Integración de animaciones, narraciones y textos para la mejora del aprendizaje en Física

Benson Adesina Adegoke

Institute of Education – University of Ibadan

Nigeria

Correspondencia: Benson Adesina Adegoke. Institute of Education, University of Ibadan, Nigeria. doctoradegoke@yahoo.com

Benson Adesina Adegoke

Resumen

Introduction. El artículo examina el efecto de la instrucción multimedia en el aprendizaje (rendimiento e interés) de la física en la Educación Secundaria.

Método. La muestra está compuesta por 517 estudiantes (294 niños y 223 niñas) de 12 escuelas de educación secundaria de la Zona Educativa 1 de Ibadan, Oyo State, Nigeria. La edad oscila entre los 15 y los 17 años. Los participantes se distribuyen en tres grupos experimentales y un grupo control. Tres versiones del curso se desarrollan para examinar los efectos de cada una. Del mismo modo, también se valora el efecto en el nivel de rendimiento matemático del alumnado. Los datos se analizan utilizando un MANCOVA.

Resultados. Los resultados muestran que el curso con animación+narración+texto en pantalla obtiene las puntuaciones más altas en rendimiento en Física y en el interés por las invenciones en Física. El alumnado que aprendió Física en un contexto multimedia obtuvo mejores resultados que otros colegas que aprendieron Física sólo con la presencia del profesor. Además, el alumnado con más alto nivel en Matemática logró un mejor rendimiento en Física que los compañeros con bajo nivel en matemáticas. La interacción entre el efecto del tratamiento y el nivel en matemáticas no resultó significativa.

Discusión y conclusiones. Los resultados señalar que el uso paralelo de animaciones, narraciones y textos en pantalla ayuda al alumnado a mantener el interés en contextos de aprendizaje multimedia. Más importante, los resultados muestran que la integración de estos tres aspectos ayuda a mejorar los resultados del alumnado en Física. Los resultados no permiten validar el principio de redundancia en aprendizaje multimedia de Richard Mayer.

Palabras Clave: Física, instrucción mutlimedia, interés, rendimiento.

Integrating animations, narratives and textual information for improving Physics learning

Abstract

Introduction. This article examined the effect of multimedia instruction on students' learning outcomes (achievement and interest) in secondary school physics.

Method. The sample comprised of 517 (294 boys and 223 girls) students who came from 12 senior secondary schools in Ibadan Educational Zone 1, Oyo State, Nigeria. Their ages ranged between 15 and 17 years. There were three experimental groups and a control group. Three courseware versions were developed to examine the interface effects. A conventional lecture method group served as control. The moderating effect of mathematics achievement level on students' learning outcomes in physics was also examined. Data were analyzed using Multivariate Analysis of Covariance (MANCOVA).

Results. Results showed that students in the animation + narration + on-screen text group had highest post mean scores in physics achievement test and interest in physics inventory. Students who learnt physics in computer-based multimedia environment had better learning outcomes in physics than the colleagues who learnt physics under teacher-based environment. Also, students with high math achievement level performed better in physics achievement test than their colleagues in low math achievement level group. Interaction effect of treatments and math achievement level was not statistically significant.

Discussion and Conclusions. Results point out that concurrent use of animation, narration and on-screen text in an instructional interface may help maintain students' interest in multimedia learning environments. More importantly, results show that integrating animations, narratives, and textual information in computer based environment may help to improve students' learning outcomes in physics. The results failed to validate Richard Mayer's redundancy principle of multimedia learning

Keywords: Physics education; Multimedia instruction; Interest in Physics; Physics achievement.

Introduction

The level of students' interest and performance in physics continues to decline and this phenomenon seems to cut across cultures. In fact, literature on physics education world wide confirms this observation. Researchers (e.g., Kim & Ogawa, 2007; Kuti, 2006; Lavonen, Mei-salo, Byman, Uiito, & Juuti, 2005; Lorenzo, Crouch, & Mazur, 2006; Osborne, Simons & Collins, 2003; Stokking, 2000) had raised similar concerns in their studies. For example, in Nigeria, on the average, less than 30% of total students who registered for senior secondary school certificate examination (SSSCE) between 2005 and 2009 entered for physics (West African Examination Council (WAEC) 2009). More importantly, on the average, less than 40% of the students who sat for physics between 2005 and 2007 in SSSCE passed at the credit level (WAEC, 2009)

Some authors (e.g., Kim & Ogawa, 2007; Lavonen *et al.*, 2005; Osborne, Simons & Collins, 2003) have shown that students will study and learn physics better and moreover, at the post secondary level choose courses that require knowledge of physics if they are interested in it. Thus, because students' interest in physics learning is so important to their present and future involvement in the subject, it is useful to know how physics teaching should be developed and learning materials designed to be more interesting for them.

How can we help students understand and learn physics better and more importantly, encourage their future involvement in physics? One promising approach, according to some authors (e.g., Chuang, 1999; Kuti, 2006; Mayer, Dow, & Mayer, 2003; Mayer & Moreno, 2003; Ozdemir, 2009; Taber, Martens, & van Merriëboer, 2004) is multimedia instruction. Multimedia instruction, according to Mayer and Moreno (2003), can be defined as presenting both *words* and *pictures* that are intended to foster learning. To Mayer and Moreno (2003), the *word* can be printed (e.g. on-screen text) or spoken (e.g., narration). The *picture* can be static (e.g., illustrations, graphs, charts, photos, or maps) or dynamic (e.g., animation, video, or interactive illustrations). An important example of multimedia instruction in secondary school physics lesson is a computer-based narrated animation that explains the concepts of motion and trajectory (Chuang, 1999), lightnining formation (Moreno & Mayer, 2000; Ozdemir, 2009), and wave motion (Kuti, 2006).

Worldwide, multimedia is now permeating the educational system as a tool for effective teaching and learning. It is increasingly providing richer environments for learning in a wide variety of formats. Multimedia is increasingly being used in many developed countries in computer-based narrated animation that explains how a causal system works and one rationale for this trend is the assumption that multimedia has properties that can aid learning, particularly the learning of abstract subject matter. In fact, in many developed countries, the use of computer-based instruction, and indeed information and communication technology in general (ICT), has been found, by many authors (e.g. Coll, Rochera, Mayordomo, & Naranjo, 2007; Garcia-López & Romero, 2009; Ragosta, 1983; Steinberg, 1991), to be effective in enhancing students' learning outcomes.This phenomenon according to Kuti (2006) is gradually being observed in developing countries too. However, observations have shown that the use of computer in developing countries, for example in Nigeria, as a teaching and learning aid is being restricted to privately owned institutions and public schools where children of the affluent attend.

The power of multimedia lies in the fact that it is multi - sensory. It stimulates both the visual and auditory senses of the learner. It helps the teacher turn the classroom into a dimension of sight, of sound and of mind. Dual-coding theory introduced by Allan Paivio (1986) in his influential book *"Mental representations: A dual coding approach"* provides theoretical support for the use of verbal and non-verbal codes in lesson presentations. Dual-coding theory rests upon the assumptions that humans possess two distinct systems for symbolic representation in cognition: one which specializes in verbal information and the other which specializes in non-verbal information (Swisher, 2007). Of particular interest for multimedia learning (Mayer & Anderson, 1991; Mayer & Moreno, 2003) is the ability of the learner to not only build both verbal and visual modes of mental representation but also establish meaningful connections between them.

Figure 1 shows the Paivio's dual coding model for cognitive processing of animation and speech. Mayer (2001) adapted the model to explain the connection between verbal and visual modes of mental representation. The cognitive theory of multimedia learning assumes that students represent the animation and on – screen text in visual working memory and represent narration in auditory working memory.

Allan Paivio's (1986) dual-coding theory and Mayer's (2001) multimedia learning theory provide the theoretical framework for this study. By using multiple modes of media, such as words and pictures, Mayer (2001) says that instructors can help students build, connect and integrate new information with prior knowledge. The use of multimedia has been found to enhance students' learning outcomes. Several researchers (e.g., Chuang 1999; Kalyunga, Chandler, & Sweller, 1995; Kuti 2006; Mayer, Heiser, & Lonn, 2001; Ozdemir, 2009; Taber, Martens, & van Merriëboer, 2004) have confirmed the dual code theory. For example, in their several studies, Mayer and his colleagues found that when words and pictures were presented together, as in a narrated animation, for example, students performed well on both retention (the ability to recall what they've learned) and transfer (the ability to apply what they've learned to solve a problem) test items.
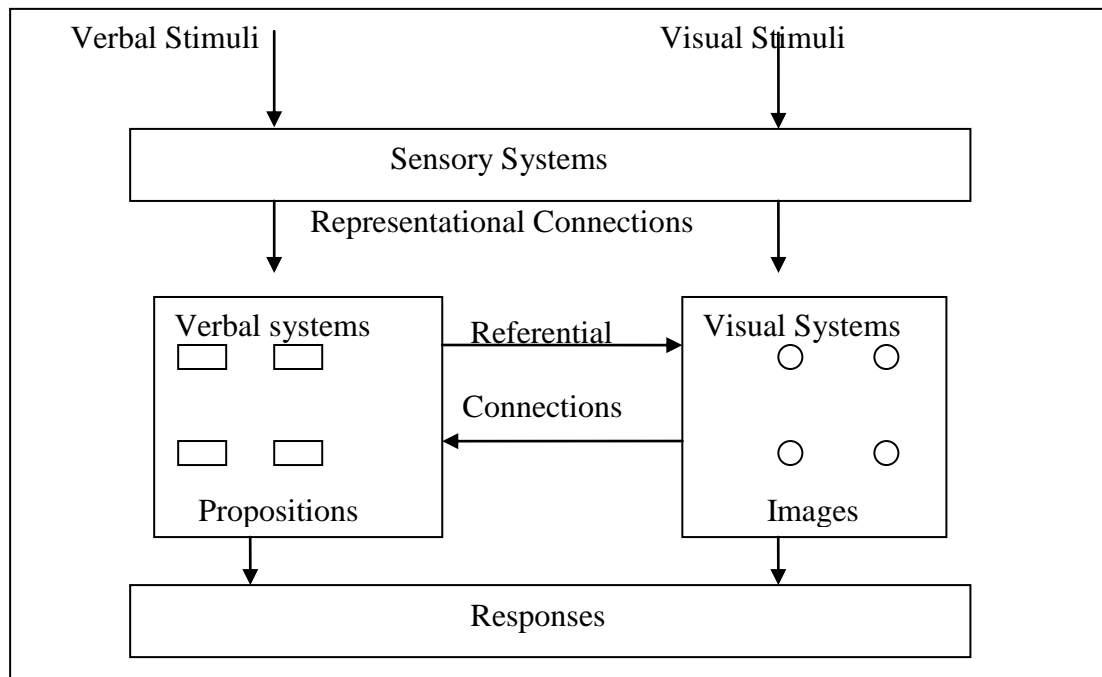
Figure 1. The dual-coding model for cognitive processing of animation speech.
Adapted by Richard E. Mayer (2001) from Paivio (1986, 1990)

Mayer and his colleagues propounded six principles of multimedia learning. These principles are: (a) the multimedia principle – students learn better from words and picture than from words alone, (b) the spatial contiguity principle - students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen, (c) the temporal contiguity principle – students learn better when corresponding words and pictures are presented simultaneously rather than successively, (d) the coherence principle

– students learn better when extraneous words, pictures, and sounds are excluded rather than included (e) the modality principle – students learn better from animation and narration than from animation and on-screen text, (f) the redundancy principle – students learn better from animation, narration and on-screen text (See Mayer,2001 for more detailed discussion).

Although some authors (e.g., Clark & Mayer, 2003 for spatial contiguity; Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 2000 for redundancy principle; Mousavi, Low & Sweller, 2005 for modality principle; Taber, Martens, & van Merriëboer, 2004 for redundancy principle) have confirmed multimedia learning principles, not all research has found that the principles apply generally outside of laboratory conditions. For example, Muller, Lee, and Sharma (2008) found that the coherence principle did not transfer to normal classroom situation. Muller and his colleagues opined that addition of interesting information may help maintain the learners' interest in normal classroom environment. The findings of some authors (e.g., Chuang, 1999; Ozdemir, 2009; Thalheimer, 2004) were also not in agreement with the redundancy principle.

Lack of congruence between the results of Mayer et.al and those of other authors (e.g., Chuang, 1999; Muller, Lee, & Sharma 2008; Thalheimer, 2004) suggests that there is the need to further examine the effect of the combination of animation + narration + on-screen text on students' learning outcomes in physics, in normal classroom situation. The results of this study will give instructional designers a clearer idea of the effects of combination of narrated animation plus textual presentations of content in a computer-based environment on students learning.

Thus the first question to be answered in this study is: What is the most effective way to combine text, narration and computer animation in the presentation of instructional materials? Is it by animation + narration only? Is it by animation + on-screen text only? Or is it by animation + on-screen text + narration? Which element or combination of elements will contribute most to the students understanding and, therefore, enhance the learning outcomes in physics? More importantly under what condition(s) will Richard E. Mayer's multimedia learning principles hold or fail to hold? The conventional mode of instruction i.e. lecture method is still in vogue in most schools in Africa. It seems reasonable to compare learning when information is presented via classroom lecture to learning when the information is presented via computer-based multimedia. This explains the inclusion of a control group in which in-

struction was carried out through the use lecture method in a teacher-based learning environment.

The second question to be answered in this study is: What type of students benefits from each of the three presentation modes? Mayer and Sims (1994) found that high-spatial learners performed much better on problem-solving transfer test from simultaneous presentations (i.e., presenting corresponding animation and narration at the same time) than from successive presentation (i.e., presenting the complete animation before or after the complete narration). The low-spatial learners performed at the same level for both modes of presentation. That is the contiguity effect (computer animation + oral narration presented simultaneously) is strong for high but not for low-spatial ability students. Chuang (1999) found that animation + text + narration interface effect was only strong for Field Independent, males, and students with low mathematics aptitude.

In this study, the author decided to incorporate students' mathematics achievement level because literature (e.g. Griffith, 1984; Okpala & Onocha, 1988; Olatoye, 2008) has shown that a basic knowledge of mathematics is needed to cope effectively with the fundamental principles of physics. Physics no doubt is basically surrounded by topics that involve the use of equations, formulae, measurements and mathematics reasoning ability. Thus the author sought to find whether there exist significant differences in learning outcomes in physics between students with high and low mathematics achievement levels in a multimedia learning environment.

Finally, most of the previous studies had concentrated on the effect of multimedia instruction on students' achievement (using recall and application test items). Indeed, very few studies have examined the effect of multimedia instruction on students' interest in physics. Therefore, in this study, the author examined the effect of multimedia instruction on students' interest in physics.

Specifically, the following hypotheses were advanced for testing.
1.   There is no statistically significant mean differences in the combined DV of achievement in physics and interest in physics among the four groups (treatment conditions): (a) animation + on-screen text only, (b) animation + narration only,

(c) animation + text + narration, and (d) conventional lecture method after removing the effects of covariates (previous scores in physics and further math)

2. There is no statistically significant mean differences in the combined DV of achievement in physics and interest in physics between students with high achievement level and low mathematics achievement level after removing the effects of covariates (previous scores in physics and further math)

3. There is no statistically significant 1st order interaction effect of treatments and mathematics achievement level on combined DV of achievement in physics and interest in physics after removing the effects of covariates (previous scores in physics and further math)

Method

Participants

The sample for this study consisted of 517 senior secondary school two (SS 2) students. They were randomly drawn from 12 senior secondary schools in Ibadan Educational Zone 1, Oyo state, Nigeria. Nigeria operates 9 - 3 - 4 system of education. The nine (9) represents basic education of which the first six years is for primary school education and the last three years is for junior secondary school (JSS) education. The three (3) represents senior secondary school (SSS) education i.e SSI, SS2, and SS3. While the last four (4) represents tertiary education i.e. University or Polytechnic. In Nigeria, senior secondary school students are usually streamed into science class (students must offer Physics and Chemistry), Arts and social science class (students offer liberal arts subjects), and Commercial class (students offer commercial subjects). In this study only students in science classes took part. Twelve intact science classes were used. Among the 517 students that were sampled, 294 (56.9%) were boys, while 223 (43.1%) were girls. Their ages ranged between 15 and 17 years (Mean age = 16.3; SD = 1.06).

The scores of the students in mathematics in the previous state-wide examination were used to divide them into two mathematics achievement levels: students whose math scores fell on or above 60th percentile were classified as the high mathematics achievement level group. There were 253 (48.9%) students in this group with an average math score of 62.3%

based on a 100 point scale. The remaining students were classified as the low mathematics achievement group. There were 264 (51.1%) students in this group with an average math score of 49.7%. The students' previous scores in physics and further mathematics were used as covariates.

Instruments

Two instruments were used. These include: Physics Achievement Test (PAT), and Interest in Physics Questionnaire (IPQ).

1. PAT: This was a 28-item multiple choice test with four options A, B, C and D. It was constructed by the author to determine students' cognitive achievement in physics. It was used as a post-test. The content of the items covered the topics which were taught during the three weeks experiment. Eighteen items tested students' ability to recall what they have learnt while ten items tested students' ability to apply what they have learnt to solve problems. The difficulty indices of the items ranged from 0.73 to 0.84. The reliability coefficient of the PAT was 0.86, which was determined using Kuder-Richardson 20 formula. The administration of the physics achievement test took 45 minutes.

2. IPQ: This was a 20-item questionnaire. It was developed by the author though the idea of Lavonen and colleagues (2005) and Kim and Ogawa (2007) were adopted. It was used to measure students' interest in physics after the experiment. In the questionnaire, students were asked to state the level of their interest in school physics context. The question was: "How interested are you in learning about the following?" Examples of items include: How forces are related to motion; Why passengers in a fast moving car tend to move forward when the car suddenly stops; Why passengers in a vehicle tend to be pushed backwards when the vehicles suddenly speeds off; What generates the pain that one experiences when the head hits a hard wall; Why people in a satellite orbiting close to the earth experience apparent weightlessness; Why objects appear to have no weight in a freely falling elevator; Why walking is possible. Students answered by ticking the appropriate box on a four-point Likert scale. The extreme categories were "not interested" and "very interested". The responses were scored 0, 1, 2, and 3 i.e., 0 for "not interested" and 3 for "very interested". The reliability coefficient of IPQ was 0.79. This was determined by using Cronbach alpha.

Lesson content and Courseware

The experimental courseware used for this study covered the topics of linear momentum as prescribed in the science curriculum for senior SS2 students by the Federal Ministry of Education, Abuja, Nigeria. Previous studies have shown that understanding topics such as this in physics can be enhanced by computer animation (e.g., Park & Hopkins, 1993; Rieber, 1991), animation + narration only (Moreno & Mayer, 2000); animation + text + narration (Chuang, 1999; Kuti, 2006). The lesson materials were divided into six major parts (1) Impulse and Momentum (2) Newton's first law of motion (3) Newton's second law of motion (4) Newton's third law of motion (5) Conservation of Linear Momentum (6) Review and Practice. All instructions were presented at an introductory level.

Three courseware versions were created for the purpose of this study. The three courseware versions were (a) animation + on-screen text – Group I (b) animation + narration only - group II (c) animation + text + narration - Group III. The three versions differed only in the presentation media. The instructional content was the same in all the versions. Each version was prepared using the Microsoft Power Point application and converted to video by using window movie maker. Accessories like digital projector, a laptop, digital versatile disks, and white screen board were also used.

In the fourth group, students were taught by the instructor through lecture method spiced with questioning.

Procedure

Twelve instructors were recruited for the study. They were graduate students taking physics method in the Department of Teacher Education/ Institute of Education, University of Ibadan, Nigeria. They hold bachelor's degree in physics. They are computer literate, and they have received some training in the use of multimedia in the teaching of physics in senior secondary schools. Nevertheless, the author explained the purpose of the experiment to them and they were trained for 4 working days on how to dispense the treatments

Three intact classes were randomly assigned to each of the four groups. In Oyo State Nigeria, the government and the school heads usually frown at the idea of breaking classes for

the purpose of conducting true experiments. In view of this, the study was quasi-experimental. Nevertheless, efforts were made to reduce all contaminants that could have confounded the findings. For example, the students were not pre-tested and instead, their scores in the previous exam conducted by Oyo State Government were used as covariates. The students were also told to pay attention to presentations and that their scores in the post physics achievement test will form part of their continuous assessment for the month of January 2010.

In each of the experimental groups, during each session, the instructor set up the equipment – laptop and the digital projector and then slotted in the DVD on which the presentations had been saved. The video was then projected on the white board screen. The instructor then told the students to jot down in their physics notebooks, key points heard or seen while viewing animation depicting stationary and moving objects along with concurrent narration or along with concurrent on-screen text of the concepts of momentum, laws of motion, and principles of conservation of linear momentum. The same instruction was passed to students viewing animation with concurrent narration and on – screen text. Once the session started, the instructor sat at the back of the classroom and watched the video like the students. Students in the control group were also told to take notes of important key points written or the board or spoken by the instructor.

Experimental Group I: animation + on-screen text only

There were three classrooms designated as A (44), B (45), and C (48). One hundred and thirty seven students were in this group. In this group, the author sought to verify Mayer's (2001) modality principle that students learn better from animation + narration than from animation + on screen text. Students in this group viewed animation depicting concepts of momentum, laws of motion, and principles of conservation of linear momentum with concurrent presentation of on-screen text. To reduce cognitive load, the corresponding words and picture were presented near each other on the page.

Experimental Group II: animation + narration only

One hundred and twenty six students were in this group. There were three classrooms designated as D (43) E (41), and F (42). The students in this group viewed animation depict-

ing the explanations of concepts of momentum, laws of motion, and principles of conservation of linear momentum along with concurrent narration in a female voice.

Experimental Group III: animation + on-screen text + narration.

One hundred and twenty five students were in this group. There were three classrooms designated as G (42) H (43), and I (40). The students in this group viewed animation depicting the explanations of concepts of momentum, laws of motion, and principles of conservation of linear momentum via narration in a female voice along with concurrent on screen text. The narration in groups II and III were done by the same person. Although Moreno and Mayer (2000) had raised the issue of redundancy, this experiment was to test one, the tenability of this principle in an Africa context having found that it failed in Taiwan an Asian culture and two, the conditions under which it will hold or fail to hold.

Control Group: Conventional Lecture Method

There were 129 students in this group. There were three classrooms designated as J (43), K (41), and L (45). The control group was treated with lecture method spiced with questioning. The instructor presented the subject matter using teaching aids to explain the concept of momentum, laws of motion, and principles of conservation of linear momentum. Drawings on charts were used to explain the concepts of Newton's laws of linear momentum as well as principles of conservation of linear momentum. The instructor asked the students questions during the teaching and learning process, and the students were also given the opportunity to ask the instructor questions.

The experiment took three weeks. In each group, there were three sessions per week and each session took 40 minutes. Lessons were taught in each of the intact classes during the normal time allocated for physics on the school official time-table to avoid disruptions of the schools' schedules. Immediately after the students took the physics achievement test their physics note books were collected. The instructors and the author assessed the quality of notes taken by the students. The quality of note taken during lessons (in terms of content) was rated as Good =2, Fair = 1, and Poor = 0. The score formed part of student's final score in physics achievement. This is in line with continuous assessment practice in Nigeria schools. Continuous assessment does not mean continuous testing rather all learning experiences to which

the student is exposed is usually assessed. This includes attendance in class, punctuality, neatness, assignments given, and quality of note taken during lessons. According to Sprinthall, Sprinthall, and Oja (1998) the act of note taking in class during lessons is rehearsal strategy and more over they have the notes to refer to later. Students who take quality notes during lessons are likely to remember more information after taking notes, even if they lose the notes, than do those who simply sit and listen (probably because the act of writing also engages procedural memory)

Data Analysis

A two-way multivariate analysis of covariance (MANCOVA) was conducted to determine the effect of multimedia instruction and mathematics achievement level on students' achievement in and interest in physics. The decision to use MANCOVA was justified in that this method permits the use of more than one criterion measures. According to Tabachnick and Fiddell (2001), the use of several criterion measures permits the researcher to obtain a more holistic picture and therefore a more detailed description, of the phenomenon under investigation. This stems from the idea that it is extremely difficult to obtain a good measure of a trait (e.g. physics learning outcomes) from only one variable. Multiple measures on variables representing a common characteristic are bound to be more representative of that characteristic. A detailed discussion on the conduct of MANCOVA is beyond the scope of the present presentation and is available elsewhere (e.g. Tabachnic & Fidell, 2001).

Results

Linearity between the dependent variables (cognitive achievement in physics and interest in physics) was tested using Pearson correlation co-efficient. Results indicate a statistically significant linear relationship r (517) = .267, p <.001. The relationships between each of the dependent variables and each of the covariates (previous scores in physics and further mathematics) were also statistically significant. MANCOVA test for homogeneity of regression slopes showed that factors and covariates interactions were not significant. For previous scores in physics, Wilks' λ= .962, F (16, 990) = 1.21, p = .253; and for previous scores in further math, Wilks' λ= .962, F (16, 990) = 1.21, p = .250, therefore Wilks' Lambda was used as test statistic. There were no univariate or multivariate within-cell outliers at p = .001.

Descriptive Statistics

Table1. *Adjusted means for physics achievement and interest in physics*

Ind. Variable.	Physics Achievement		Interest in Physics	
	M	SD	M	SD
Treatments				
(i) animation + text	16.18	3.23	14.42	2.37
(ii) animation + narration	16.64	3.16	14.31	2.13
(iii) animation + text + narration	21.49	3.86	15.17	2.15
(iv) lecture	15.36	2.98	12.05	3.83
Math Achievement level				
(i) High	18.18	4.02	13.62	2.63
(ii) Low	16.64	3.99	14.05	2.91

Comparison of adjusted physics achievement means as shown in table 1 indicates that students who learnt physics under multimedia environment in which animation was combined with narration and on screen text had best performance in physics achievement test (M = 21.49; SD = 3.86). The mean score of students who learnt physics under multimedia environment in which animation was combined with narration and those who learnt physics under multimedia environment in which animation was combined with on screen text were (M 16.64; SD= 3.16) and (M = 16.18; SD = 3.23) respectively. Table 1 shows that students who learnt physics under conventional method had the least performance in the physics achievement test (M = 15.36; S = 2.98).

Table 1 also shows the students mean score in interest inventory. The table shows that students who learnt physics under multimedia environment in which animation was combined with narration and on screen text had highest score in interst in physics (M = 15.17; SD = 2.15). The mean score of students who learnt physics under multimedia environment in which animation was combined with narration and those who learnt physics under multimedia environment in which animation was combined with on screen text were (M 14.42; SD= 2.37) and (M = 14.31; SD = 2.13) respectively. Table 1 shows that students who learnt physics under conventional method had the least performance in the physics achievement test (M = 12.05; SD = 3.83).

Table 1 shows that students who were classified as high in math achievement level had higher adjusted mean score (M = 18.18; SD = 4.02) in post physics achievement test than their colleagues who were classified as low in math achievement (M = 16.64; SD = 3.99). Table 1 also shows that students who were classified as low in math achievement level had higher adjusted mean score (M = 14.05; SD = 2.63) in interest in physics than their colleagues who were classified as high in math achievement (M = 13.62; SD = 2.63)

Testing of specific hypotheses

Hypothesis 0ne: There is no statistically significant mean differences in the combined DV of achievement in physics and interest in physics among the four groups (treatment conditions): (a) animation + on-screen text only, (b) animation + narration only, (c) animation + text + narration, and (d) conventional lecture method after removing the effects of covariates (previous scores in physics and further math)

Table 2 which is the Multivariate test of MANCOVA shows that treatment had statistically significant effect on the combined dependent variables (i.e., achievement in physics and interest in physics), Wilks' $\lambda = .57$, $F (6, 1012) = 55.38$, $P < .001$, multivariate $\eta^2 = .247$. . More importantly, the effect size (24.7%) was fair. Therefore the null hypothesis which states that there is no statistically significant mean differences in the combined DV of achievement in physics and interest in physics among the four groups (treatment conditions): (a) animation + on-screen text only, (b) animation + narration only, (c) animation + text + narration, and (d) conventional lecture method after removing the effects of covariates (previous scores in physics and further math) was rejected. There was statistically significant effect of treatment on the combined dependent variables of achievement in physics and interest in physics.

In order to discover which of the two dependent variables (achievement in physics or interest in physics?) is being affected by the treatment, Univariate ANOVA was conducted. In order to counteract the potential of an inflated error due to multiple ANOVAs, Bonferroni-type of adjustment was made (See e.g. Tabachnic & Fiddell, 2001 for more details). Since there were two DVs, the alpha level was` adjusted to .025 for the test of each DV. The results are presented in Table 3.

Table 2. *Multivariate test.*

Effect	Wilk's λ	F	Hypothesis df	Error df
Intercept	.62	155.62***	2	506
Previous Physics Score. (Covariate)	1.00	.60	2	506
Previous further math score (covariate)	.99	2.06	2	506
Treatments	.57	55.38***	6	1012
Math achievement levels	.99	14.13***	6	506
Treatments X Math achievement levels	.99	.95	6	1012

***p< .001

Results as shown in Table 3 indicate that both the DV of physics achievement and interest in physics were significantly affected by treatments after adjusting for the effect of the covariates. For physics achievement, $F (3, 507) = 95.02$, $P <.001$, partial $\eta^2 =.360$. The effect size (36.0%) was fair. This shows that the observed difference in the students' mean score in physics achievement was not due to chance. The treatment produced the effect.

Table 3 also shows that the observed difference in students' mean score in interest in physics was not due to chance. It was statistically significant, $F (3, 507) = 27.79$, $P <.001$, partial $\eta^2 = .141$. The effect size (14.1%) was fair. The treatment produced the effect

Table 3. *Univariate ANOVA Summary of Between-Subjects Effects.*

Source	Dependent Variable	SS	Df	MS	F	Eta Squared
Corrected Model	Achievement	33373.072	9	374.786	36.33***	.392
	Interest	609.306	9	67.701	10.22***	.153
Intercept	Achievement	1606.137	1	1606.137	155.70***	.235
	Interest	1124.988	1	1124.988	169.74***	.251
Previous Physics Score	Achievement	10.456	1	10.456	1.01	.002
	Interest	1.552	1	1.552	.23	.000
Previous Further Math	Achievement	30.843	1	30.843	2.99	.006
	Interest	8.639	1	8.639	1.30	.003
Treatments	Achievement	2940.578	3	980.193	95.02***	.360
	Interest	552.520	3	184.173	27.79***	.141
Math. Achievement levels	Achievement	252.878	1	252.878	24.52***	.046
	Interest	21.914	1	21.914	3.31	.006
Treatments X Math Ach. Levels	Achievement	40.506	3	13.502	1.31	.008
	Interest	12.661	3	4.220	.64	.004
Error	Achievement	5229.880	507	10.315		
	Interest	360.322	507	6.628		

***$p < .001$

Hypothesis Two: There is no statistically significant mean differences in the combined DV of achievement in physics and interest in physics between students with high achievement level and low mathematics achievement level after removing the effects of covariates (previous scores in physics and further math)

Table 2 which is the Multivariate test of MANCOVA shows that math achievement level had statistically significant effect on the combined dependent variables (achievement in physics and interest in physics). Wilks' $\lambda = .95$, $F (2, 506) = 14.30$, P $<.001$ multivariate $\eta^2 =$ .054. However, the effect size (5.4%) was small. Nevertheless, the hypothesis which states that there is no statistically significant mean differences in the combined DV of achievement in physics and interest in physics between students with high achievement level and low mathematics achievement level after removing the effects of covariates (previous scores in physics and further math) was rejected. There was statistically significant effect of treatment on the combined dependent variables.

In order to discover which of the two dependent variables (achievement in physics or interest in physics) is being affected by the math achievement level, Univariate ANOVA was

conducted. The results are presented in Table 3. Results show that only the `DV of physics achievement was significantly affected by math achievement level after adjusting for the effect of the covariates. For physics achievement, F (1, 507) = 24.52, P<.001, partial η^2 = .046. However, the effect size (5.4%) was small. Table 3 shows that the DV of interest in physics was not significantly affected by students' math achievement level.

Hypothesia Three: There is no statistically significant 1st order interaction effect of treatments and mathematics achievement level on combined DV of achievement in physics and interest in physics after removing the effects of covariates (previous scores in physics and further math)

MANCOVA summary of results as presented in Table 2 (Multivariate Tests) indicates no statistically significant interaction effect of treatments and math achievement levels on the combined dependent variables, Wilks' λ = .95, F(6, 1012) = .95, p = .460. Therefore the null hypothesis which states that there is no statistically significant 1st order interaction effect of treatments and mathematics achievement level on combined DV of achievement in physics and interest in physics after removing the effects of covariates (previous scores in physics and further math) was not rejected. There was no statistically significant 1st order interaction effect of treatment and math achievement level on the combined dependent variables

Discussion and conclusions

The findings of this study showed that the concurrent use of animation, narration, and on–screen text in an instructional interface resulted in a significantly better learning outcomes in physics when compared to using animation with text alone or animation with narration alone. This result is in consonnance with that of Chuang (1999) who found that student learning outcome in physics was better with concurrent use of animation, text, and narration, when compared to using animation + text only or animation + narration only. However, the results of this experiment failed to validate Richard Mayer's (2001) multimedia redundancy principle. More over, the result is not in consonance with the findings of some authors (e.g., Mayer, Heiser, & Lonn, 2001; Mayer & Moreno, 2003; Taber, Martens, & van Merriëboer, 2004) who found that learning outcomes of students who learnt Physics with course ware version of

animation + narration was better than their colleagues who learnt physics either with animation + on-screen text or animation + narration + on-screen text.

That the concurrent use of animation, narration, and text in an instructional interface resulted in a significantly better learning outcomes when compared to using animation with text alone or animation with narration only can be explained from the quality of notes taken by the students during the lessons. From the results of quality of notes taken by the students, it was found that students who were in the animation + on-screen text + narration group made more quality jottings than their colleagues in other experimental groups. This could be due to the fact that points missed from narration could be read from on-screen text and vice versa. These double opportunities might have not been available to students in either animation + on-screen text only or animation + narration only. It appears that the more the sources of information the better. The jottings could have been responsible for the observed differences in the learning outcomes. Educational psychologists e.g. Sprinthall, Sprinthall, and Oja (1998) said that jottings made while reading or listening to instructions can enhance retention of information. Sprinthall, Sprinthall, and Oja (1998) maintained that persons remember more after taking notes, even if they lose the notes, than do those who simply sit and listen (probably because the act of writing also engages procedural memory).

The successful integration of instructional information through text, animation and narration is likely to be beneficial to the student. The argument is that the three modes are likely to have complementary roles, and by combining representations that complement each other, learners will benefit from the sum of their advantages. One, the combination of the three modes tends to catch the attention of the students more than having the combination of only two elements. Two, the use of animated narration plus on-screen text tends to provide more opportunities of the students to take more quality notes. Therefore rather than removing what Mayer (2001) referred to as redundant materials, such materials should rather be incorporated when designing multimedia course ware. According to Muller, Lee, and Sharma (2008) the addition of more interesting information via on-screen text in narrated animation tends to maintain the learners' attention and interest in multimedia teaching and learning in a normal classroom situation.

This study revealed that there was statistically significant effect of treatments (i.e. multimedia instruction versus conventional lecture) on students' learning outcomes in phys-

ics. The learners exposed to multimedia instruction performed better in cognitive achievement as well as in the affective domain than those who were taught under teacher-based non multimedia environment. This finding is in accord with Neo and Neo (2000) and Kuti (2006), where technological aids were harnessed for effective teaching and learning of physics.

That multimedia instruction tends to be more effective than the conventional instruction may be explained from the fact that it offers visual and auditory models which literature e.g. Paivio (1986) has identified as very vital factors responsible for what we remember. Multimedia offers a multi-sensory experience to the students and thereby arouses their active participation in the teaching and learning activities in the classroom. While the conventional method of teaching physics may incite cognitive stimulus, multimedia instruction provokes both sensory stimuli as well as cognitive stimuli. Carefully designed, multimedia instruction with its wide variety of interactive formats tends to engage more senses than conventional teaching methods and thus facilitate better learning.

The fact that students with high mathematics achievement level performed better in physics achievement test than their colleagues with low mathematics achievement should not be a surprise. This is because over the years, the correlation between mathematics achievement and physics learning has always being positive and very high (Griffith, 1984; Okpala & Onocha 1988; Olatoye, 2007). Students who are good at mathematics and especially in further mathematics tend to be good also at physics. Physics, no doubt, is surrounded by topics that involve the use of equations, formulae, measurements, and numerical reasoning ability. Students need a fair knowledge of mathematics and further mathematics to be able to cope effectively with these operations as well as understand the fundamental notions and principles of physics.

In conclusion, this study has shown that integrating animations, narratives, and textual information in computer-based environment may help to improve students' learning outcomes in physics. These results suggest that multimedia instruction is a way of reducing students' low level of interest and cognitive achievement in physics. More importantly, students who learn physics in computer-based multimedia environment tend to achieve better learning outcomes in physics than their colleagues who learn physics under teacher-based environment.

References

Chuang, Yea-Ru (1999). Teaching in a multimedia computer Environment: A study of the effects of learning style, gender and math achievement. *Interactive Multimedia Electronic Journal of Computer – Enhanced Learning.* Retrieved December 15, 2000 from http://ime.wfu.edu/articles/1999/1/10/index.asp.

Clark, R.C. & Mayer, R.E. (2003*) e-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*. San Francisco: Jossy-Bass/Pfeiffer.

Coll, C., Rochera, M. J., Mayordomo, R. M., Naranjo, M. (2007). Continuous assessment and support for learning: an experience in educational innovation with ICT support in higher education. *Electronic Journal of Research in Educational Psychology*, *7,* 369 – 396.

Escallada, L.T., & Zollma, D. A (1998). An investigation on the effects of using interactive digital video in a physics class on students learning and attitudes. *Journal of Research in Science Teaching, 34*(5), 467-489.

Garcia-López, M. N., & Romero, I. M. (2009). The influence of new technologies on learning and attitudes in mathematics in secondary students. *Electronic Journal of Research in Educational Psychology*, *5,* 783 – 804.

Griffith, W. T. (1984). Factors affecting performance in introductory physics course. *American Journal of Physics*, *53*(9), 839 – 842

Kim, M., & Ogawa, M. (2007). Development of an instrument for measuring affective factors regarding conceptual understanding in high school physics. *Journal of Korea Association of Research in Science Education, 27*, 497-509

Kuti, J.B. (2006*). Effect of multimedia instructional strategy on Senior Secondary Students' learning outcomes in Physics in Ogun State, Nigeria.* An unpublished M.Ed project, University of Ibadan, Ibadan.

Lavonen, J., Meisalo, V., Byman, R., Uiito, A., & Juiit, K. (2005) Pupil interest in Physics: A survey in Finland. *NORDINA, 2, 72-85*

Lorenzo, M. Crouch, C.H. & Mazur, E. (2006) Reducing the gender gap in the physics classroom. *American Journal of Physics*, *74*(2), 118-122.

Mayer, R.E. (2001). *Multimedia learning.* Cambridge: Cambridge University Press

Mayer, R.E. & Anderson, R. B. (1991). Animations need narrations: An experimental test of a dual-coding hypothesis. *Journal of Educational Psychology*, *83*, 484-490

Mayer, R.E., Dow, G.T., & Mayer, S. (2003). Multimedia Learning in an interactive self explaining environment: what works in the design of agent-based micro worlds? *Journal of Educational Psychology*, *95*(4), 806-813.

Mayer, R.E., Heiser, J. & Lonns, S. (2001). Cognitive Constraints on Multimedia learning: When presenting more material results in less understanding. *Journal of Educational Psychology*, *93*(1), 187-198

Mayer, R.E. & Moreno, R. (1998). A spilt-attention effect in multimedia learning: Evidence for dual processing systems in working memory. *Journal of Educational Psychology, 90,* 312-320.

Mayer, R. E. & Moreno, R. (2002).Verbal redundancy in multimedia learning. When reading helps listening. *Journal of Educational Psychologist 94*, 156-163

Mayer, R. E. & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38*(1), 43–52.

Mayer, R.E. & Sims, V.K. (1994). For whom is a picture worth a thousands words? Extensions of a dual-coding theory of multimedia learning. *Journal of Educational Psychology, 86*(3), 389-401

Mayer, R. E., Steinhoff, K., Bower, G., & Mayer, R. (1995). A generative theory of textbook design using annotated illustrations to foster meaningful learning of science text. *Educational Techology Research and Development, 43*, 31-44

Moreno, R. & Mayer, R.E. (1999). Cognitive principles of multimedia learning. The role of modality and contiguity. *Journal of Educational Psychology*, *91*, 358-378.

Moreno , R., & Mayer, R.E. (2000). A coherence effect in multimedia learning. The case of minimizing irrelevant sounds in the design of multimedia instructional messages. *Journal of Educational Psychology, 97*, 117-125

Muller, D. A., Lee, K. J., & Sharma, M. D. (2008) Coherence or interest: Which is most important in online multimedia learning? *Australasian Journal of Educational Technology, 24*(2), 211-221.

Neo, M., & Neo, K. (2001). Innovative teaching: Using multimedia in a problem-based learning environment. *Educational Technology and Society, 4*(4), 56-75.

Okpala, N.P., & Onocha, C.O. (1988) Students factors are correlates of achievement in physics. Physics *Education (A Journal of British Institute of Physics), 23*(6), 361-365.

Olatoye, R. A. (2007). Effect of further mathematics on students' achievement in mathematics, biology chemistry, and physics. *International Journal of Environmental Education, 2*(2), 48-53

Osborne, J., Simons, S., & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079.

Ozdemir, D. (2009). *The effects of context-dependency of seductive details on recall and transfer in a multimedia learning environment*. Unpublished doctoral thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Paivio, A. (1986). *Mental Representations: A dual-coding approach*. Oxford, England: Oxford University Press.

Paivio, A. (1990). *Mental representations: A dual-coding approach*. New York: Oxford University Press

Park, O. & Hopkins, R. (1993). Instructional conditions for using dynamic visual displays: A Review. *Instructional Science*, *22*, 1-24.

Ragosta, M. (1983). Computer-assisted instruction and compensatory education: a longitudinal analysis. Machine Mediated Learning, 1, 108.

Reiber, L. P. (1991). Animation, incidental learning, and continuing motivation. *Journal of Educational Psychology*, *83*(3), 318-382.

Sprinthall, R. C., Sprinthall, N.A., & Oja, S.N, (1998). *Educational psychology: A development approach (*7th ed*.)* Boston, Massachusetts: Mc Graw

Steinberg, E. R. (1991). *Teaching computers to teach*. Hillsdale, NJ: Prentice Hall.

Stokking, K. M. (2000). Predicting the choice of physics in secondary education. International Journal of Science Education*, 22*(12), 1261-1283.

Swisher, J. D. (2007). *Does multimedia truly enhance learning? Moving beyond the visual media bandwagon instructional effectiveness*. A paper presented to the faculty and staff of Kansas State University at Salina for the K-State at Salina Professional Day. January 5.

Tabachnick., B.G., & Fidell, L. S. (2001). *Using multivariate statistics (4th Ed.)*. Needham Heights MA: Allyn and Bacon.

Tabers, H.K. Martens, R.L., & Van merriënboer, J.J.G. (2004). Multimedia instructions and cognitive load theory: Effects of modality and cueing. *British Journal of Educational Psychology, 74*, 71-81.

Thalheimer, W. (2004). Bells, whistles, neons and purple prose: when interesting words, sounds, and visuals hurt learning and performance- a review of the seductive-augmentation research. Retrieved from http: www.work-learning.com/seductive_augmentation

West African Examination Council (2009). *Chief Examiners' Report*. Lagos, Nigeria: WAEC