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Creating Engaging 3-D Animation Digitization for Instructional Media and Health Communication

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Abstract: In this study, the significant difference in the post-test performance scores of students in 3-dimensional animation (3-D) production using manual animation technique for control group and computer animation for the experimental group were investigated. The researcher examined the quality of students' animation productions based on the design variables (spatial, dynamics, design, transition and sound attributes) with extrinsic variables (instructional approaches and animation production tasks). The sample consisted of forty undergraduate students drawn from a Nigerian University. A researcher designed 3-Dimensional Animation Production Skill Test (APST), was administered to the students as a pre-test. The experimental group (consisting of 20 students) was taught using computer animation techniques, while the control group (consisting of 20 students) was taught using manual animation techniques. After the treatment, the APST was re-administered as a post-test. Three research questions stated were analysed using the t-test at 0.05 significance level. Findings from the research questions indicated that students who were exposed to computer animation instruction performed better than their counterparts exposed to manual animation instruction. Based on the findings, recommendations were made on the need to improve the quality of instructional material preparations in educational technology setting.

Key words: Undergraduate, computer animation, 3-dimentional animation, animation production skill, achievement levels, manual animation

INTRODUCTION

Several animation production strategies have been proposed towards supporting the effectiveness of instructional animation and media, however the question on how animations should be designed so that learning is optimized, is still inconclusively under discussion (Koning *et al*., 2007; Moreno, 2007; Hasler *et al*., 2007). Animations are often cognitively very demanding and are often designed to present information that involves change over time, in such a way as to aid understanding and facilitate learning. Findings have reveled that segmenting instructional animations into small chunks could encourage novice students learn from complex dynamic visualizations (Moreno, 2007). Drawing of complex 3D objects moving arbitrarily in space is very difficult with the traditional method of animation as the rendition of perspective foreshortening of edges may present too many problems. However, this problem may be solved using a computer. Once a 3D object has been digitized and input to a computer, it could be viewed from any point of view in space. Furthermore, very advanced rendering software tools can be used for producing full-colored views of these objects when illuminated by imaginary lights. Software environments have also been developed that enable any feature of this virtual world of objects, lights and camera to be animated.

In recent years, great developments have been made in making synthetic objects behave the way they do in the real world. For example, a ball can be made to bounce by using the equations of motion to animate its movement. A flag can be animated by simulating the forces that act upon its surface when blown by a breeze and articulated human characters can be made to walk, run, jump and even talk with realistic human gestures. Based on the assumption of a working memory processor devoted to human movement, cognitive load theory is used to explore some conditions under which animated instructions are hypothesized to be more effective for learning than equivalent static graphics (Koning *et al*., 2007).

Constructing computer models from flat facets is very common, as modeling procedures such as surface

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extruding and contour sweeping can be used to build a wide range of useful structures. Extruding is a manufacturing process whereby a material such as plastic or aluminum is forced under pressure through a die. The die's shape then determines the cross-section of the extrusion. This same technique can be implemented in software where an outline 2D shape used to develop a 3-D extruded volume of a given length. It is often used for modeling extruded letters and artifacts such as boxes and cylinders. Another manufacturing process involves forming a surface as it turns on a lathe. In computer graphics the equivalent modeling technique is used to develop swept surfaces or surfaces of revulsion. To construct symmetrical objects such as glasses, spheres, bottles, etc., all which is required is a contour, which when rotated 360 degrees in discrete angles, sweeps out the required surface.

Once an object has been modeled it resides within the computer memory as a collection of numbers and the next stage is to view it upon a display screen for onward surface coloring and perhaps reveals illumination highlights and shadows, this is referred to as rendering. To obtain a rendered image, four pieces of information are required. First, an object must be defined and located somewhere within in the imaginary world space. Second, the object must be assigned a color; this might be in the form of levels of red, green and blue, or values of hue, saturation and lightness. Third, the computer needs to know where an imaginary camera is located in world space and its focal print to determine how the object will appear on the display screen. Finally, one or more imaginary light sources must be located in world space so that the rendering program can compute the brightness of different parts of the object's surface. Nowadays, researchers have discovered a plethora of techniques for increasing image realism to such an extent that in some circumstances it is impossible to detect its synthetic origin. The number of bits assigned to each pixel dictates the maximum number of colors associated with an image. One bit per pixel can store a BI-level image; eight bits per pixel can store 256 Grey levels, while eight bits for each primary color (i.e., 24 bits) can store 16.7 million colors. Therefore, the number of colors is determined by the number of bits allocated to each pixel in the frame store.

Realism is greatly improved by covering surfaces with a texture and this could be achieved by supplying the renderer with a photograph of a real texture such as wood, marble or cloth, which is then applied to relevant surfaces, taking into account the effects of perspective. This commonly used technique is known as environment mapping, unfortunately, none of the techniques discussed above could be used to create natural shadows, these must be calculated by separate procedures or using ray tracing. Ray tracing is responsible for a style of imagery that reveals single and multiple reflections, shadows and refraction. These images often depict scenarios where everything is perfectly clean; every ray of light bounces off precise smooth surfaces and polished surfaces reflect their environment. Other effects for improving image realism include bump-mapping, 3D texture, particle systems, glows and atmospheric absorption. Bump mapping, as the name suggests, is used to cover an object with a simulated bumpy surface such as leather or even orange peel. 3D texture is a technique where various realistic textures such as marble, wood and a computer program can describe objects. Particle systems are very large collections of coloured light points and when a computer program is used to control their colour, position and size they can be used to model a wide variety of special effects. For example, firework explosions are a perfect application for particle systems; a program simply moves the particles away from central point with a sudden expansion and then computes their fall under the action of gravity. Other applications include water spray, forests, cornfields and fire. There are several application of animation for instructional delivery in existing literatures, detailed in the related work section of the study, but none of them effectively does enough work within Nigeria phenomena under consideration in this study.

In this study, the researcher examined the quality of students' animation productions based on the design variables (spatial, dynamics, design, transition and sound attributes) with extrinsic variables (instructional approaches and animation production tasks). To achieve this, a researcher-designed 3-Dimensional Animation Production Skill Test (APST), was administered to the students as a pre-test. The significant difference in the post-test performance scores of students in 3-dimensional animation (3-D) production using manual animation and computer animation techniques were investigated. The students were made to respond to the major challenges of preparing instructional animation bearing in mind Nigeria socio-cultural environment. Computer was used to accomplish this task by the experimental group while the control group used the manual animation strategies. The result of the findings is what this paper reports.

Competence in the production of animation and development of local educational materials is seen as a projection of technological transfer that is craved for by countries all over the world. Consequently, the essence of design and development in this sector is rooted in building up an appropriate technology that will serve educational purpose in Nigeria (Ogunranti *et al*., 1982).

In the history of Nigerian educational system, animation illustration for instructional purposes are carried out manually in Educational Technology Centres in Nigeria with little or no adequate technical know-how about the advantages and versatility of computer and how computer can be used to generate indigenous 3-D animation for media purposes. Most educational technologists and artists in Nigeria still engage in manually generated animation for media purposes (Onasanya, 1997). Students have also been producing 3-D animation manually using the manual approach that is time consuming, energy-sapping and methodically outdated, in view of the profusion of ideas, concepts, values and unlimited animation facilities that abound in computer as a sign-vehicle for animation production. Most educational technologists and artists generally have positive attitude towards the relative animation through computer. But empirical studies using the educational technology students in the Nigerian universities have revealed that there is lack of computer animation awareness by students (Onasanya, 1997). The researcher observed that a lot of research works have been carried out on computer animation outside Nigeria. This is evident in the works of Halas and Manvell (1978), Todd *et al.* (2006) and Vince (2004). In Nigeria, evidence of computer animations is only seen on television in the areas of advertisement and entertainment. Literarily, works on 3-dimensional animation in Nigeria are not known to the researcher within the Nigerian school system.

Findings also revealed that for a long time in the history of the Nigerian educational system, efforts have not been intensified on the designing and production of indigenous instructional animation and cartoons where animations could be made to reflect our cultural settings, background and values with synchronized traditional languages (Yoruba, Hausa and Igbo). Rather, existing studies were done outside Nigeria (Halas and Manvell, 1978; Vince, 2004).

Presently, the areas exploiting the benefits of computer animations are the advertising and film industries, where sponsorship even comes from governmental and non-governmental organizations. Educational television in Nigeria relies mostly on foreign works on animation. These foreign works on animation are in fact produced to suit the culture and the educational values of the countries where they are produced. That explains why most of them do not fit into Nigerian classrooms but are used for mere entertainment. It is against this background that the researcher feels highly concerned about this problem as a need to be satisfied and a gap to be filled.

Research findings have proved the tremendous help that media give in instructional communication, adult training and community development all over the world. It has been noted that media have not displaced the teacher as perceived by some people, but on the contrary and more than ever before, the teachers need the media for effective communication. For effective use of the media and for the realization of the advantages they can offer, the instructional media designer and the classroom teachers must gear their efforts towards improving on the techniques of media design utilization for global instructional development. It is within that context that the full meaning of media can be realized (Ogunmilade, 1984; Ogunranti *et al*., 1982).

Computers are tool which can enhance effective instructional media design and development. Computers are also revealing new ways of creating images and are providing creative methods for processing media. But perhaps the most exciting contribution is in 3-D applications where computer animation is used in education, television, video, games, industrial and military simulations, advertising, scientific visualization, medicine and film production (Vince, 2004; Mealing, 1992; Sun Microsystems, 1992). In education, computer animation is frequently used to illustrate geometric mathematics and scientific principles. Computer animation for simulations, drama, stories and plays are evident in Walt Disney and in the popular TV production Sesame Street.

In Nigeria, Sesame Street program is a highly popular foreign Educational Television (ETV) program that has succeeded in convincing people of its effectiveness. The program is produced and transmitted through TV stations in Nigeria for the enrichment of classroom lessons and to cater for pupils in the pre-primary, early primary schools and for the consumption of the general public (Daodu, 1992).

The television industry has been using computer animation for several years. Program titles, special effects, view and current affairs programs rely on computers to provide interesting, cost-effective and flexible methods for creating synthetic images. Video games have now become very sophisticated and demand a high level of user attention and interaction. Many games take the form of simulation exercises where the player is allowed to drive a racing car or motor bike at dangerous speeds, or even fly a plane and take part in an imaginary air battle. This form of animation is rapidly moving into the domain of Virtual Reality Systems (VRS) where the player is visually isolated from the real world and placed within a virtual synthetic world. Wearing an interactive suit and gloves, the player is able to interact with objects that have no physical existence (Monaco, 2000).

Many industries are already using computers for Computer Aided Design (CAD) and can design anything from a bracket to an automobile body. One of the benefits of holding such objects in a digital form is that they can be incorporated into computer programs that subject them to imaginary rotary force. For example, a car's suspension can be investigated using computer animation techniques, given a suitable graphics workstation, a designer can observe in real time, the motion characteristics of a vehicle as it is driven over simulated road surfaces. By interactively changing the parameters controlling the features of the car's suspension, the designer can use animation to identify optimum conditions (Vince, 2004).

The advertising industry is a major employer of computer animation. Everyday objects, such as boxes of soap powder, cans of beer, bottles of bath cleaner and teapots are digitized in order to create a photo-realistic synthetic image (Onasanya, 1997). With the aid of 3-D animation programs, the object can be subjected to perform acrobatic tasks that would be impossible with their real-world counterparts. So, realistic are these renderings that, it is virtually impossible to detect what is real and what is computer-generated. The domain of scientific visualization depends considerably upon animation techniques to assist in revealing information that is often hidden within large sets of data. In the field of remote sensing, where satellites monitor the world's surface and transmit back to earth, vast amount of data, stereoscopic images enable the 3-D surface topology to be computed. Once this geometry has been extracted, it is possible, using computer animation to fly over the terrain. There are now animations that stimulate flying over the surface of Moon and Mars (Vince, 2004).

Computer animation is finding many applications within medicine. One example is found in the diagnosis of heart conditions that can be assisted with the data obtained from Scanners. The data slices obtained from such machines can be fed into computer programs that are capable of extracting various objects or isolating different layers of tissue. If the heart data are retrieved over different periods, the heart can be animated to reveal whether anything abnormal occurs while it is beating (Habbal and Harris, 1995).

Computer animation is being increasingly used in film making where it can be used for special effects, an alternative to scale models, or simply a unique method for rendering 3-D animated scenes. In the USA, the computer graphics industry even has its own animated film festivals, where animators and researchers share new methods for modelling, rendering or animating (Garnier, 1990). However, unlike manual cartoon animators who simply draw what they want, a computer has to be programmed at every stage of the animation process. This introduces new method and procedures that can be integrated with familiar unusual processes to create totally new animations. To fully appreciate the similarity between computer animation and manual animation, the researcher investigated the stages for creating manual hand-drawn animation and how computers can be used to provide alternate method in 3-dimensional situations.

Finally, series of researches have shown how computer has revealed new ways of developing design as in the works of Vince (2004) and Onasanya (1997). However, manually produced art pieces still create an impact on market. It is reported that many individuals still prefer manually produced design to computer production. This implies that there is room for manually produced designs. Many researchers have asked if computer will have a significant effect on the world of art. Another question that needs answering concerns the location of computer art in the established hierarchy of traditional art. For instance, should computer generated art be compared to Van Gogh's, Rembrandt's or Leonardo Da Vinci's works of Art? Will the medium of oil on canvas be superior to ink-jet on paper? While it is the researchers' opinion that the medium used by the artist is immaterial, analysis and deduction were made on the basis of the finding of this study.

MATERIALS AND METHODS

Research design: The target population for the study was all educational technology students and fine art students in Nigerian universities. However, the nature of the research and the number of available computer hardware resources in the educational technology computer centre, University of Ilorin, informed the limitation of the study sample to an intact class of sixteen (16) 300 level Educational Technology students in the University of Ilorin, Nigeria, for the experimental group. While the control group was made up of an intact class of twenty-four (24) 300 level Fine Arts students from Ladoke Akintola University of Technology (LAUTECH) Ogbomoso, Nigeria. All the 300 level educational technology students had previous experiences in conventional media design at the 200 level. They had also undergone training in graphic designs and in computer education at the 300 level. Also, the 300 level Fine Arts students in LAUTECH, Ogbomoso also had their training in Graphics at the 100 and 200 levels. The control group was treated in one-week computer appreciation programme before the commencement of the study. The exposure of the control group to computer appreciation was employed in order to make students in the group have at least the minimum experience in computer. The selection of the samples was purposive because computer animation is a major topic in Educational Television

Production EDT 402, which was a compulsory core course for B.ed. Educational technology programme at the University of Ilorin. The choice of University of Ilorin for experimental treatment was also purposive because it is one of the pioneering institutions offering educational technology at the undergraduate level. It also has the facilities for the training of students. Another major factor was the easy access to electronic computer system in the educational technology centre of the University.

The study was carried out during the second semester of the 2002/2003 academic session.

A quasi-experimental, of pre-test, post-test control group only (Campbell and Stanley, 1966) was used. Two levels of independent variables (computer and manual) were investigated in the study. This design permits the establishment of casual relationship between the independent. The rise of digital media offers educational technology students new possibilities for making their own productions with visuals, text and sound – but what does the development of digital media actually mean for the development of artistic, aesthetic learning among university undergraduate studying educational technology?. The research studied the aesthetic learning of undergraduate students in and outside of school environment in order to study and expand practice in the design of digital learning materials.

The researchers studied how the students learn about the animation production when they make films themselves. In practice a quasi experimental study was carried out on groups of undergraduate students studying the production of animation film with ICT in their leisure time. The intact class consisting of 40 students was randomly grouped into two. Towards the end of the study, the students participated in concept developing and designing with the purpose of working on a concept for a web-based learning resource about animation film making. The animation film genre was chosen because it appeals across gender. Also, because it is well-documented that gender can play an important role in young people's ways of using ICT and media.

At various point of investigations, the researchers used newer theories about multi-modality, multi-media and aesthetic learning (Carr and Jewitt, 2005; Manovich, 2001; Sefton-Green, 2005), theories about art education (Efland, 2002; Latta, 2008; Illeris, 2002) and theories about film genres and animation filmmaking (Monaco, 2000; Lord *et al*., 2004).

Various methods of examining learning in practice as well as to design and develop learning materials in practice were employed. The methods are inspired by design-based research (Bannan-Ritland, 2003; Collins *et al*., 2004) and a Mode 2 view on knowledge (Harvey, 2001).

Sample and sampling procedure: The target population for the study was all educational technology students in Nigerian universities. However, the nature of the research and the number of available computer hardware resources in the educational technology computer centre, University of Ilorin, informed the limitation of the study sample to an intact class of 40 300 level Educational Technology students in the University of Ilorin. The students were randomly grouped into an experimental and control groups consisting of 20 students per group.

Data gathering procedure: An overall instruction formulated for six weeks were conducted using an intact class that were grouped into two groups from 300 level educational technology students of the University of Ilorin. Both the experimental and the control groups had previous computer appreciation background, they have also been taught graphic design and aesthetics principles, therefore, both groups had the same entry experiences before the research was conducted. Thereafter, both groups (experimental and control) were given the same pre-test on 3-Dimensional animation production.

After the pre-test, the treatment conditions were administered for the research groups during regular class hours. The experimental group was presented with 10 lessons in 3-D computer animation, i.e., two lessons per week using computer application software of Adobe Premiere and Microsoft Flash for the 3-dimentional effects. The control group was also presented with 10 lessons of 2 lessons per week in manually generated animation. During the instructional period, designing principles of animation were intensified for the groups. The period of 6 weeks was used for demonstration and experimentation with 2 demonstration lessons per week for each group. The test, which was given before the treatment as pre-test was also given as the post-test in the sixth week after the treatment.

Instrumentation: The primary data-gathering instrument for this study was Animation Production Skill Test (APST). This test, which was practical oriented, was given to all the subjects in the experimental and the control groups. The test involved computer animation software (ANIMO, Adobe Photoshop, Photo-Express and Windows-Movie-Maker) to animate the process involved in pounding the pounded yam using the mortal and the pestle at a refresh rate of 24 frames per second for the inbetweening. The animations prepared and recorded bearing in mind all the elements of animation production fix: Spatial attributes, dynamics, design, transition and Sound effects, for the experimental group.

For the control group, the test instrument involved the use of manual technique, in animating the processes involved in Pounding the pounded yam using the mortal and the pestle at a refresh rate of 24 frames per second for the inbetweening. Animations were prepared and recorded bearing in mind all the elements of animation production. The experimental group were exposed to the computer animation instruction for 6 weeks, (two lessons of 1 h each per week), with emphasis on the elements of a good animation production. Animation of Pounding the pounded yam using the mortal and the pestle was given to conventional groups for six weeks (two lessons of 1 h each per week) with emphasis on the elements of a good animation production. The control group was exposed to conventional animation rudiments for 6 weeks (two lessons of 1 h each per week) with emphasis on the elements of a good animation production.

Data analysis technique: The Animation Production Skill Test (APST) had the highest obtainable point of 100. A modified format for assessing instructional animation production (Halas and Manvell, 1978) was adopted for assessing and scoring the pre-test and post-tests production of the groups. All the three research questions raised for the study were tested using t-test at 0.05 level of significance.

RESULTS

Three research questions were posed and answered using the t-test Analysis to find out the significant difference between the computer animation and the manual animation groups when various attributes of animation production were considered. The results are presented as follows.

Hypothesis one: There is no significant difference between the performance in 3-dimensional animation production of students exposed to computer animation instruction and those exposed to manual animation instruction when all attributes of animation productions are considered.

In order to test this hypothesis, the t-test statistics was used to compute the mean of post-test scores of the experimental and the control groups when all attributes of animation production were considered (Table 1). It is evident that there was a difference in the post-test mean scores for the computer animation group and the manual animation group. When hypothesis one was tested using the t-test (Table 1), the calculated value of 12.570 was recorded while 2.024 was the critical value (t_c = 12.57> t_t =2.02 at alpha 0.05). This result implies that the null hypothesis be rejected because the calculated t value is greater than the critical value. In other words, the 3-dimensional computer animation group performed significantly better than their manual animation counterpart when assessment was based on all the attributes of 3-dimensional animation production.

Hypothesis two: There is no significant difference between the performance in 3-dimensional animation production of students exposed to computer animation instruction and those exposed to manual animation instruction when spatial attribute is considered

In testing hypothesis two, a t-test analysis was used on the post-test scores obtained from the manual animation and the computer animation groups in spatial attributes of animation production (Table 2). From the t-test analysis in Table 2, it could be inferred that the differential performance of post-test mean score of the computer animation group (2.93) over the post-test mean score of the manual animation group (2.08) was clear evidence that computer instruction had effect on 3-dimensional animation production when the spatial attributes were considered. When hypotheses two was tested using the same t-test analysis, the calculated t-value of 4.25 was recorded against the t-critical value of 2.02 (t_c = 4.25 >t_t = 2.02 at alpha 0.05). This implies that the null hypothesis be rejected since the calculated t-value (4.25) is greater than the t-critical value (2.02). In other words, there was significant difference between the performance in 3-dimensional animation production of students exposed to computer animation instruction and those exposed to manual animation instruction when parameters are based on the spatial attributes of animation production.

Hypothesis three: There is no significant difference between the performances in 3-dimensional animation production of students exposed to computer animation instruction and those exposed to manual instruction when all the elements of dynamics are considered. T-test statistics were applied to test this hypothesis (Table 3).

It is evident in Table 3 that there was a marginal difference in the post-test mean scores in dynamics attributes for the computer group. However, when hypothesis three was tested using the same t-test, the calculated t-value of 1.97 was lower than the critical t-value of 2.02 (t_c = 1.97<t_t =2.02 at 0.05 alpha level). This result implies that the null hypothesis be accepted. In other words, the result shows no significant difference between the performance in 3-dimensional animation

Table 1: The t-test Analysis on the post test performance of experimental and control groups

Variables	No.	Mean	Variance	SD	df	Calculated t-value	t-table critical value	Remark
Computer animation group	20	2.93	1.59	1.26	38	*12.570	2.024	Reject hypothesis
Manual animation group	20	2.08	0.86	0.93				

*Significant at 0.05 alpha level

Table 2: The t-test analysis on the post test scores in spatial attribute for the computer animation and manual animation groups

Variables	No.	Mean	Variance	df	Calculated t-value	Critical t-tail value	Remark
Computer animation group	20	2.93	0.73	38	*4.25	2.02	Reject hypothesis
Manual animation group	20	2.08	0.17				

*Significant at 0.05 alpha level

Table 3: The t-test analysis comparing the post test mean scores of computer and manual animation group in dynamic attributes

Variables	No.	Mean	Variance	df	Calculated t-value	Critical t-tail value	Remark
Computer animation group	20	2.81	0.83				Accept hypothesis
Manual animation group	20	2.38	0.24	38	1.97	2.02	

*Significant at 0.05 alpha level

production of students exposed to computer animation instruction and those exposed to manual animation instruction when dynamics attributes were taken into consideration.

DISCUSSION

The findings in this study that computer is more effective for 3-dimensional animation production than the manual technique of animation production is in agreement with the results of some earlier studies such as Brightman and Dimsdale (1986), Vince (2004), Watt and Watt (1992) and Onasanya (1997). These studies that look similar to the present one observed computer as a modern tool for preparing and producing visual presentations that could take the form of graphs and drawings printed on paper, displayed on video display units (VDU) or presented before an audience as motion, slides and transparencies.

On the other hand, this finding (of superiority of computer animation over manual animation) disagrees with Dwyer (1978), who carried out similar experiments using various media example, prose text, workbooks, programmed instructions, tape-slides films televisions, etc. and with learners who varied in age, ability, motivation and prior knowledge, etc. Dwyer (1978) statistical analysis showed no relationship between the test scores and the realism of the graphic presentation. Different results were also found with different tests and different media. This made Henich *et al*. (2002) remarked that the period between 1976 and 1985 witnessed rapid growth of information technology and researchers continued exploitation of the advantages of using these information media for instruction. Studies of the effectiveness of different types of pictorial effects have yielded similar conflicting evidences, thus the need for these results to be sieved for practical instructional usefulness. Lord *et al*. (2004) had also observed the remarkable little evidence concerning the effectiveness of each specific medium and how it is more rewarding to consider vast literature on pictorial communication research. This finding is therefore an attempt towards balancing the view and opinions relevant to pictorial communication research and as a result of this, the inherent attributes of computer are relevant for 3-dimentional-animation production and for media communication generally.

Since, education is a dynamic instrument for change, educational technology programs need to be constantly reviewed to ensure their adequacy and continued relevance to national objectives and needs. This study has highlighted all the techniques and benefits derivable from the use of computer for preparing animation and other audio-visual presentations. Therefore, findings of this study are a pointer to the present states of educational technology in Nigeria, thereby providing educational technology planners, teachers and students in educational technology, the need to embrace interactive computer appreciation. The findings of this study also provide the basis for improving the educational technology curriculum in our tertiary institutions.

Furthermore, the research should be of tremendous relevance to instructional materials designers and developers, educational technology centres, educational resource centres, media establishments, either print or electronics, etc. They were provided with empirical information on the potentials of computer animation within the Nigerian school system.

In view of the findings in this study, the following recommendations are hereby put forward that the computer graphics approach to multimedia production be adopted and intensified in all educational technology programme. Lecturers in higher institutions, especially in educational technology should be encouraged to embrace interactive computer graphics appreciation.

The Nigerian Association for Educational Media and Technology (NAEMT) should provide a forum for closer reflection on computer for animations and multimedia production through symposia, seminars and workshops among students, teachers and practitioners of educational technology.

The Federal Ministry of Education in collaboration with the Nigeria Universities Commission (NUC) should make computer equipment with all necessary graphics/multimedia facilities available for instruction in the Universities, Colleges of Education and in other educational resource centres.

To other Nigerian educational bodies, e.g., the National Commission for Colleges of Education (NCCE), National Board for Technical Education (NBTE) and Nigeria Teachers Institute (NTI), they should modify the curriculum of their programmes to accommodate computer education in all segments of their training.

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