Interactive Computer Simulation and Computer Simulation Video: Comparative Perspective in Cognitive Achievement in Petrol Engine

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ABSTRACT: *This study compared two groups of four technical college classes studying automobile engine. One group learned using interactive computer simulation; the other group learned using computer simulation video. The study adopted a pretest, posttest, control group, quasi-experimental research design. There were three weeks (of 45 minutes each) of treatment for the study. Cognitive achievement test was used to obtain data. Pearson Product Moment Correlation was computed to establish a correlation coefficient of 0.82 after test-retest of cognitive achievement test. The area of the study is Enugu State of Nigeria. 526 NTC 1 (average of 16-17 years old) students of Motor Vehicle Mechanics' Work formed the population of the study; while 120 students were sampled from 4 schools out of the 22 schools managed by Science Technical and Vocational Schools Management Board (STVSMB), Enugu. Arithmetic mean was utilised to answer the research question, while the hypothesis was tested, at .05 level of significance, using Analysis of Covariance (ANCOVA). The study found that the group taught using interactive computer simulation performed better than those using computer simulation video. It was also found that the difference was not significant. Based on the findings, one of the recommendations made is that interactive computer simulation teaching technique should be incorporated in the teaching of Motor Vehicle Mechanics' Work.*

I. Introduction

Interactive computer simulation is a human in the loop simulation programmed inside a computer. Hyunjeong, Jan, & Bruce (2006) defines computer simulations as interactive software programs in which individuals explore new situations and complex relationships of dynamic variables that model real life. Rigby (2015) defines a computer-based simulation as a program that embodies some model or an aspect of the world, allows the user to make inputs to the model, runs the model, and displays the results. Interactive computer simulation software enables users (teachers and students) make decisions and input these decisions into the computer. The computer uses the model to calculate new values for the new inputs in the system. The computer then displays them to the user. Holzinger, Kickmeier-Rust, Wassertheurer, & Hessinger (2009) stated that interactive computer simulations allow learners to change the input variables of complex systems, to manipulate parameters of that processes and to directly receive feedback on the changes. In Lotus Engine Simulation for instance, an 80.32mm cylinder bore may be changed to 85.04mm. This new value would be used to calculate the compression ratio in the engine. The new values and the differences would be compared. This dynamic characteristic makes it invaluable in designing different vehicle models. This is because it would be less costly in terms of money and time, to try out in virtual environment than in real models of automobile.

In school system, several companies have programmed different kinds of interactive computer simulation softwares to aid instruction. Klopfer, Scheintaub, Huang, and Wendel, (2009) gave one example of such as starLogo TNG (The Next Generation). The Next Generation is an open-ended tool that allows the user, in this case the teacher and the student, to create and alter a simulation they themselves as the users are building. Starlogo TNG is a 3D (three dimensional) modelling and simulation software which its programming possibilities are seemingly endless. Also numerous teachers in Mathematics and Science have created an array of applications with it – including a model of a health epidemic to a simulation of the dynamics between fish and plankton; Klopfer, Scheintaub, Huang, and Wendel, (2009) concluded**.**

This study used starLogo TNG type of simulation but in automobile application known as Lotus Engine Simulation. Lotus Engine Simulation is an engine cycle simulation tool which enables the user to generate models very quickly, using a mixture of embedded design criteria and well-structured interface functionality. Lotus Engine Simulation can be used to simulate the performance of two stroke, four stroke, petrol, diesel, and naturally aspirated, supercharged and turbocharged engines using advanced numerical algorithms to model the gas dynamics in the engine manifolds. Use of sensors and actuators enable the virtual complex operating modes used in modern engines to be simulated. Lotus Engine Simulation has been developed by automotive engineers, using them on many powertrain and vehicle projects. Lotus engine simulation models

the gas dynamics in the engine manifolds and enables the complex operating modes used in modern engines to be simulated (Samuel, 2015).

There are other industrial simulations in the market which can be used to teach virtually all courses. Direct Industry (2015) defines industrial computer simulation software as a computer program designed by software industry to predict outcomes for planned projects. These range from the behaviour of an object to that of any organized system, regardless of field. Rigby (2015) affirmed that computer-based simulations have become commonly available. They can be purchased commercially and run on a high-end mainframe, or downloaded for free via the internet and run on a personal computer. One can also programme their own simulation to serve a specific purpose in the learning activities; maybe, according to a particular curriculum and unique classroom situation.

There is also the computer simulation video, as another type of electronic physical simulation, which could also be bought from the market. This is a read-only simulation, which can be used in learning activities. A computer simulation video describes a diverse super-category of video, generally designed to closely simulate aspects of a real or fictional phenomenon (Rollings & Ernest, 2003). This study used computer simulation video in 3D form which the learner can watch several times as they wish. The assembling of a particular generic petrol engine can be taught using a computer simulation video. One main advantage of computer simulation video is that it can be used for the beginners of automobile technology. This is because a generic unaltered simulated process can be taught effectively using a computer simulation video.

Computer simulation video could also be referred to as computer video simulation or computer simulation animation. Computer animation encompasses a variety of techniques, the unifying factor being that the animation is created digitally on a computer. 2D animation techniques tend to focus on image manipulation while 3D techniques usually build virtual worlds in which characters and objects move and interact. 3D animation can create images that seem real to the viewer. Animation is the process of creating the illusion of motion and shape change by means of the rapid display of a sequence of static images that minimally differ from each other (Rojas, 2013). Computer simulation video allows learners to learn by viewing. Animation is used to illustrate concepts and ideas that could not be created and captured in real life. For example, if you wanted to illustrate the human circulatory system showing the heart pumping blood throughout a body, you would have to re-create this using animation technique as it would be impossible to illustrate this with a real live person (Steven, 1997). This also applies to automobile engine as it would be impossible to illustrate engine strokes in real life. Teachers can also use computer animation to demonstrate things visually exactly how they want to since they have control of most aspect of the animation.

The difference between interactive computer simulation and computer simulation video is in the interaction. Unlike the interactive computer simulation, the computer simulation video cannot 'interact' with the student. Interaction here means that the student can input different values in order to experience the output of those different values of what could be in real life situation. The only input that could be made in computer simulation video is speed reduction and increment or pause, on the processes of interest. Interactive computer simulation and computer simulation video can be used as a teaching technique.

Computer simulation teaching technique is taken here to refer to classes that used interactive computer simulation and computer simulation video as a replacement for or supplement to conventional classroom instruction in order to teach students. Conventional teaching method on the other hand is referred to classes that used traditional methods of instruction, that is, non-computer-based methods, to teach students. The basic replacement in this study is in the learning resources, that is teaching materials. Kalekar (2015) stated that learning resources are texts, videos, software, and other materials that teachers use to assist students to meet the expectations for learning. Computer simulation teaching technique in this study compared two different system models (interactive computer simulation and computer simulation video) as a replacement to conventional teaching method.

This study used computer simulation teaching technique in technical college students. According to NBTE (2001), technical colleges offer various mechanical trades, among which is Motor Vehicle Mechanics. The programme of Motor Vehicle Mechanics' Work trade in Nigeria technical colleges is designed to produce competent auto-mechanics craftsmen for Nigeria technological and industrial development. According to NBTE (2009), auto-mechanics craftsmen are expected to test, diagnose, service and completely repair any fault on the motor vehicle to the manufacturer's specification. For this to be achieved, a national curriculum was adopted in all technical colleges accredited by the National Board for Technical Education. The curriculum for Motor Vehicle Mechanics' Work in the technical colleges was developed to offer a complete secondary school education in general education in addition to occupational area while the central purpose of Motor Vehicle Mechanics' Work trade is to provide its recipient with the skills required for work in the automobile industry.

One of the modules of Motor Vehicle Mechanics' Work is titled Introduction to Petrol Engine and Fuel System/circuit. It has the code CMV13. CMV means Curriculum of Motor Vehicle. Introduction to Petrol Engine and Fuel Systems/circuit is a second term of first year course of a three year programme of the modules

of Motor Vehicle Mechanics' Work. It has a theory to practical ratio of 1:2. Some of the general objectives as enumerated by NBTE (2009) include that the trainee (student) should be able to: know the different variety of petrol engine that exist; know the main engine components and their function; and understand the basic working principles of petrol engine and restore it to peak performance. When a student achieves the cognitive academic objectives set for him/her, he/she   must have achieved in academic cognition.

Cognitive achievement connotes attainment in a school subject as symbolized by a score or mark on a cognitive test. Cognitive achievement is achieved through cognitive testing. According to Fitzalan (2014) Cognitive testing is a process of engaging in activities with a student that provides a broad sampling of his or her thinking abilities. A cognitive test measures a student's knowledge and academic skills in a standardized way, typically through multiple-choice questions. Most cognitive achievement tests focus on specific subjects, such as Science, Mathematics, Social Studies, English and Motor Vehicle Mechanics. Cognitive achievement tests are used for more than measuring a student's learning ability. They provide insight into teacher effectiveness, such as in his/her teaching strategies, quality of a school's academic programme and information on classroom progress. This information can be used for future class groupings and placement, school funding and teacher assessments.

The cognitive achievement is typified in this study in the objective test scores of the Cognitive Achievement Test. Bloom (1971) identified six major classes of objectives in cognitive achievement domain, arranged in order of increasing complexity. The classes are knowledge, comprehension, application, analysis, synthesis and evaluation. The objective test in this study which focuses on the cognitive achievement involved the first three classes aforementioned, which are knowledge, comprehension and application. The study sought to find out the academic achievement scores of students of Motor Vehicle Mechanics' Work taught using interactive computer simulation teaching technique and students taught using computer simulation video teaching technique. The study further sought to find out if the mean gain difference is significant.

II. Methods

In this study, a quasi-experimental research design of pre and post test, experimental-control-group model was used. This study was carried out on 120 NTC 1 students in second term of 2015/2016 academic session. The study involved two groups of subjects. They control themselves. One group were taught using interactive computer simulation teaching technique and the other group were taught using computer simulation video teaching technique. Only the scores of students who participated in pretest, treatment and post test were taken to analyse the data; therefore the interactive computer simulation (ICS) group consists of 51 students and that of the computer simulation video (CSV) group were 47 students. The study was conducted in Enugu State, Nigeria. Cognitive achievement test was used to obtain scores from students.

The study was conducted during the school lesson period. It followed the classes' time table of Motor Vehicle Mechanics' Work. The regular school Motor Vehicle Mechanics' Work teachers were used in the study. Pretest was administered to both groups before the commencement of the lessons. During the lessons, the ICS group used interactive computer simulation teaching technique lesson plan to learn, while the CSV group used computer simulation video teaching technique lesson plan to learn. The regular Motor Vehicle Mechanics' Work teachers were trained on how to teach the selected topics using the computer simulation teaching techniques. This was done before the pretests. After the training and pretests, then the treatment (that is actual teaching) commenced. Each lesson lasted for a period of 45 minutes, two periods in a week and the lessons were a period of three weeks. A total of six lesson periods were therefore involved in the study. At the end of the lessons, post tests were administered to both groups. The data collected from the pretest and post test were used for further analysis. The analysis determined if there are significant differences in the cognitive achievement between the two groups.

Results: The results are presented according to the research question and hypothesis that guided the study.
Research Question

What are the mean cognitive achievement scores of students of Motor Vehicle Mechanics' Work taught using interactive computer simulation teaching technique and students taught using computer simulation video teaching technique?
The answer to this research question is provided in table 1.

Table 1: Mean of Pre-test and Post-test Scores of Interactive Computer Simulation (ICS) Technique and Computer Simulation Video (CSV) in the MVMW Cognitive Achievement Test

Techniques	N	Pre-test $\overline{X}$	Post-test $\overline{X}$	Mean Gain
ICS	51	29.20	50.58	21.38
CSV	47	30.41	47.17	16.76

Table 1 shows that the group taught Motor Vehicle Mechanics' Work (MVMW) using Interactive Computer Simulation (ICS) had a mean score of 29.20 in the pre-test and a mean score of 50.58 in the post-test; making a pre-test, post-test cognitive achievement mean gain in the ICS technique to be 21.38. The Computer Simulation Video (CSV) group taught MVMW had a mean score of 30.41 in the pre test and post test mean score of 47.17 with a pre-test, post-test mean gain of 16.76. With these results, the ICS technique is more effective in improving students' cognitive achievement in MVMW than the CSV.

Null Hypothesis
There is no significant difference between the mean cognitive achievement scores of students of Motor Vehicle Mechanics' Work taught using interactive computer simulation teaching technique and students taught using computer simulation video teaching technique.
The data analysed for this hypothesis is presented in Table 2.

Table 2: Summary of Analysis of Covariance (ANCOVA) for Test of Significance between the Mean Scores of Experimental 1 and Experimental 2 Groups in the Cognitive Achievement Test

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	6027.179[a]	3	2009.060	15.852	.000
Intercept	167811.440	1	167811.440	1.324E3	.000
Group	397.175	1	397.175	3.134*	.081
Location	5616.816	1	5616.816	44.319*	.000
Group * Location	.078	1	.078	.001	.980
Error	8871.469	70	126.735		
Total	200900.000	74			
Corrected Total	14898.649	73			
*significant at sig of F< .05					

The data presented in Table 2 shows that F calculated value for group is 3.134 with significance of F at .081 which is greater than 0.05. Therefore, the null hypothesis of no significant difference between the effect of experimental 1 and experimental 2 groups of students, in the cognitive achievement in MVMW is accepted at 0.05 level of significance. Hence, there was no significant difference between experimental 1 and experimental 2 groups of students in respect to their mean scores on the MVMW Cognitive Achievement Test.

III. Discussion
The data presented in Table 1 provided answer to the research question. Findings revealed that the interactive computer simulation teaching technique is more effective in improving students' cognitive achievement in Motor Vehicle Mechanics' Work than the computer simulation video teaching technique. This is similar to the findings of Hu, Johnston, Hemphill, Krishnamurthy & Vinze (2012) who in their studies found out that the adoption of interactive computer simulation in the teaching of Public Administration Education; students had an improved cognitive achievement in the course than the students taught using computer simulation video.

A possible explanation for the effectiveness of the interactive computer simulation teaching technique is its ease of being recycled and hence its sustainability. It can be reworked, retried and used by the learners. Furthermore, Hick (1997) opined that video is a wonderful medium for displaying certain types of "broadcast" information. The key word here is broadcast, because that is what video was designed for, to be viewed by a large number of people at the same time. While this may be effective for some training and education, it often lacks one of the major elements required by many individuals for effective training and education; a simple hyper-navigation system (which interactive computer simulation possesses), that allows the user to decide where they will go next.

Video is linear by nature, meaning that, like a television show, it is meant to be viewed from beginning to end. Moving to certain portions of a video tape is really not all that easy without a lot of back and forth searching. A well designed hyper-navigation system however allows the user to "path" their learning by branching off to other topics when they are ready to continue. This hyper-navigational element addresses the fact that most people learn at different speeds and it allows the user to progress at their own rate, based on prior subject knowledge and needs.

Another major benefit of (well designed) multimedia courseware, such as interactive computer simulation over computer simulation video is user interactivity. This allows the student to delve as far into a subject as they wish. For example, a training course on four stroke process; may make reference to the engine strokes. One student may know what engine strokes are, whereas another may not. The second student may wish to explore a little further if there were a hypertext link to an explanation of engine strokes, or the student may study on engine stroke package as may be depicted in an icon. If this were the case, the second student could find out more about engine strokes to aid in their understanding, while the first student could skip right over that

area if they wished. This is a very powerful feature in a learning tool as it allows students to work at their own pace and thereby avoiding the possibility of going too fast for some, and too slow for others.

Analysis of covariance explained the null hypothesis in Table 2. It revealed that at calculated F-value of 3.134, significant of F at .081 and confidence level of 0.05 there was no statistically significant difference in the mean gain effect of interactive computer simulation teaching technique and computer simulation video teaching technique, on students cognitive achievement in Motor Vehicle Mechanics' Work; confirming that the difference between the mean gain effect of interactive computer simulation teaching technique and computer simulation video teaching technique can be attributed to chance. Hence, the null hypothesis of no significant difference between the effects of treatment on students' cognitive achievement in MVMW was upheld at 0.05 level of significance.

IV. Conclusion

Based on the analysis of data, it is concluded that interactive computer simulation teaching technique is better than computer simulation video teaching technique in cognitive achievement. The study also revealed no significant difference in cognitive achievement between the two teaching techniques. These results therefore showed that interactive computer simulation teaching technique is viable alternative to the conventional teaching method in cognitive achievement for Motor Vehicle Mechanics' Work.

V. Recommendations

Based on the findings of this study, the following recommendations are made:

1. National Board for Technical Education (NBTE) should consider review of curriculum for Motor Vehicle Mechanics' Work with a view to incorporating interactive computer simulation teaching technique into the teaching of Motor Vehicle Mechanics' Work.
2. In order to promote cognitive achievement in Motor Vehicle Mechanics' Work, their teachers and school administrators should incorporate the use of interactive computer simulation teaching technique in their teaching Motor Vehicle Mechanics' Work.
3. Workshops, seminars and conferences and in-service training should be organized by the government and professional bodies like the National Board for Technical Education (NBTE) and the Nigerian Association of Teachers of Technology (NATT) on the use of interactive computer simulation teaching technique for improving students' performance in Motor Vehicle Mechanics' Work.
4. Teachers training tertiary institutions, where Information and communication Technology (ICT) has not been introduced, should include ICT in their curricula and impact the use of interactive computer simulation instruction strategy to the student teachers.

Reference

[1]. Bloom, B. S. (1971). *Taxonomy of educational objectives.* New York: Longman Publishers. Retrieved from http://teaching.uncc.edu/learning-resources/articles-books/best-practice/goals-objectives/b.. on September 17, 2014
[2]. Direct Industry (2015). *Simulation software.* Retrieved from http://www.directindustry.com/industrial-manufacturer/simulation-software-64379.html. on June 24, 2015
[3]. Fitzalan, G. (2014). *Cognitive testing vs. achievement testing.* Retrieved from http://everydaylife.globalpost.com/cognitive-testing-vs-achievement-testing-3814.html on January 14, 2013
[4]. Hick, S. (1997). *Benefits of interactive multimedia courseware.* Retrieved from http://http-server.carleton.ca/~shick/mypage/ benifit.html on February 4, 2016
[5]. Holzinger, A., Kickmeier-Rust, M., Wassertheurer, S., & Hessinger M. (2009). Learning performance with interactive simulations in medical education: Lessons learned from results of learning complex physiological models with the HAEMOdynamics SIMulator. *Computers & Education* 52 (292–301). Retrieved from http://www.sciencedirect.com/science/article/pii/ S0360131508001346 on August 16, 2015
[6]. Hu, Q., Johnston E., Hemphill, L., Krishnamurthy R. & Vinze A.(2012). Exploring the role of interactive computer simulations in public administration education. *Journal of Public Affairs Education.* Retrieved from https://spaa.newark.rutgers.edu/sites/default/ files/ files/TRG/ Teaching% 20Resources%20 Guide%203rd%20Edition.pdf
[7]. Hyunjeong, L., Jan, L. P., & Bruce, D. H. (2006). Optimizing cognitive load for learning from computer-based science simulations. Journal of Educational Psychology, 98 (4). DOI: 10.1037/0022-0663.98.4.902 on June 24, 2015
[8]. Kalekar, S. (2015). *Styles of learning.* Retrieved from https://sites.google.com/ site/myvirtualcourse/learning-styles. on August 16, 2015
[9]. Klopfer, E., Scheintaub, H., Huang, W., & Wendel, D. (2009). *StarLogo TNG: making agent based modelling accessible and appealing to novices in artificial life models in software.* Retrieved from http://education.mit.edu/ publications on September 17, 2014
[10]. NBTE (2001). *National technical certificate and advanced national technical certificate curriculum and module specification for vehicle mechanics' work.* Kaduna: NBTE
[11]. NBTE (2009). *National technical certificate and advanced national technical certificate curriculum and module specification for vehicle mechanics' work.* Kaduna: NBTE
[12]. Rigby, K. T. (2015). Real-time Computer-based Simulation as an Intervention in Aerodynamics Education. *Journal of Aviation/Aerospace Education & Research, 24*(2). http://dx.doi.org/10.15394/jaaer.2015.1634 on June 24, 2015
[13]. Rojas, C. (2013). *The oxford handbook of Chinese cinemas.* Retrieved from https://books.google.com.ng/books?id=8F1p AgAAQBAJ&pg=PA5&hl=en

[14]. Rollings, A. & Ernest, A. (2003). *Andrew Rollings and Ernest Adams on game design.* Retrieved from http://my.safaribooksonline.com/1592730019/ ch14?portal=adobepress. on January 14, 2015

[15]. Samuel G. (2015). *Lotus engine description.* Retrieved from https://imapssl.eng.auburn.edu/software/software/software_showone. php?software_id=334

[16]. Steven, H. (1997). *Benefits of interactive multimedia courseware.* Retrieved from http://http-server.carleton.ca/~shick/mypage/benifit.html