EFFECTS OF COMPUTER-BASED CONCEPT MAPPING INSTRUCTIONAL STRATEGIES ON PERFORMANCE OF PHYSICS STUDENTS IN SECONDARY SCHOOLS IN KADUNA STATE

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Abstract

This study examined the effects of computer-based concept mapping strategies on the performance of physics students in secondary schools in Kaduna state. The study was guided by three research questions and three hypotheses. The study employed quasi-experimental research design using hierarchical and spider concepts mapping. The population of the study was 3683 SSII physic students drawn from 50 Senior Secondary Schools in Kaduna metropolis. A sample of 110 SSII Physics students was purposefully used for the study. The instrument used in the study were: researcher adapted Physics Performance Test, Computer-Based Concept Mapping Instructional Packages and Computer Assisted Instruction Package. Face and content validation were adjudged to the instrument and a reliability coefficient of 0.86 using Kuder-Richardson 20 was obtained Mean and standard deviation were used to answer the three research questions while ANCOVA was used to test the three null hypotheses at 0.05 level of significance. Findings of the study revealed that students taught physics with computer-based concept mapping strategies have almost the same level of performance with those taught using computer-assisted instruction and gender has no significant effect on the academic performance of students. It is recommended that Governments and Non-governmental organization should assist in providing functional computers and ICT infrastructure to schools and there should be computer literacy skills for secondary school students.

Keywords: Physics Performance Test, Computer-Based Concept Mapping Instructional Packages, Hierarchical Concept Mapping, Spider Concept Mapping

Introduction

The growth and development of any nation is dependent on science, technology and mathematics education. Science is an organized body of knowledge, which enhances the ability to acquire skills. It is a search for meaning or exploration of events in nature (Ifeakor, 2006). Science and technology related subjects that would enable students to have a substantial understanding of science and be able to apply scientific knowledge in solving problems in their ever-changing society are Mathematics, Chemistry, Biology, Health Science, Introductory technology and Physics.

Physics is one of the compulsory subjects for one to study science and technology related courses in tertiary institutions. It is a science that uses quantitative measurement and experimental observations in order to understand natural events. It can explain natural events mathematically and can relate these events to daily life events (Tekbiyik & Akdeniz, 2010; Eren & Gurdal, 2010). Of all the sciences, Physics is the one that students experience the most difficulties with because most of the physical notions are abstract. Also, when compared to other lessons, although there are many relationships between main subjects and number of

the subjects to be learned, simply knowing definitions is not enough to learn the subject (Karaca, 2013). Theories and numerical expressions also make it difficult to understand Physics and to make a connection between the subjects (Ergul & Cigrik, 2013; Jian-Hua & Hong, 2012; Arvind & Heard, 2010; Bakac, Tasoglu & Akbay, 2011).

The role of Physics in national development is acknowledged in the whole world. The significance of Physics in all fields of science and technology has made Physics imperative to be included in the curriculum of senior secondary school to be offered by science-oriented students. With the importance of Physics and provisions made by the Federal Government of Nigeria for effective teaching and learning of Physics, the objectives of its teaching and learning as stated in the Nigerian secondary school Physics curriculum is yet to be achieved

All around the world, teachers are becoming more aware of new teaching strategies and tools that can be used in the classroom with initiatives in teaching-learning that integrates the inquiry-based learning with Information Communication Technology, Audio-visual interactivity packages, Visual models, and Concept-mapping instructional strategies in an effort to aid and effect student-centred learning (Dean, 2008). Several researchers in education show the efficacy of these new teaching strategies (Cañas, Novak & Gonzalez, 2004; Hay, Kinchin & Lygo-Baker, 2008; Kathy, Wendy, Noah, Christopher, Carl, Mike, Krista, Ron, Sam & Noah, 2006). Despite these advances, physics teaching and learning in Nigeria still retain the old and conservative approach.

A concept map is a description of how propositions are organized (Novak, 2008). Concept maps reflect how ideas, opinions, and propositions are organized in the knowledge structure of students who construct the concept maps and give observations on students' states. From the observations, the teacher can assess the knowledge structure of students. They are forms of graphical organizers which allow learners to perceive the relationships between concepts through diagramming of keywords representing those concepts. These concepts are usually enclosed in circles or boxes of some type and relationships between concepts indicated by connecting lines linking two or more concepts. The process of using these graphical tools for organizing and presenting knowledge is referred to as concept mapping (Novak, 2008).

Computer-based instructional strategy refers to instruction or remediation presented on a computer. These modes of instructions are interactive and can illustrate a concept through attractive animation, sound, and demonstration. It allows students to progress at their own pace and work individually. Computers provide immediate feedback, letting students know whether their answer is correct or not. If the answer is not correct, it shows how the students can get the correct answer. Many researchers have used computer-based instruction in different subject areas to improve effective teaching and learning. Computer-based concept mapping instructional strategy incorporates the use of computer instruction and other ICT tools with concept mapping. With computer-based concept mapping, concept representations and their respective links are not static; both can be expanded as knowledge or elaboration of an idea increases. Errors in describing ideas can be easily corrected and adapted. Most computer-based concept mapping tools allow the user to point and drag a concept or group of concepts to another place on the map and automatically update all the appropriate links (Anderson-Inman & Zeitz, 2013).

Gender in relation to performance has been an issue of interest and concern to researchers in education. There are varying opinions on which gender (either male or female) achieves better than the other. The issue of gender becomes crucial in this present day because the schools in the research are co-educational. Also, the contradictive evidence in academic performance due to gender has necessitated the need to verify how computer-based concept

mapping instructional strategies can influence students' performance in physics. This study, therefore, examined the effects of computer-based concept mapping instructional strategy on students' performance in physics.

Statement of the Problem

The performance of students in science generally has been quite unsatisfactory over the years (Olorukoba, 2007). The external examining bodies such as West African Examination Council (WAEC) and National Examination Council (NECO) have repeatedly reported poor performance in physics. The report of the chief examiner, West African Examination Council, WAEC (2015) revealed that candidates' performance was poor. Furthermore, a critical look at the statistics of candidates' enrolment and performance in physics in Kaduna state for the years 2011 to 2016 shows that the performance of the candidates was poor. The persistent poor performance, according to the chief examiner for the year 2015- 2016 was as a result of Poor understanding of general principles and concepts, heat, energy changes, matter and motion (WAEC, 2016). This poor performance as indicated by the results can be attributed to many factors which include; ineffective teaching methods, unqualified and inexperienced teachers teaching the subject, lack appropriate and effective use of media among others (WAEC, 2016). This persistent poor performance also implies that a larger percentage of science students will not be admitted to study science and technology related courses in higher institutions since physics is one of the subjects that must be passed at least at credit level in SSCE in order to study science and technology related courses in higher institutions. Despite all that has been done to improve students' achievement especially in physics, students still perform poorly. Therefore, this study seeks to determine the effects of computer-based concept mapping instructional strategies on students' performance in physics.

Research Questions

The study was guided by the following research questions:

(i) What is the difference between the performance of students taught physics using hierarchical and spider computer-based concept mapping strategies and those taught using computer-assisted instruction?

(ii) What is the difference between the performance of male and female students taught physics using hierarchical mode of computer-based concept mapping instructional strategy?

(iii) What is the difference between the performance of male and female students taught physics using spider mode of computer-based concept mapping instructional strategy?

Research Hypotheses

The following research hypotheses were formulated and tested at 0.05 alpha level:

Ho_1: There is no significant difference between the performance of students taught physics using hierarchical and spider computer-based concept mapping strategies and those taught with computer-assisted instruction.

Ho_2: There is no significant difference between the performance of male and female students taught physics using hierarchical mode of computer-based concept mapping instructional strategy.

Ho_3: There is no significant difference between the performance of male and female students taught physics using spider mode of computer-based concept mapping instructional strategy.

Methodology

The research design adopted for this study is a quasi-experimental design. It is a pretest, posttest, non-randomized, non-equivalent control group design. A 3 x 2, multiple treatment factorial design was used in this study. This design represents three levels of treatment

(computer-based concept mappings using hierarchical and spider modes respectively and computer-assisted instruction method; and two levels of gender (male and female). This is illustrated in the figure 1:

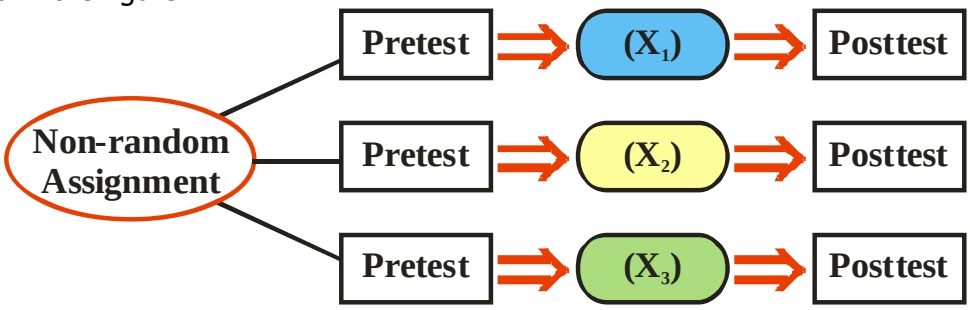

Figure 1: Research Design Layout

Key:
X_1: treatment for Experimental group 1 (using CBCM hierarchical model).
X_2: treatment for Experimental group 2 (using CBCM spider model)
X_3: treatment for Control group (using CAI)

The target population of this study is 3,683 Senior Secondary School Physics students in SS II. This population comprises 1,542 males and 2,141 females. The population for this study consists of all senior secondary two (SSII) physics students in all the 50 private senior secondary schools in Kaduna South Local Government Area of Kaduna State. A two-stage sampling technique was adopted. Firstly, purposive random sampling was adopted to obtain three private secondary schools in Kaduna South Local Government Area of Kaduna State. The schools were purposefully sampled based on equivalence in (laboratories, facilities, and manpower), school location (urban area, Kaduna metropolis), gender composition (mixed schools), well-equipped computer laboratories, exposure (students and teachers exposure to the use of the computer in their schools). Secondly, the three sampled equivalent and co-educational schools were randomly assigned to the experimental groups and the control group. The three schools are co-educational schools that consist of both male and female students. The study adopted the use of intact class approach where all the students in the class were involved in teaching and testing sessions. The schools selected to be used in this study were tagged as school A, B and C respectively. The total number of students that were used for this study from the three sampled schools is 110. The sample is illustrated in table 1.

Table 1: Distribution of Sample for the Study

	Number of SS II Physics Students		
School	**Male**	**Female**	**Total**
A	16	14	**30**
B	16	20	**36**
C	25	19	**44**
Total	**57**	**53**	**110**

Source: Field Survey, 2017

Physics Performance Test (PPT) was used as an instrument for collecting data in this study. The researcher adapted Physics Performance Test (PPT) consists of 20 multiple choice items adapted from past examination questions of West African Examination Council (WAEC) and National Examination Council (NECO) from 2011 to 2016. The Physics Performance Test (PPT) is based on SSII curriculum on the concepts of the Centre of gravity and Newton's laws of motion. These chosen topics were selected from the senior secondary two (SSII) physics

syllabuses and scheme of work and correspond to what the students should be taught in their schools at the time of the study. Each item of the instrument was a multiple choice question with four options (A-D) as possible answers to the question. Only one of the four options was the correct answer. The students responded to the instrument in two sections. The first part (section A) was for eliciting information on the students' personal data, while section B contains multiple-choice objective questions for students to answer. This was administered to the experimental groups and control group as pretest and posttest. To reduce the effect of pretest and posttest, the questions were reshuffled and administered in a different random order in the posttest. On the scoring of the multiple-choice items, five (5) marks were awarded for each correct answer and zero (0) mark for each wrong answer. The instrument was scored over 100 (5x20 items).

The instruments used for the treatments were the Computer-Based Concept Mapping Instructional Packages (CBCMIP) and Computer Assisted Instruction (CAI) package on Physics. They were developed by the researchers and a programmer. Because the commercially produced computer-based instructional packages are not common, there was the need for the researchers to developed their own packages. Even where the commercially made packages are available, they may not be directly relevant to the topic or objectives to be achieved in a lesson. Moreover, using imported software to implement physics instruction in Nigeria may not be culturally relevant. As a result of this, developing instructional packages for use by the researcher is inevitable. They are individualized programmes in which the individuals who are interacting with the computer had to make some entries by clicking available options. The computer presented information and displayed an animation to the learners on each of the sub-units after which the students attempted some multiple choice objective questions. Each of the units was presented by the computer through interaction mode, that is, exposure to information, facts and practice on the topic and immediate response/feedback to the application questions. The students could proceed further or repeat a unit if they were not satisfied with the interaction, also, in the questions/evaluation section, students could only proceed to another question if the previous questions are satisfactorily answered. The students were expected to have 100% mastery of the course content before exiting the package. The production of the package was effected through a team of professionals and specialists including a system programmer and the instructional designer (the researcher).

The researcher visited the schools to check the facilities available in the schools. Also, approval was sought from the school authorities to carry out the study. The cooperation of the students and the staff in all selected schools were sought. The subject teachers were trained as research assistants in the use of the computer-based concept mapping instructional strategies. The study lasted for four weeks. There was orientation with the physics teachers, and students in each of the three schools that were involved in the study. This training and demonstration sessions on the procedure for carrying out the experiment lasted for one week. The training was done in each school according to the type of treatment that was given to such schools. The teachers and students were adequately briefed, trained and demonstrated competence in the successful implementation of the Operational Guides to Instruction (OGI). During the experiments, three different treatments were applied. The treatment lasted for two weeks. The experiment was conducted using the schools' timetables and at their normal lesson periods. Immediately after the treatment ends, a posttest was administered to measure the performance of the sampled students in each school. The posttests (Physics Performance Test (PPT) was reshuffled and administered after the experiments. The test was conducted in all the selected schools for the study at the same time and the scripts were collected immediately for marking. At the expiration of the treatment, the items in the Physics Performance Test (PPT) were reshuffled and re-administered to the students. The scores obtained from the

second administration served as post-test scores in the study. The essence of item reshuffling was to distract the students from realizing that they had responded to such test items in the past.

The data obtained from the pre-test and post-test were marked and subjected to data analysis. The research questions were answered using mean and standard deviation while the hypotheses for the study were tested using ANCOVA with Statistical Package for Social Sciences (SPSS) version 21. The significance of the various statistical analyses was ascertained at 0.05 alpha levels of significance

Results

Research Question 1: What is the difference in the performance of students taught physics using computer-based concept mapping strategies and those taught using computer assisted instruction?

Table 2: Mean and standard deviations of students scores using computer based concept mapping strategies and computer-assisted instruction

Group	N	Pre-test		Post-test		Mean Gain
		Mean	SD	Mean	SD	
CBCM (Hierarchical)	30	49.50	11.55	77.17	10.80	27.67
CBCM (Spider)	36	47.22	11.24	76.81	10.22	29.59
CAI	44	43.52	12.92	75.34	10.91	31.82

Table 2 shows the mean and standard deviation of the pre-test and post-test scores of all students in the experimental and control groups. From the result, it can be deduced that the mean score and standard deviation of the pre-test for the Computer-Based Concept Mapping (CBCM) of students in Hierarchical group are 49.50 and 11.55 while the mean score and standard deviation of the same students in the post-test are 77.17 and 10.80. The mean gain was 27.67 in favour of the post-test scores. Similarly, the mean score and standard deviation of the pre-test for the CBCM of students in Spider group are 47.22 and 11.24 while the mean score and standard deviation of the same students in the post-test are 76.81 and 10.22 respectively. The mean gain is 29.59 in favour of the post-test score. Also, the mean score and standard deviation of the pre-test for the CAI of students in Control Group are 43.52 and 12.92 while the mean score and standard deviation of the same students in the post-test are 75.34 and 10.91. The mean gain is 31.82 in favour of the post-test scores.

Research Question 2: What is the difference between the performance of male and female students taught physics using hierarchical mode of computer-based concept mapping instructional strategy?

Table 3: Pre-test and post-test scores of male and female students taught physics using hierarchical mode of computer-based concept mapping strategy

Group	N	Pre-test		Post-test		Mean Gain
		Mean	SD	Mean	SD	
Male	16	49.69	13.48	77.50	11.40	27.81
Female	14	49.29	9.38	76.79	10.49	27.50

Table 3 showed the mean and standard deviation of the pre-test and post-test scores of male and female students in the experimental group 1 (CBCM hierarchical). From the result, it can be deduced that the mean score and standard deviation of the pre-test for the male students are 49.69 and 13.48 while the mean score and standard deviation of the same students in the post-test are 77.50 and 11.40. The mean gain is 27.81 in favour of the post-test scores.

Similarly, the mean score and standard deviation of the pre-test for the female students are 49.29 and 9.38 while the mean score and standard deviation of the same students in the post-test are 76.79 and 10.49 respectively. The mean gain is 27.50 in favour of the post-test score. Therefore, male students (27.81) had a higher mean gain score than the females (27.50).

Research Question 3: What is the difference in the performance of male and female students taught physics using spider mode of computer-based concept mapping instructional strategy?

Table 4: Pre-test and post-test scores of male and female students taught physics using spider mode of computer-based concept mapping strategy

Group	N	Pre-test		Post-test		Mean Gain
		Mean	SD	Mean	SD	
Male	16	44.06	12.55	74.06	10.36	30.00
Female	20	49.75	9.66	79.00	9.81	29.25

Table 4 showed the mean and standard deviation of the pre-test and post-test scores of male and female students in the experimental group 2 (CBCM spider). From the result, it can be deduced that the mean score and standard deviation of the pre-test for the male students are 44.06 and 12.55 while the mean score and standard deviation of the same students in the post-test are 74.06 and 10.36. The mean gain is 30.00 in favour of the post-test scores. Similarly, the mean score and standard deviation of the pre-test for the female students are 49.75 and 9.66 while the mean score and standard deviation of the same students in the post-test are 79.00 and 9.81 respectively. The mean gain is 29.25 in favour of the post-test score. Therefore, male students (30.00) had a higher mean gain score than the females (29.25).

Hypotheses Testing

Hypothesis One: There is no significant difference in the mean performance of students taught physics using computer-based concept mapping strategies and those taught with computer assisted instruction.

Table 5: ANCOVA results of the treatment groups (CBCM and CAI)

Source	Type III Sum of Squares	df	Mean Square	F-value	p-value
Corrected Model	1343.845[a]	3	447.948	4.360	.006
Intercept	26383.944	1	26383.944	256.813	.000
Pre-test	1271.673	1	1271.673	12.378	.001
Groups	3.304	2	1.652	.016	.984[ns]
Error	10890.019	106	102.736		
Total	652925.000	110			
Corrected Total	12233.864	109			

ns: Not significant at 0.05 alpha level

Table 5 shows the ANCOVA results of the two experimental groups (CBCM Hierarchical, CBCM Spider) and the control group (CAI). As illustrated in the table, $F(3, 106) = 0.016$, $p = 0.984$. This implies there was no significant effect of the learning strategies on post-test performance of the students. The result indicates that the treatments using CBCM and CAI accounted for no difference in the post-test achievement scores of the students. Hence, hypothesis one is not rejected.

Hypothesis Two: There is no significant difference in the mean performance of male and female students taught physics using hierarchical mode of computer-based concept mapping instructional strategy.

Table 6: ANCOVA results of male and female students in experimental group 1 (CBCM Hierarchical)

Source	Type III Sum of Squares	df	Mean Square	F-value	p-value
Corrected Model	252.394	2	126.197	1.088	.351
Intercept	6256.675	1	6256.675	53.941	.000
Pre-test	248.584	1	248.584	2.143	.155
Gender	2.799	1	2.799	.024	.878[ns]
Error	3131.773	27	115.992		
Total	182025.000	30			
Corrected Total	3384.167	29			

ns: Not significant at 0.05 alpha level

Table 6 shows the ANCOVA results of male and female students in experimental group 1 (CBCM hierarchical). From the result, F(1, 27) = 0.024, p = 0.878. This implies that there is no significant difference in the mean performance of male and female students taught physics using hierarchical mode of computer-based concept mapping instructional package. Hence, hypothesis two is not rejected.

Hypothesis Three: There is no significant difference in the mean performance of male and female students taught physics using spider mode of computer-based concept mapping instructional strategy.

Table 7: ANCOVA results of male and female students in experimental group 2 (CBCM spider)

Source	Type III Sum of Squares	df	Mean Square	F-value	p-value
Corrected Model	694.769[a]	2	347.385	3.869	.031
Intercept	6550.784	1	6550.784	72.962	.000
Pre-test	478.068	1	478.068	5.325	.027
Gender	74.976	1	74.976	.835	.367[ns]
Error	2962.870	33	89.784		
Total	216025.000	36			
Corrected Total	3657.639	35			

ns: Not significant at 0.05 alpha level

Table 7 shows the ANCOVA results of male and female students in experimental group two (CBCM spider). From the result, F(1, 33) = 0.835, p = 0.367. This implies that there is no significant difference in the mean performance of male and female students taught physics using spider mode of computer-based concept mapping instructional package. Therefore, hypothesis three is not rejected.

Discussion

The findings of this study revealed that the use of computer-based concept mapping instructional strategy had no significant effect on students' performance in physics. This finding disagrees with that of Lou, Wen and Tseng (2013) who investigated the effect of integrating concept mapping into computer-assisted instruction in chemistry learning achievement and found out that the students in the experimental group who were treated

with computer-assisted concept mapping achieved significantly better than those in the control group. The finding is in agreement with the findings of Yusuf and Afolabi (2010), who reported that computer-assisted instruction had a significant effect on students' performance in science.

The use of the computer as a medium of instruction may be responsible for no significant difference among the three groups. The trend of performance by the treatment (CBCM) group could be as a result of self-evaluation and remedial activities provided by (CBCM) which helped students to master the physics concepts without much difficulty. It could also be as a result of excitement over the use of computers, and individualized learning by the students that cater for individual difference. Furthermore, the pictorial representations and concept maps provided by the computer can be a factor that contributed to the better performance of the groups. The study revealed that both the hierarchical and spider modes of Computer-Based Concept Mapping have no significant effect on gender.

Recommendations

Based on the results of this study, the following recommendations were made:

(i) Since the use of CBCM in teaching has been found to enhance the quality of performance in physics, physics teachers should be encouraged to employ it more in the teaching of the subject. By so doing, the performance of students in the subject could be increased.

(ii) Workshops and seminars should be organized for teachers by Education Authorities – Federal and State Ministries of Education, Institutes and Colleges of Education on the use of computer-assisted concept mapping strategies to improve students' performance in Physics.

(iii0 Governments and Non-governmental organization should assist in providing functional computers and ICT infrastructure to schools and there should be computer literacy skills for secondary school students.

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