EFFECTS OF MOBILE TECHNOLOGY ACCESSIBLE LEARNING OBJECTS ON STUDENTS' COGNITIVE ACHIEVEMENT IN NATURAL SCIENCE AND METAL WORK TECHNOLOGY.

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Abstract

Digitaltechnologies of various forms are increasingly integrated into instructional delivery. These digital materials such as Learning Objects (LOs) are widely used by instructors without empirical basis on their effects on learning. Thus, this study sought to assess the instructional effects of LOs on students" low, middle and high cognitive competencies in natural science and metalwork technology courses. The study was guided by one research question and a hypothesis. It adopted the quasiexperimental design of non-randomized intact groups of all year one students that offer the course from Industrial Technical Education and Food Science & Technology, at the University of Nigeria, Nsukka. The population for the study was 61. This consists of 26 natural science students and 35 metalwork technology students. Validated instruments referred to as Natural Science II Achievement Test (NASAT) and Metal Work I Achievement Test (MWAT) were used for data collection. The treatment for the experimental group consisted of teaching metal work contents using LOs accessed from the laptop computer (tablet PC) for 12 weeks while the control group was used the typical conventional method of teaching and learning as well as LOs. The pre and post - tests data were analysed using mean to answer the research questions, while one-way analysis of covariance (ANCOVA) was used to test the null hypothesis at .05 statistical level of significance. The study revealed that the LOs accessed from the laptop was effective in improving the students" low, middle and high cognitive competencies in natural science and metalwork technology. However, there was no statistically significant difference between the mean achievement scores of the control and experimental groups on their performances in lower, middle and high levels cognitive competencies in science and metalwork technology courses as a result of using LOs accessed from the laptop. This implies that LOs, when used in both conventional and mobile-based learning environments, were effective in enhancing students" cognitive achievement in natural science and metalwork technology. As a result, the study recommended that curriculum planners should develop an appropriate curriculum that incorporates LOs and computers for teaching and learning of science and technical education courses. Thus the study concludes that the integration of mobile technology accessible LOs would enhance the attainment of higher order cognitive instructional objectives.

Keywords: *Mobile Technology; Learning Objects, Students" Cognitive Achievement in Natural Science and Metal Work Technology; Quality Instruction.*

Introduction

Mobile technology devices are movable as well as portable digital appliances that are easy to use. Examples of mobile Information Technology (IT) devices include laptops and notebook computers, palmtop computers or personal digital assistants, and smart phones (EDUCASUE, 2005). Nordin, Embi and Yunus (2010) outlined a number of general requirements that constitute the basic features of mobile technology. The requirements include technology that is highly portable, individual-focused, unobtrusive, available, adaptable, and persistent. The high portability means that it the mobile technology should support learning whenever and wherever while the individual-focus entails the design being able to support individual learning, cater to individual learning styles and be adaptable to learner‘s abilities. The unobtrusive requirement means that learners should be able to retrieve knowledge without the technology becoming the determent while adaptability requires the technology to contextualize learning to various situations, individual skills, and knowledge development. The persistent requirement of mobile technology enables the learner to manage changes in the technology itself and provides the easy-to-use quality that ameliorates technophobia among new users.

A number of different mobile technology devices are being used in higher education for teaching the sciences and metalwork technology. These, according to McKenzie (2001), McGhee and Kozmes (2001); Fryer (2002), Attewel (2004), include webenabled wireless phones (e.g. smart phones), webenabled wireless handheld computers (e.g. palmtop, and tablet personal computer (PC)), wireless laptop computers and personal digital assistants (PDAs). The focus of this study was on the use of laptop computers (tablet PC) in higher education, especially for the study of natural science and metalwork technology. In addition to possessing the same capabilities as other personal computers (PCs) (typically including wireless internet access), these meter-book-sized computers have a re-configurable screen that allows the user to employ them as a flat note book that can be written with a special stylus (Bienkowski, Haertel, Yamaghchi, Molina, Adason and Peck-Theis, 2005). Unlike PDAs, the screens of some tablet PCs are not touch-sensitive. Bienkowski et al (2005) stated further that the tablet PC ―inking‖ features include advanced handwriting recognition, and the stylus can be used as an input device to the computer. By repositioning the screen, the tablet PC can be used as a regular laptop with a keyboard.

Owing to its versatile features, a couple of digitalized instructional materials can be used on the tablet PC, such as the learning objects (LOs). A learning object is defined as any digital resource that can be used and re-used to achieve a specific learning outcome or outcomes (Ally, 2004). Richard and Cameron (2008) stated that the learning objects‘ design comprises three key elements: the content or resources learners interact with, the tasks or activities learners are required to perform, and the support mechanisms provided to assist learners to engage with the tasks and resources. Learning objects offers new approaches to the sharing of good practice for online teaching (Dalziel, 2010) and offline learning. Some learning objects focused on the textual and visual description of good practices, others focus on the sharing of runnable (executable) files that contain the technical instructions that make learning more meaningful.

Given the increasing popularity of LOs for instructional delivery, this study, therefore, aimed at determining the effects of the Learning Objects (LOs) accessed from laptop in improving students' low (knowledge, comprehension), middle (application, analysis) and high (synthesis, evaluation) level cognitive competencies in natural science and metalwork technology courses. The Natural Sciences emphasize the scientific process and inquiry. It covers the natural world and factors affecting it and is a highly evolving branch of science appealing to those with questioning and wondering minds. Courses in Natural Sciences include topics on the environment, AIDS and energy for medical and food science. Metalwork technology according to Aluwong (2004) is the application of scientific knowledge in the activity of making objects out of metal in an artistic and skillful way. In other words, it is the totality of all the processes involved in the production of metal articles. The metal work technology content includes the production of steel using the electric arc furnace, the Bessemer converter the basic oxygen process, production of pig iron using the blast furnace, etc. Concept mapping principle was used to develop the LOs that provide very rich instructional media with data on different cognitive tasks and mobile technology was used to make these materials readily accessible in and out of class sessions. These LOswere used in classroom instruction as well as hosted on the University of Nigeria website so that students could access them outside the class sessions using mobile devices (e.g. Flash applications, MP4, smart phones) and there were also standalone versions stored in the CDs. In addition, the development/ adaptation of LOs is a joint effort of subject matter specialists, programmers, multimedia designers, and evaluators/researchers which provided a very rich instructional tool that is clearly distinct and constitutes major redesigning efforts of existing course content. The use of these mobile technology instructional media and especially the LOs makes the instruction more interactive, flexible, and eliminating the limitations of real-time curriculum implementation.

Research Question

What is the effect of the LOs accessed from the laptop on improving the students' low, middle and high-level cognitive competencies in science and metalwork technology courses?

Hypothesis

There is no statistically significant ($P \leq .05$) difference between the mean achievement scores of the control and experimental groups on their performance in lower (knowledge, comprehension), middle (application, analysis) and high (synthesis, evaluation) level cognitive competencies in science and metalwork technology courses as a result of using the learning objects accessed from the laptop.

Theoretical Framework

Cognitive Learning Theory and the use of Mobile Technology for Improving Students Achievement

Learning is a relatively permanent change in behaviour, knowledge and thinking skills that occurs through experience (Santrock, 2009). A number of approaches to learning have been proposed viz behavioural and cognitive approaches to learning. Behaviorism is the view that behaviour should be explained by observable experiences, not by mental processes. For the behaviourist, the behaviour is everything that we do both verbal and non-verbal, which can be directly seen or heard (Shanks, 2009). Cognition means ―thought‖ and cognitive psychology focus more on thought processes. There are four major cognitive approaches to learning viz social cognitive, information processing, cognitive constructivist and social constructivist approaches. The social cognitive approach emphasizes how behaviour, environment and personal (cognitive) factors interact to influence learning. Information processing approach focuses on how children process information through attention, memory thinking and other cognitive processes (Galotti, 2008). The cognitive-constructivist approach emphasizes the child‘s cognitive construction of knowledge and understanding while the social constructivist approach focuses on collaboration with others to produce knowledge and understanding (Holzman, 2009). Cognitive learning involves the process of storing, transformation and retrieval of information. The focus of understanding how humanslearn is essentially the problem of understanding how information is stored in memory, how the transformation of the stored information may occur and how stored information is retrieved for use in further learning and problem solving (Stenberg, 2008). The cognitive learning theory viewed learning as a reorganization of knowledge structure. It is worthy of note that the main emphasis of cognitive learning theory is on the sequence of learning materials and experiences in a well-organized environment so as to create order, meaningfulness, and understanding that is learner-environment interacting meaningfully.

Specifically, most of the theories like Piaget's‘ theory by Jean Piaget, Vygotsky theory by Lev Vygotsky, Bruner's theory and Ausubel‘s theory emphasized that environmental influences on the learner‘s cognitive development consequently influence learner‘s achievement in learning. Furthermore, for any meaningful learning to occur, the learner and his environment are always participating in a simultaneous mutual interaction. Under a very interesting, rich and stimulating environment and a very supportive and stimulating teacher, students‘ achievement could be greatly improved. Mobile technology provides powerful tools to support the paradigm shift from teacher-centred to learnercentred learning and is capable of creating a more interactive and imaging learning environment for teachers and learners. When mobile technology is used as a learning tool, the students do readily interact with the devices (mobile technology devices) because of their multimedia capabilities name, audio, video, and animation. The mobile technology device provides feedback to the student or learner, allowing the learner to see the result of his actions and store the information into his mental structure, consequently engaging the learner to learn through first-hand experience. Invariably, the mobile technology affords the instructor the potentials of applying any of the approaches prescribed by different learning theories.

Cognitive Interaction Learning Theory, Development and use of Learning Objects

The cognitive interaction learning theory asserts that learning occurs when cognitive function interacts with the meaningful psychological environment around it. Bandura (1993) proposed two forms of cognitive interaction theories namely: linear and field. The linear and field forms of the cognitive interaction theory are very similar in nature. The linear form of cognitive interaction postulates that perception and behavioural changes (learning) occur in sequence; while the field version of cognitive interaction states that there is a simultaneous interaction occurring between the learner and their psychological environment. Kellam and Gattie (2007) stated that the field theory postulated that behaviour is not only a function of the individual person but is also a function of their environment. This theory indicates the phenomena of quickly learning new forms of behaviour that children often exhibit with games, especially video games. The theory takes into account a person's behaviour, personal factor, and the environment as a way to better understand and even predict a learner's success or failure and adapting to a new condition and perception (Bandura, 1986). The same condition would apply to learners using mobile technology devices on already developed regulated learning objects in learning a new content in sciences and technology courses.

Learning by doing provides the interaction that is present in the interaction learning theory. For example, if the learner is able to interact with the laptop/tablet PC and the developed learning objects, then according to the cognitive interaction theory by extrapolation, the learner should be able to improve depth perception and increase conceptual ideas through the development of mental models which in turn improves his/her proficiency in the use of the tablet PC and understanding of basic concepts of science. Also, the interaction between the learner and the learning object via the mobile device (Tablet PC) also provides immediate feedback. When the learner provides commands to control the learning objects, the learning objects provides the learner with feedback allowing the learner to see the result of his actions. The learner is then able to gain knowledge through experience.

Methodology

A quasi-experimental design was used in this study. Specifically, the pretest-posttest non-equivalent control group design was adopted for the study. This design was considered suitable for conducting this study because intact classes (non-randomized groups) were assigned to two different groups (control and experimental) in order to determine the effect of learning objects (LOs) accessed from the laptop on students' achievement in natural science and metalwork technology.

The population of the study was 121 year one students from the Department of Food Science & Technology and Metal Work Technology students from Department of Industrial Technical Education, University of Nigeria, Nsukka. Simple random sampling technique was used to draw 61 students, comprising 26 Natural Science year one students and 35 Metalwork year one students. Students in the groups are within the age brackets of 19-22 years and 23 years plus. Irrespective of their departments, the students were grouped into two classes. Those that studied in Mobile learning environment (Experimental group) and those that studied in conventional lecture method (Control group).

The two major instruments used in the study for data collection were Natural Science II (GS 106) Achievement Test (NASAT) and Metal Work I (VTE 154) Achievement Test (MWAT). The instruments including the marking schemes were developed by the lecturers-in-charge of the courses and were validated by three experts from Department of Natural Science, Industrial Technical Education and Psychology, University of Nigeria, Nsukka. The two instruments consisted of 30 multiple choice items each carrying 30 marks answered within 45 minutes. They were designed to test how well the developed Learning Objects (LOs) have improved students' low, middle and high level cognitive competencies in Natural Science and Metalwork Technology courses. However, the instruments were used for the Pre-test and Post-test exercises. The scores obtained from the instruments were not converted to percentages. They were used as raw scores during data analysis. In addition, the Natural Science II (GS 106) and Metalwork I (VTE 154) lesson plans that were used to develop the learning objects and to teach the groups during the experiment were also developed by the lecturers-in-charge of the courses.

Firstly the research assistants including the lecturers for the various courses were trained and were provided with detailed instructions on what actually is expected of them. Secondly, the experimental group students were also trained on the use of laptop/tablet PC and the e-learning portal; these enabled the students' master their way around the basic components of the PC and features of the e-learning portal.

The Study's Experimental Procedures

Activities/Period /Steps	Teacher's /Research Assistant's Activities	Student's Activities	Outcome
Administration of PreTest Instruments. Period: 1hr. The pre-test is aimed at ascertaining students' previous knowledge on the courses	**Experimental Groups**, the pre-test was administered online using the university elearning portal after which it was removed from the portal so that the student will not have unauthorized access to it. **Control Groups**, the instruments were administered to them in their respective classes.	The students checked the correct answer for each question by circling or ticking 'Good' on the correct option. After which the scripts were submitted for marking.	Obtained students achievement scores before the treatment. Provided a baseline data on the achievement of the groups before the treatment.
Extensive Training with the Developed Learning Objects (LOs) accessed through Mobile Technology Seven Lessons were taught One Semester of two hours per contact	**The Experimental Groups** were trained with the learning objects accessed through mobile technology via the University Intranet services on the e-learning portal. All the students' were given a Tablet PC each and a password that enabled them togain access to the e-learning portal. **The Control Groups** were trained in the ideal classroom conventional method of teaching and learning using the developed learning objects as instructional aides by the research assistants.	Based on the training they received before the treatment, the experimental groups were able to launch into the learning environment and were guided throughout the training by research assistants (Lecturers) using the already uploaded lesson plans to teach the students.	The use of Tablet PC to access the learning objects incorporated in the lesson emphasized student active participation throughout the teaching and learning process.
Administration of Post Test Instruments Period: 1hr. This took place immediately after the training to ascertain students' present knowledge of the courses. The same instruments used in pre-test exercise were during the post-test exercise.	A post-test was administered to the **treatment groups** and was attempted on-line via the elearning portal while the **control groups** were given to them in their respective classes	The students checked the correct answer for each question by circling or ticking 'Good' on the correct option. After which the scripts were submitted for marking.	Obtained students achievement scores sequel to the training & were used for data analysis in conjunction with the Pre-test scores. Provided additional data on the achievement of the groups after the treatment.

The data collected from the administration of pretest and posttest were analysed using mean to answer the research questions. The pretest-posttest mean gain/loss of each of the treatment and control groups were computed to determine the effect of Learning Objects (LOs) on students' cognitive competencies in natural science and metalwork technology courses.

The formulated hypothesis was tested at .05 level of significance using Analysis of Covariance (ANCOVA). This is because ANCOVA is a statistical technique which adjusts the initial differences between groups, so that the selected or pre-tested groups can be correctly considered as equal or equivalent by removing score differences in the pre-test performance across groups and reducing the between-group source variation (Ali, 1996). In addition, it is a method for analysing differences between experimental groups on the dependent variable after taking into account any initial differences between the groups on pre-test measures or on any other measures of relevant independent variables (Ary, Jacob and Razavieh, 2000). Such a measure used for control is called covariate. The Statistical Package for Social Sciences (SPSS) was used for the data analysis.

Table 1: Mean of Pre-test and Post-test Scores of the two groups in Science and Metalwork Achievement Tests.

Course/Group	**N**	**Pre-test**			**N**	**Post-test**			**Mean Gain/Loss**		
			X				**X**				
		Low	**Middle**	**High**		**Low**	**Middle**	**High**	**Low**	**Middle**	**High**
Natural Science II (GS106) ***Experimental***	13	6.00	2.85	5.23	13	8.08	3.54	6.08	**2.08**	0.69	0.85
Natural Science II (GS106) ***Control***	13	6.77	2.15	5.31	12	7.25	2.67	6.33	0.48	0.52	**1.02**
Metal Work I (VTE 154) ***Experimental***	19	6.00	1.84	4.47	13	7.92	3.38	6.77	1.92	1.54	**2.30**
Metal Work I (VTE 154) ***Control***	16	6.65	5.69	2.31	16	6.63	2.50	5.75	-0.02	-3.19	**3.44**

Results and Discussions

Results Presentations: Findings on the research question are presented in table 1 below.

The data presented in Table 1 shows that the *experimental group* taught natural science II with the Learning Objects accessed from the laptop had pretest, post-test mean gain to be 2.08 (Low), 0.69 (Middle) and 0.85 (High) while the *experimental group* were taught metalwork technology I had pre-test, post-test mean gain to be 1.92 (Low), 1.54 (Middle) and 2.30 (High). With these results, the natural science II and metalwork technology content integrated in the LOs and accessed from the laptop were effective in improving the students' low, middle and high level cognitive competencies in both natural science II and metalwork technology but the effects are higher in low level cognitive competencies in natural science II (2.08) and high level cognitive competencies in metalwork technology I (2.30).

The table 1 also shows that the control group taught natural science II with the LOs had pre-test, post-test mean gain to be 0.48 (Low), 0.52 (Middle) and 1.02 (High) while the control group taught metalwork technology had mean loss/gain to be -0.02 (Low), 3.19 (Middle) and 3.44 (High). With these results, the redesigned course contents (LOs) in natural science II and metalwork technology I were effective in improving the students‘ low, middle and high level cognitive competencies in natural science II and students‘ high level cognitive competencies in metal work technology I but not effective in improving the students‘ low and middle level cognitive competencies in metalwork technology I. Thus, the effects are high on both natural science II and metalwork technology I high level cognitive competencies (1.02 and 3.44).

The Analysis of Covariance (ANCOVA) for test of significance is presented in table 2 below:

Table 2: Summary of Analysis of Covariance (ANCOVA) for test of significance.

Source of Variation	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	135.236[a]	4	33.809	2.211	.081
Intercept	371.915	1	371.915	24.319	.000
Pre-test	42.336	1	42.336	2.768	.103
Groups	76.754	3	25.585	1.673	.185
Error	749.356	49	15.293		
Total	15818.000	54			
Corrected Total	884.593	53			

a. R Squared = .153 (Adjusted R Squared = .084)
b. significant at sig F<.05, Not Significant at sig of >.05
c. F (3, 49) = 1.67, p= .19, partial eta squared = .09

The data presented in table 2 above shows one-way between-groups Analysis of Covariance (ANCOVA) that was conducted to compare the effect of LOs accessed from the laptop on improving students' achievement in Science and Metalwork technology courses. The F-calculated value for the groups at the degree of freedom (3, 49) is 1.67 with a probability value of .19 which is above the statistical level of .05. Thus, the null-hypothesis (Ho) was accepted at .05 level of significance. This implies that there is no significant differences among the mean achievement scores of the control and experimental groups on the effect of the LOs accessed from the laptop on improving the performance of students in low (knowledge, comprehension), middle (application, analysis) and high (synthesis, evaluation) level cognitive competencies in science and metalwork technology courses. The corresponding Partial Eta Squared value is .093, indicating how much of the variance in the dependent variable is explained by the independent variable. When converted to a percentage by multiplying by 100, it is able to explain 9.3 per cent of the variance which indicates a small effect size. However, the significant value of the covariate (pre-test) is .10 which is actually greater than .05, this indicates that there is no significant relationship between the covariate and the dependent variable while controlling for the independent variable (groups). In fact, it explained 5.3 per cent of the variance in the dependent variable (Partial eta squared of .053 multiplied by 100).

Discussion of the Results

The analysis of the results of the achievement tests shown on table 1 and 2 showed that the LOs in natural science II and metalwork technology I accessed from laptopwere effective in improving the students' low, middle and high level cognitive competencies in natural science II and metalwork technology I. However, the effects is higher on low level cognitive achievement of natural science experimental group, high level cognitive achievement of natural science control group, and of both the experimental and control groups in metalwork technology. This may be as a result of the complex interaction between the students' and the learning environment. Educational technologists have, of course, always understood that a student must interact with an environment for learning to occur (Winn, Hoffman, Hollander, Osberg, Rose and Char, 1997). They noted that interaction is a critical component to students' knowledge construction. Brewer (2003) opined that computer-based technologies are powerful pedagogical tools and can turn the passive students into an active participant in the learning environment. In addition, it provides powerful tools to support the shift to student-centred learning and is capable of creating a more interactive and engaging learning environment for teacher and learners (UNESCO, 2002). It enhances how students learn by supporting four fundamental characteristics of learning: active engagement, participation in groups, connections to real-world contexts, frequent interaction and feedback (Basham, 2007).

However, the analysis of covariance presented on table 5 confirmed that there is no significant difference between the mean achievement test of the control and experimental groups on the effect of the Learning Objects (LOs) accessed from the laptop on improving the performance of students in lower (knowledge, comprehension), middle (application, analysis) and high (synthesis, evaluation) level cognitive competencies in science and metalwork technology courses. These findings indicate that the Learning Objects (LOs) in natural science II and metalwork technology I accessed from the laptop had a positive effect on students' low, middle and high level cognitive competencies in natural science II and metalwork technology I courses. This implies that learning objects accessed from the laptop when used in both conventional and mobile-based learning environments are effective in enhancing students' cognitive achievement in natural science and metalwork technology. Hence, the implication of these findings to curriculum planners of natural science and metalwork technology is that they should develop an appropriate curriculum that will make provision for adoption of learning objects and mobile technology equipment for teaching and learning natural science and metalwork technology courses in various Nigeria level of education.

Recommendations

Based on the findings and implications derivable from the discussions, the following are recommended**:**

1. Workshops, seminar, and conferences should be organized by the National University Commission, Ministry of Education and administrators of tertiary institutions, companies and organizations like HP-Nigeria, World Bank, etc. to enlighten the science and technology teachers and to enable them develop competencies on the use of digital learning objects and mobile technology for improving the students achievement in learning natural science and metalwork technology courses.
2. Science and technology curriculum planners should consider reviewing the curriculum for natural science and metalwork technology with a view of incorporating digital learning objects and mobile technology equipment into the teaching of natural science and metalwork technology courses.

Conclusion

The study found the use of learning objects and mobile technology to be effective in increasing students' achievement, in natural science and metalwork technology courses, these viable learning materials and method could be adopted to other various disciplines. Using these LOs will guarantee graduating students with the knowledge and skills needed for work in the present world of work. Besides administrators should also greatly appreciate the need to constantly provide enough learning materials and mobile technology equipment as the need arises for the teaching of natural science and metalwork technology courses. Hence, given the technological advancement which has occasioned ample use of digital learning material and technology like computer and mobile phones in educational sector and industry, the need to find the best method to assist teachers in designing, developing and implementing effective use of the learning materials and equipment in instructional delivery of their courses is paramount.

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