

EFFECT OF MULTIMEDIA INSTRUCTION ON SENIOR SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN PHYSICS

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Abstract: In this article, the author examined the effect of multimedia instruction on senior secondary school students' cognitive achievement in physics. The sample comprised of 198 (106 boys and 92 girls) students who came from four senior secondary schools in Isokan and Ayedade local Government Areas, Osun State, Nigeria. There were three experimental groups and a control group. Three courseware versions namely, animation + on-screen text, animation + narration, animation + on – screen text + narration were developed to examine the interface effects. A conventional lecture method group served as control. The dependent variables were cognitive achievement in recall and transfer items in physics test. The quality of notes taken by the students during lessons was also assessed. Results showed that, on the average, students in the animation + on-screen text + narration group took best *quality* notes and this seemed to have influenced their superior cognitive achievement in physics. Generally, students under multimedia instruction performed better than their colleagues in the lecture group. These findings suggest that learning outcomes of students in physics can be enhanced with multimedia instruction.

Key words: Physics education, Multimedia instruction, Richard E. Mayer, Physics achievement, Multimedia learning principles

INTRODUCTION

Developing countries especially in Africa have realized the importance of physics education in their quest for technological development. This is because physics is the basic index for understanding the complexities of modern technology. In her bid towards encouraging secondary school students to offer and perform excellently in physics the Federal Government of Nigeria in collaboration with the States' Ministries of Education, every year, supply physics equipment to schools and employ physics teachers. Despite this, the current trend in the enrolment figure of students in physics at the secondary school level in developing nations is quite low. For example, in Nigeria, between 2005 and 2009, on the average, less than 30% of the total students who registered for senior secondary school certificate examination (SSSCE) entered for physics (The West African Examination Council (WAEC), 2009). More importantly, statistics of entries and results (e.g., WAEC, 2009) show that the level of performance of students in physics in SSSCE is low. On the average, about 40% of the students who sat for Physics in SSSCE passed at the credit level. The same trends were observed in 2008, 2007, and 2006 SSCE results released by WAEC.

This phenomenon seems to cut across cultures. Literature on physics education world wide (e.g. Kim and Ogawa, 2007; Lavonen, Meisalo, Byman, Uitto & Juuti 2005; Osborne, Simons and Collins, 2003; Lorenzo, Crouch, and Mazur 2006, Stokking, 2000) confirms this observation. Many reasons have been adduced for the observed low level of enrolment and poor performance of students in physics in SSSCE. These include, among others, students' poor attitude towards physics (e.g., Onadeko, 2009; Sheikh, 1982), perceived abstract and difficult nature of physics (e.g. Okpala and Onocha, 1988), poor teaching and learning environment and lack of modern equipment (e.g., Adegoke, 2010; Kuti, 2006), poor mathematical ability of the students (Griffith, 1984; Olatoye, 2007; Tuminaro & Reddish, 2003), and poor teaching method being adopted by many physics teachers (Onadeko, 2009).

In what ways can we help students understand and learn physics better and more importantly, encourage their future involvement in physics? One promising approach, according to Adegoke (2010), Chuang (1999), Kuti (2006), Mayer, Dow, and Mayer (2003), Moreno and Mayer (2000), involves multimedia presentations of explanations in visual and verbal formats such as presenting a computer-generated animation synchronized with narration or on-screen text.

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), lightning formation (Moreno & Mayer, 2000), 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. This phenomenon according to Adegoke (2010) is gradually being observed in developing countries too. However, observations have shown that the use of computer in developing countries, for example Nigeria, as teaching and learning aid is being restricted to privately owned institutions and public schools where children of the affluent attend.

Dual-coding theory (Paivio, 1990) and cognitive theory of multimedia learning (Mayer, 2001) provide theoretical support for the use of verbal and non-verbal codes in lesson presentations and these theories provide the theoretical framework for this study. 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) 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.

According to Mayer "there are two ways of conceptualizing the differences between the two channels – one based on representation modes and the other based on sensory modalities" (Mayer, 2005, p.34). With the *representation mode* approach, the conceptualization which is most consistent with Paivio's (1990) theory of dual coding, one channel processes presented stimuli which are verbal – such as spoken or printed words, and the other channel processes presented stimuli which are pictorial – such as pictures, video, animation, and background sounds (as cited by Mayer, 2005, p.34). With *sensory modalities* approach, the conceptualization most consistent with Baddeley's (1999) distinction between the visuo-spatial sketchpad and the phonological (or articulatory) loop, the emphasis is on which of the senses is used: the eyes (pictures, video, animations, or printed words) or the ears (spoken words or background sounds) (Mayer, 2005, p.34; Swisher, 2007).

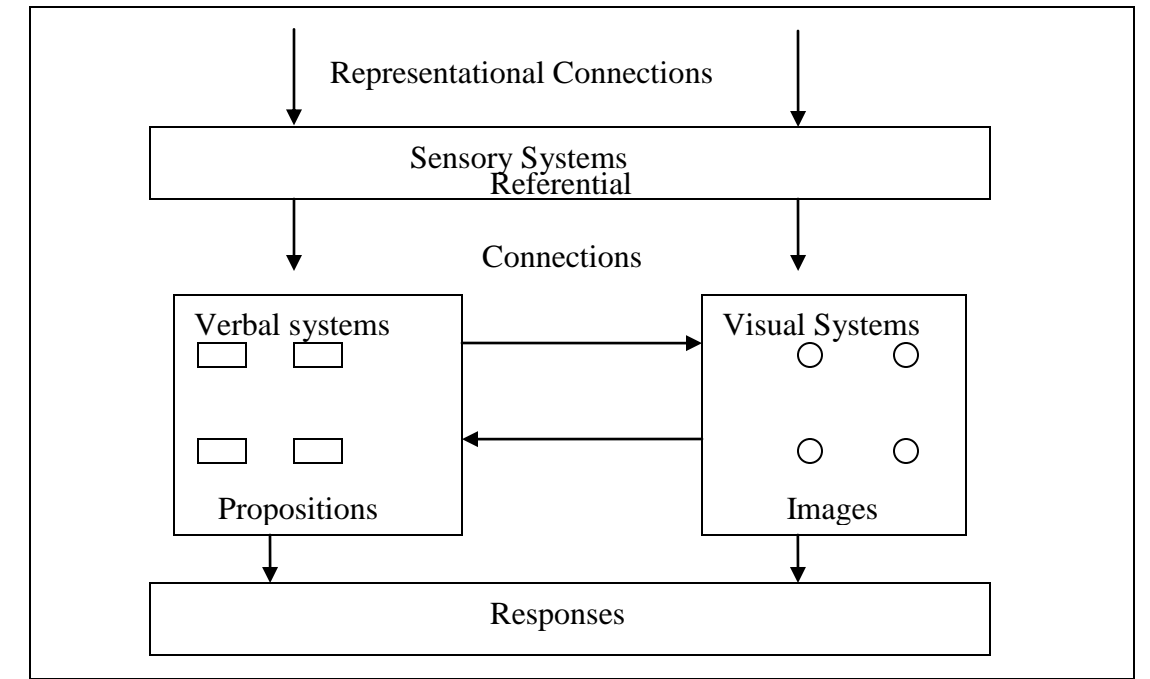


Figure 1: The dual-coding model for cognitive processing of animation speech Adapted by Richard E. Mayer (2001) from *Mental Representations: A Dual-Coding Approach*, p.67 by A. Paivio (1990)

Building upon Paivio's dual-coding theory, Mayer, developed cognitive theory of multimedia learning. 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. As a result of series of studies on multimedia, 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 when words in a multimedia are presented as spoken text rather than printed text (f) the redundancy principle – students learn better from animation and narration than from animation, narration and on-screen text (See Mayer,2001 for more detailed discussion).

All the six principles are well established and well documented, are solidly grounded in theory, and have been proven repeatedly in empirical research (e.g. Mayer, Bove, Byrman, Mars, & Tapangco, 1996 for multimedia principle; Mousavi, Low & Sweller 2005 for modality principle; Kalyunga, Chandler, & Sweller, 1995; Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 2000; Taber, Martens, & van Merriëboer, 2004 for redundancy principle)

However, not all studies have upheld Mayer's (2001) principles of multimedia learning. Studies (e.g. Chuang, 1999; Doolittle & Aldstaedter, 2009; Lusk, 2008; Muller, Lee, & Sharma, 2008; Ozdemir, 2009; Thalheimer, 2004) have reported findings that were not in consonance with Mayer's (2001) multimedia learning principle. For example, Muller, Lee, and Sharma (2008) found that the redundancy principle did not transfer to normal classroom situation. In their study, Muller et al (2008) suggested that addition of interesting information may help maintain the learners' interest in normal classroom environment. The findings of Chuang's (1999) and Adegoké (2010) studies were also not in agreement with the redundancy principle. For example, Adegoké (2010) and Chuang (1999) in their studies examined the effect of animation, narration and on screen text-based materials when combined simultaneously, the result showed

that students in the animation + narration + on-screen text group scored significantly higher on the post physics achievement test than their colleagues who were in the animation + narration only group as well as those who were in the animation + on-screen text group.

On redundancy principle, the lack of congruence between the findings of (Moreno & Mayer, 2000; Taber, Martens, & van Merriëboer, 2004) and those of (Adegoke, 2010; Chuang, 1999; Muller, Lee, & Sharma, 2008) 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 text presentations of content in a computer-based environment on students learning, generally, and in physics in particular. This study will also provide empirical evidence whether there are potential effects of narrated animation plus text presentations of physics concepts, in a computer-based environment, on students' cognitive achievement in physics. This becomes more important in settings like Nigeria where it has been observed that students' level of performance and enrolment in physics is low.

The first goal of this study was to determine the most effective way of combining 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 combination of elements will contribute most to the students understanding and, therefore, enhance learning outcomes in physics? The conventional mode of instruction i.e. lecture method is still in vogue in most schools in Africa. In fact, the use of computer as an aid to teaching and learning in most schools in Africa is restricted to very few privately owned schools and public schools where the children of the affluent attend. Will the learning outcomes of students in physics in teacher-based teaching and learning environment be better than their colleagues learning physics in computer-based multimedia environment? This explains the inclusion of a control group in which instruction was carried out through the use lecture method.

The second goal of this study was to find whether there exist significant differences in the quality of notes taken by the students in each of the contrasting groups. Therefore the quality of notes taken by the students was assessed to determine whether it could be used to establish a link between treatment and students' learning outcomes. 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 students were exposed is usually assessed. These include attendance at class meetings, punctuality, neatness, promptness in doing home assignments, and quality of notes taken during lessons. All these are usually assessed to have a holistic picture of students' learning outcomes. The need for assessing the quality of notes taken by the students becomes clearer if one considers the submission of educational psychologists. For example, Sprinthall, Sprinthall, and Oja (1998) stated that the act of note taking in class during lessons is rehearsal strategy and more over, students 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).

Specifically, the following hypotheses were advanced for testing.

- 1) Students' achievement in recall and transfer tests depends on the multimedia treatment group they belong.
- 2) The quality of notes taken by senior secondary schools students in physics class depend on the multimedia treatment group which they belongs.

METHODOLOGY

Participants:

One hundred and ninety eight senior secondary two students who were drawn from four senior secondary schools in Isokan and Ayedade Local Government Areas, Osun State, Nigeria participated in the study. Four intact science classes were used. Among the 198 students who were sampled, 106 were boys, while 92 were girls. Their ages ranged between 15 and 17 years (Mean age = 17.8; SD = 2.74).

Instruments

Two instruments were used. These were: Multimedia Instruction Software (MIS) and Physics Achievement Test (PAT).

MIS: There were three versions of multimedia instruction software. These were: animation + text; animation + narration; animation + text + narration. Each version of MIS was prepared using the Microsoft Power Point application and presented using Window Movie Maker. Accessories like digital projector, a laptop, digital versatile disks, and white screen board were also used. The experimental courseware used for this study covered the topics of linear momentum (i.e. impulse and momentum, Newton's laws of motion, and principle of conservation of linear momentum) as prescribed in the science curriculum for senior secondary school students by the Federal Ministry of Education, Abuja, Nigeria.

PAT: This was a 25-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 five weeks experiment. Thirteen items tested students' ability to recall what they have learnt while twelve items tested students' ability to apply what they have learnt to solve problems. (See Appendix 1 for the details of the 25 items). The difficulty indices of the items ranged from 0.73 to 0.84 (recall items) and 0.69 to 0.81 (transfer items). The reliability coefficient of the PAT was 0.86 (recall items) and 0.78 (transfer items). The administration of the physics achievement test took 50 minutes.

Procedure: Four intact classes were used for this study. The physics teacher in each school served as an assistant. 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 physics scores (converted to standard scores by the researcher) in the previous first term examination conducted by their schools were used as covariates.

Before the commencement of the experiment, the students were told to pay attention to the presentations during sessions and that their scores in the post physics achievement test will form part of their continuous assessment for the month of May 2010. In each of the experimental groups, during each session, the researcher with the assistance of the physics teacher in each school set up the equipment – laptop and the digital projector and then slotted in the DVD on which the presentations had been saved. This was then projected on the white board screen. Once the session started, the researcher and the physics teacher sat at the back of the classroom and also watched the video.

The study lasted five weeks. In each of the groups there were five sessions (i.e. one session per week). Each session lasted 80 minutes. The presentation in each session had 20 segments and each segment was programmed to last four minutes. The examples of frames used are as presented in figures 2 (i.e. animation + on screen text), 3 (i.e. animation + narration), and 4 (i.e. animation + on screen text + narration). These frames illustrate the Principle of conservation of linear momentum (i.e. momentum of bodies before they collide).

In each of the groups, the students were instructed to jot down in their physics notebooks, key points seen or heard while watching the video during the experimental sessions. Students in the control group were also

told to take notes of important key points written on the chalk board or spoken by the instructor during the experimental sessions.

Experimental Group I: animation + on-screen text only

Fifty one students were in this group. Students in this group watched the video which showed animations 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

Forty seven students were in this group. The students in this group watched the video which showed animations depicting 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.

Fifty students were in this group. The students in this group watched the video which showed animations 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.

To avoid differences in voice, the same woman who carried out narration for the presentations in the animation + narration group also did the narration in the animation + on - screen text + narration.

Control Group: Conventional Lecture Method

Fifty students were in this group. The control group was treated with lecture method. The researcher 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.

In each of the groups, lessons were taught in the intact classes during the normal time allocated for physics on the school official time-table. This was to avoid disruptions of the schools' schedule. PAT was administered on the last day of the fourth week. At the end of each presentation the researcher collected the physics note of each student and appended his signature. At the end of the of the experiment, in line with the continuous assessment practice in Nigeria educational system, the quality of notes taken by each of the students during the experimental sessions (in terms of content) was rated and the maximum point obtainable was 100 while the minimum point obtainable was 10. In continuous assessment practice in Nigeria, zero point (0) is rarely given. For the purpose of this study, two graduate students in the Department of Teacher Education, University of Ibadan rated the quality of note taken by each of the students and the average score for each student was recorded. The inter-rater reliability of their ratings ranged between 0.85 and 0.89.

The scores of the students in the quality of note taken during the experimental sessions were used to divide them into four groups: Very Good Note; Good Note; Very Fair Note and Fair Note. Students whose scores fell on or above 75th percentile were classified as the Very Good Note Group with an average score of 77.0 on a 100-point scale. Students whose scores were between 74th and 50th percentile were classified as the

Good Note Group with an average score of 60.5 on a 100-point scale. Students whose scores were between 50th and 25th percentile were classified as very Fair Note Group with an average score of 50.5 on a 100-point scale, while students whose scores were between were below 25th percentile were classified as Fair Note Group with an average score of 26.5 on a 100-point scale.

Data Analysis: Mean Standard Deviation, Multivariate Analysis of Covariance (MANCOVA), Frequency Counts, Percentages and Chi Square.

RESULTS

A one – way MANCOVA was conducted to determine the most effective way of combining text, narration and computer animation in the presentation of instructional materials in physics teaching and learning in the classroom. The conventional lecture method served as the control. The dependent variables were achievement in recall as well as transfer items in the physics test. Linearity between the dependent variable variables was tested using Pearson correlation coefficient. Results indicate a statistically significant linear relation, $r(198) = .501, p < .05$. The relationships between each of the dependent variables (students’ achievement in the recall and transfer items) and the covariate were low. MANCOVA test for homogeneity of regression slopes showed that factors and covariate interaction was not significant; therefore Wilk’s Lambda was used. There were no univariate or multivariate within cell outliers at $p < .001$.

Descriptive Statistics

Tables 1 and 2 present the mean scores (and standard deviation) of the students’ achievement in the recall and transfer items respectively.

Table 1: Descriptive Statistics of Recall scores

Group	N	Mean	SD	Lower Bound	Upper Bound
				95% Confidence Interval	
A + T	51	7.75	2.59	7.23	8.75
A + N	47	6.94	2.89	6.03	7.87
A + N + T	50	8.55	2.94	7.71	9.22
CLM	50	6.70	2.76	5.64	7.87

Note: A+ T, A + N, A + N + T, and CLM represent animation + on screen text only, animation + narration only, animation + narration + on screen text, and conventional lecture method respectively.

Comparison of students' achievement in recall items in table 1 indicates that students in the animation + narration + on screen text group had the best performance. This group was closely followed by students who were in the animation + on –screen text group. Students in the conventional lecture method group had the least performance.

Comparison of students' achievement in transfer items in table 2 indicates that students in the animation + narration + on screen text had the best performance. This group was closely followed by students who were in the animation + narration group. Students in the conventional lecture method group had the least performance.

Table 2: Descriptive Statistics of Transfer scores

Group	N	Mean	SD	Lower Bound	Upper Bound
95% Confidence Interval					
A + T	51	6.53	3.70	5.86	7.74
A + N	47	7.62	3.32	6.82	8.76
A + N + T	50	8.36	3.77	7.32	9.20
CLM	50	6.14	2.98	6.81	6.76

Note: A+ T, A + N, A + N + T, and CLM represent animation + on screen text only, animation + narration only, animation + narration + on screen text, and conventional lecture method respectively.

Testing of specific hypotheses

Hypothesis One: Students' achievement in recall and transfer tests depends on the multimedia treatment group they belong.

Table 3 presents the MANCOVA results and it reveals significant differences among the four groups (A + T, A + N, A+ N + T and CLM) on the combined variables (recall and transfer items in PAT), Wilks' $\Lambda = .866$, $F(6, 384) = 4.78$, $p < .001$, multivariate $\eta^2 = .070$. The significant difference observed in the achievement among the four groups indicates that the null hypothesis one must be rejected. The covariate (previous score in physics) significantly influenced the combined dependent variable, Wilks' $\Lambda = .922$, $F(2, 192) = 8.09$, $p < .001$, multivariate $\eta^2 = .078$.

Table 3: Multivariate Test

Effect	Wilk's λ	F	Hypothesis df	Error df
Intercept	.992	7.50**	2	192
Previous score (Covariate)	.866	8.09***	2	192
Treatment	.866	4.78***	6	384

Note: ** $p < .01$; *** $p < .001$

In order to discover which of the two dependent (recall items and transfer items) is being affected by the treatment, univariate ANOVA was conducted. Also to counteract the potential of an inflated error due to multiple ANOVAs, Bonferroni – type of adjustment was made. Since there were two dependent variables, the Alpha level was adjusted to .025 for the test of each dependent variable (See Tabachnic & Fidell, 2001). The results are presented in Table 4.

Table 4: Univariate ANOVA summary of between – subjects' effect

Source	Dependent Variable	SS	Df	MS	F	Eta Squared
Corrected Model	Recall	286.568	4	71.642	6.52***	.116
	Transfer	206.145	4	51.536	7.04***	.127
Intercept	Recall	66.618	1	66.618	5.87*	.030
	Transfer	109.924	1	109.924	15.01***	.072
Covariate	Recall	132.466	1	132.466	11.68**	.057
	Transfer	100.770	1	100.770	13.76***	.067
Treatments	Recall	175.859	3	58.620	5.17**	.074
	Transfer	124.580	3	41.527	5.67**	.081
Error	Recall	2188.886	193	11.341		
	Transfer	1413.850	193	7.326		

Note: * $p < .05$; ** $p < .01$; *** $p < .001$

Results as shown in Table 4 indicate that both the DVs of recall and transfer were significantly affected by treatments after adjusting for the effect of the covariates. For recall items, $F(2, 193) = 5.17$, $p < .01$, partial $\eta^2 = .074$. The effect size of 7.4% is however small. Nevertheless, the observed difference in the students' achievement in recall items was not due to chance. The treatment effect produced the effect. Scheffé post hoc results for recall items show that students in the animation + narration + on –screen text group differ significantly from those in the animation + narration and conventional lecture method groups.

For transfer items, $F(2, 193) = 5.67$, $p < .01$, partial $\eta^2 = .081$. The effect size of 8.1% is however small. Nevertheless, the observed difference in the students' achievement in transfer items was not due to chance.

The treatment effect produced the effect. Scheffé post hoc results for transfer items show that students in the animation + narration + on-screen text group differ significantly from those in the animation + text and conventional lecture method groups.

Hypothesis Two: The quality of notes taken by senior secondary schools students in physics class depend on the multimedia treatment group which they belongs

Treatment and quality of note taken by the students

Table 5 presents the relationship between treatment and quality of notes taken during the experiment.

Table 5: Relation between Treatment and Quality of Notes taken by the Students

	Number of students in each category				
	Very Good	Good	Very Fair	Fair	Total
Treatment					
A + T	5	10	7	29	51
A + N	6	6	29	6	47
A + N + T	6	26	15	3	50
CLM	5	10	25	10	50
Total	22	52	76	48	198

Note: A+ T, A + N, A + N + T, and CLM represent animation + on screen text only, animation + narration only, animation + narration + on screen text, and conventional lecture method respectively

Although among the four groups, there is no major difference in the number of students whose quality of note taken were rated very good, there is a major difference in the number of students whose quality of note taken were rated good. The table shows that out of 52 students whose quality of note taken during the experiment were rated as good, 26 representing 50.0 % were in the animation + narration + on-screen text group. By collapsing very good and good, table 5 shows that students in the animation + narration + on-screen text group took the best quality note. The observed difference in the quality of note taken by the students was statistically significant, $\chi^2(9, N = 198) = 67.34, p < .001$.

DISCUSSION AND IMPLICATION OF FINDINGS

In both the tests of recall and transfer of knowledge, students who were in the group of animation, narration, and on-screen text had the highest mean score. 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 when compared to using animation with text alone or animation with narration alone. The results of this experiment failed to validate Richard Mayer's (2001) multimedia redundancy principle. More over, these findings are not in consonance with the findings of Moreno and Mayer (2000) and Taber, Martens, and 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. In contrast, this results are in agreement with Chuang (1999) and Adegoke (2010) who found that students' learning outcomes in physics were better with concurrent use of animation, text, and narration, when compared to using animation + text alone or animation + narration alone.

Data on the assessment of the quality of note taken by the students show that student in the animation + text + narration group, on the average 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 who were in either animation + on-screen text alone or animation + narration alone. It appears that the more the sources of information the better. The jottings could have been responsible for the observed differences in the learning outcome. Educational psychologists e.g. Sprinthall, Sprinthall, and Oja (1998) said that jottings made while reading or listening to instructions in the classroom can enhance retention of information. They 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 implication of this is that when students are listening in the class to computer-based instruction they should be encouraged to take notes. Not only do they have the note to refer to later, but the act of note taking is a rehearsal strategy.

To improve students' cognitive achievement in physics, the findings of this study show that when designing multimedia course ware, and taken into consideration that students will be given the opportunity to take notes, the author wishes to suggest that, rather than removing what Mayer (2001) referred to as redundant materials, such materials can be incorporated. According to Muller, Lee, and Sharma (2008) the addition of more interesting information via on-screen text in narrated animations tends to maintain the learners' attention in multimedia teaching and learning in the classroom situation. The author is of the view that addition of more interesting information tend to afford the students the opportunity to take more notes.

This study revealed that learners who were exposed to computer-based multimedia instruction performed better in both recall and transfer items than their colleagues who were taught under teacher-based environment. That multimedia instruction tends to be more effective than the conventional instruction may be explained from the assumption that it is multi - sensory. It stimulates both the visual and auditory senses of the learner and helps the teacher turn the classroom into a dimension of sight, of sound. Therefore multimedia has properties that can aid learning, particularly the learning of abstract subject matter. The findings of this study lay credence to this idea. This result is in accord with the findings of Kuti (2006) where technological aids were harnessed for effective teaching and learning of physics. It is, however, not in consonance with Koehler, Yadav, Phillips and Cavazos-Kottke (2000) who concluded that the use of video does not improve learning.

No matter how highly organized lecture method might be the use of computer-based multimedia instruction in most African countries tends to arouse the interest of students in physics (and indeed in most school subjects) more than teacher - based instruction. The use of computer-based instruction in schools is still something of novelty in most African countries including Nigeria. For example, in Nigeria, statistics show that about 70% of senior secondary school students have never touched a computer not to talk of

experiencing teaching - learning activities which are computer based (Kuti, 2006). The reader can imagine the level of enthusiasm that its use generated in the schools and among the students who were sampled in this study.

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