: Animation 2

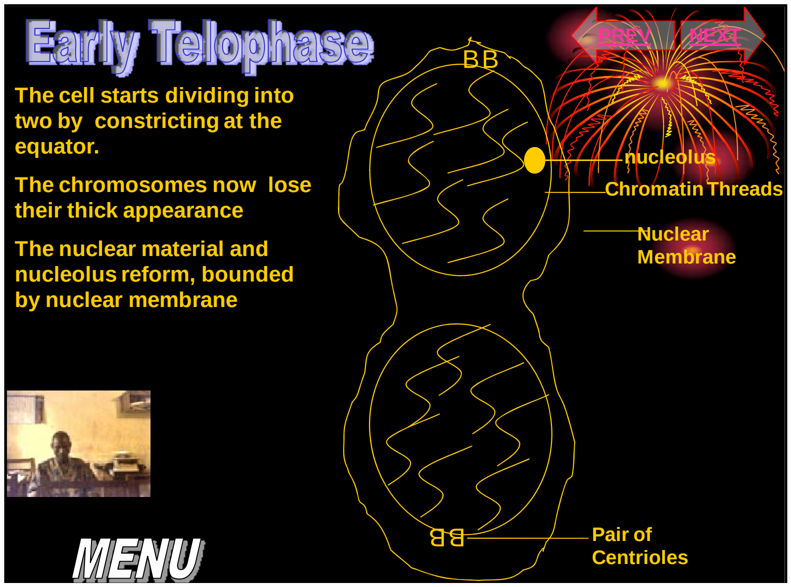


*Figure 3:* Animation 3

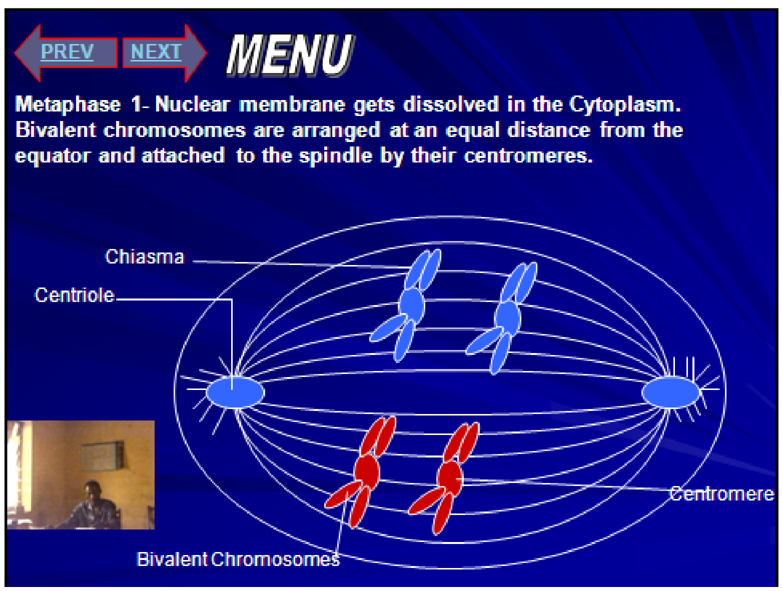


*Figure 4:* Animation 4

*Instruments*

Two instruments were used to collect student data:

1. Biology Achievement Test (BAT). This instrument was developed based on the biology syllabus of the senior secondary school year II (SS II). It consists of 40 multiple-choice items with four possible answers for each question (A-D). To ensure the validity of the test items, a table of specifications, which showed the various levels of learning against the genetics topics, was prepared. Based on the learning objectives, test items were developed in all categories. The BAT was trial tested on 20 SS II students from two schools not participating in the research. From the students' responses a reliability coefficient of 0.71 was

established using the Kuder-Richardson (KR 20) formula. The Kuder-Richardson 20 formula is a measure of internal consistency of a test. It gives the degree of reliability of a test, yielding values between -1 and +1. Cap (1995), citing various other authors, explains that a coefficient of .71 to .86 is regarded as high, that most teacher-made tests regarded as good, usable tests achieve reliabilities between .60 and .80 and that nothing below .50 would suffice. Thus our reliability co-efficient of .71 can be seen as adequate. The BAT was used as the pre-test as well as the post-test.

2. Mental Ability Test (MAT). The Australian Council for Educational Research Standardized Mental Ability (ACER) Test was adopted from Abimbade (1987). It is a test of general intellectual ability, designed to assist teachers in their assessment of students' learning potential and aptitude. It consists of 25 items, using a 4-option multiple-choice test. This instrument was used to group students into high and low mental ability. Using the KR 20 formula, its reliability value was 0.82.

Both the experimental and control groups were given the pre-test (BAT ) at the same time to determine their previous knowledge in genetics (BAT). To assign them into mental ability groups, the MAT was administered on the students; they were thus assigned to low or high mental ability levels . Following the pre-test, the two groups were exposed to their treatment – computer animation in genetics and conventional instruction in genetics, respectively. Students in both groups were also tested after the intervention using the BAT.

**Data Analysis**

Data collected from the BAT were analyzed using Analysis of Covariance (ANCOVA) to determine the impact of computer animation, gender, and mental ability, with pre-test scores as the covariate. Estimated Marginal Means (EMM) were also used to determine the magnitude and direction of differences among groups.

**Results**

Table 2 shows that there is a significant main effect of computer animation use on students' achievement in biology ($F_{(1,176)} = 21.33$; $p < 0.05$). Therefore, $HO_1$ is rejected.

*Table 2*: Summary of Analysis of Covariance Using a 2x2x2 Factorial Design

| Source | Sum of Squares | *df* | Mean Square | *F* | *p* | Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 2123.840 | 12 | 176.196 | 19.196 | .000 | .464 |
| Intercept | 2274.980 | 1 | 2274.980 | 246.750 | .000 | .481 |
| Covariate (Pre-test) | 743.090 | 1 | 743.090 | 80.600 | .000 | .233 |
| Treatment | 393.090 | 1 | 196.700 | 21.330 | .000 | .138 |
| Mental Ability | 136.370 | 1 | 136.370 | 14.790 | .000 | .053 |
| Gender | .332 | 1 | .332 | .036 | .850 | .000 |
| Treatment * Mental ability | 7.443 | 2 | 3.721 | .404 | .668 | .003 |
| Treatment * Gender | 8.790 | 2 | 4.40 | .477 | .621 | .004 |
| Mental ability * Gender | 6.818E-02 | 1 | 6.818E-02 | .007 | .932 | .000 |
| Treatment * MAbility * Gender | .125 | 2 | 6262E-02 | .007 | .993 | .000 |
| Error | 1622.720 | 176 | 9.220 | | | |
| Total | 97985.000 | 189 | | | | |
| Corrected Total | 4576.310 | 188 | | | | |

*Table 3:* Post Hoc Analysis with Estimated Marginal Means, Showing Performance across Groups on the BAT

| Variable | *N* | *M* (Grand Mean = 18.00) | Std. Error |
|---|---|---|---|
| TREATMENT | | | |
| Animation | 109 | 19.77 | .320 |
| Control | 80 | 16.23 | .418 |
| MENTAL ABILITY | | | |
| Low | 84 | 17.37 | .295 |
| High | 105 | 18.93 | .277 |
| GENDER | | | |
| Male | 115 | 18.11 | .258 |
| Female | 74 | 18.19 | .307 |

Table 3 shows the magnitude of differences in each group, and reveals that those exposed to computer animation performed better ($M$ = 19.77) than those in control group ($M$ = 16.23).

Second, Table 2 also reveals that there is significant main effect for mental ability on student achievement in biology ($F_{(1,176)}$ = 14.79; $p < 0.05$). Therefore, $HO_2$ is rejected. Table 3 illustrates that students with high mental ability performed better ( $\bar{x}$ =18.93) than those with low mental ability ( $\bar{x}$ =17.37).

Third, Table 2 shows that there is no significant main effect of gender on student achievement in biology ($F_{(1,176)}$ = 0.036; $p > 0.05$). Therefore, $HO_3$ is accepted.

Fourth, Table 2 shows that there is no significant interaction effect of treatment, mental ability, and gender on students' achievement in biology ($F_{(2,176)}$ = .007; $p > 0.05$). Therefore, $HO_4$ is accepted. The implication of this is that within all the mental ability groups and gender groups, the difference in achievement is not significant. Thus using this treatment will not discriminate within groups (mental ability and gender) of learners.

**Discussion**

From table 2, it can also be seen that the covariate (pre-test) yielded a statistically significant F, ($F_{(1,176)}$ = 80.600; < 0.05), implying that the groups were not homogenous from the onset. This may have been due to factors not accounted for in this study; for example it is not uncommon for parents to pay for extra private lessons for their wards during the vacation period preceding a term where students are taught topics that would be taken during the term. However, the use of ANCOVA for analysis controls for the variance that has been observed. Therefore the significant effect of the treatment observed could be said to be due to the treatment.

Table 2 shows that there is a significant difference in achievement between students in the two groups. The EMM in Table 3 with grand mean of 18.00 revealed that the experimental group contributed significantly to the gain score of students' achievement in biology. Therefore, the results indicate that the experimental approach was more effective in promoting achievement than the conventional teaching method. This agrees with the findings of Egunjobi (2002), who found computer based instructional strategies to have significant positive effects on student achievement, and likewise the findings of Pollock et al. (2002), Tversky and Morrison (2002), Stith (2004). McClean (2005), and O'Day (2006). The reasons for these results are not farfetched; first, the novelty of the learning package makes it attractive enough for students to use, the fact that they can see movements and changes in the colorful diagrams and graphics, which show the processes, is quite motivating. Being able to click on a button to go to another slide, i.e. the interactivity, immediate feedback of results, and the convenience of going at your own pace have always been the rationale for using computers in the classroom, and they are reasons why such an intervention of this nature would be successful. Finally, the enthusiasm of the teachers in using this computer-based strategy could be one of the factors that ensured the workability of the intervention. The role of teachers in integrating new technologies and strategies can never be overemphasized. If they do not believe in the usefulness, workability, and efficacy of a tool or strategy, the probability of such a tool or strategy improving achievement is almost nil.

There is also a significant main effect of mental ability on student achievement scores in biology (genetics). The EMM in Table 3 clearly shows that the high ability students had the highest post-test achievement mean ( $\bar{x}$ =18.93). This shows that much of what teachers teach in science appears to require formal reasoning, which is reasoning based on abstraction that transcends concrete experience. This finding corroborates similar findings of Udousoro (2000) and Egunjobi (2002) who found that high-ability learners performed significantly better than low-ability learners when exposed to computers in mathematics and geography, respectively. This finding is also in consonance with the work of Reyes (1984) and Deary (2010), who asserted that students with low mental ability need special attention in their work. The implication of this result is that students with low ability would still need to be given special attention even if tools like computers are introduced into the classroom.

There is no significant main effect for gender with regards to student academic achievement mean scores in biology (genetics): $F_{(1,176)} = 0.036$; $p < 0.05$). This means that the females in both groups performed as well as the males. The non-significant effect of gender could be attributed to the animations used, which are novel and practical in nature, and which involve active participation of learners. This finding corroborates the results of similar studies carried out by Afuwape and Olatoye (2004) and Okoruwa (2008). They also reported no significant gender effect on achievement in science.

In sum, the results of this study are indicative of the fact that computer animation has the capability of motivating students to higher performance by bringing about higher gains in achievement when compared to conventional teaching methods. Computer animation used in teaching is a better facilitator of learning than the traditional chalk and talk method. However, the results also show that students with lower mental abilities still need special attention, while gender does not seem to have an effect on student achievement in science. The gender disparity in achievement (Aremu, 2008) that tends to appear at times may be due to cultural factors, inappropriate teaching strategies, or the use of gender-biased instructional materials. Therefore, if these aspects are adequately taken care of, there is the possibility that girls will be more willing to engage in science subjects and perform as well as boys.

## Recommendations

Based on the results of this study, it is recommended that the use of computer animation, a type of instructional mode that is capable of transforming students from passive receptacles of knowledge into active learners, should be used to teach biology and other science subjects in Nigeria's secondary schools. Science teachers and software developers should be encouraged to collaborate to develop relevant and interesting animations for teaching, especially for complex concepts like those taught in genetics. Collaborations could be initiated through in-service programs such as workshops, seminars, and conferences, which can be jointly organized with educational agencies such as the West African Examination Council and other examination bodies, as well as local, state, and federal governments. Teacher training programs also need to include courses on the use of computer-based tools and strategies in the curriculum. Where these courses already exist, it is important that teacher trainees be exposed to new and emerging tools and software that are relevant for the classroom and can motivate students, thereby increasing their achievement, particularly in science subjects.

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