EFFECTS OF HIERARCHICAL CONCEPT MAPPING INSTRUCTIONAL STRATEGY WITH SCAFFOLDING AID ON STUDENTS' ACHIEVEMENT IN SENIOR SECONDARY SCHOOL PHYSICS IN JOS, NIGERIA

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Abstract

This study investigated the effects of hierarchical concept mapping instructional strategy with scaffolding aid on students' achievement in senior secondary school Physics in Jos, Nigeria. It was based on the fluctuations and poor achievements of students in Physics examinations over the years. The research design employed was the quasi-experimental design of the non-equivalent control group pretest-posttest type. Sixty-three (63) Senior School three (SS 3) students from two secondary schools were used as sample for the study and were tested on the concepts of electricity using a developed 25-item Physics Achievement Test (PAT) whose reliability coefficient was 0.85, obtained from Kuder-Richardson formula 20. Two research questions were raised and answered using mean and standard deviation while one hypothesis was formulated and tested using One-way Analysis of Variance (ANOVA). The analyses revealed that students taught using hierarchical concept mapping instructional strategy with scaffolding aid achieve significantly higher than those instructed under the expository method of instruction. Based on the findings, recommendations were made which include suggesting that teachers should be encouraged to utilize hierarchical concept mapping instructional strategy with scaffolding aid in teaching Physics.

Keywords

Hierarchical concept mapping instructional strategy, Scaffolding aid, Achievement, Physics, Expository method

Introduction

Physics is a subject that is taught in secondary schools and it is the branch of science that is concerned with the nature and properties of inanimate matter and energy. It is the scientific study of matter in relation to energy and is one of the core science subjects that tries to answer some of the questions asked about nature and wonders of the world. It is not concerned with chemical changes that occur but with the forces that exist between objects and the interrelationship between matter and energy. The study of Physics at the secondary school level of education in Nigeria includes studying mechanics, heat energy, optics, wave motion, electricity and magnetism, electronics, atomic and nuclear Physics. The applications of physics, through its principles, laws and theories, can be observed in the surroundings and homes. The knowledge of physics is used in the construction of land, sea, and air vehicles; it is also used in x-ray machines in hospitals and in non-medical areas such as at boarder and airport to detect some unpermitted or contraband goods. Radio-activity in physics has also contributed to national development, especially in agriculture. Josiah (2012) opined that the knowledge of Physics is required in developing fixed line and optical-fibre network in the telecommunications sector.

Despite the importance of Physics in all spheres of the development of a nation, the teaching of the subject for proper comprehension in secondary schools seems to be relegated to the background. Most methods of instruction in Physics used by teachers are teacher-centred, especially the expository method of instruction (Boyo, 2010). Omosewo (2009) had earlier pointed out that this expository method of instruction,

which dominates the science classrooms, has continuous poor achievement as a consequence. There is the need to facilitate the learning of Physics in secondary schools through the utilization of contemporary learner-centred instructional methods. This is apt because the standard of achievement in Physics by secondary school students leaves much to be desired (Josiah & Mankilik, 2018). Earlier, Ogunleye (2006) had remarked that despite the efforts aimed at improving science, technology and mathematics education in Nigeria, there has been in recent times a growing public anxiety about the fallen standards in these all important areas. Another possible reason attributed to the poor achievement of students in Physics as pointed out by Inyang and Josiah (2016) is that physics is a difficult subject for secondary school students to construct meaningful learning, and so the achievement of such students in Physics can be poor. In addition, Mankilik and Usman (2009) were of the view that students do not understand Physics concepts and principles up to application levels. It is, therefore, pertinent that considerable effort must be put in place to address this worrisome situation.

Emerging trends in pedagogy advocate for a shift from the teacher-centred methods of instruction to learner-centred ones, which are contemporary and effective in facilitating the understanding of concepts by students. This, therefore, calls for resourcefulness and innovation on the part of the Physics teacher. As a facilitator, the teacher applies new teaching methods and evaluates self while also examining students' understanding of Physics concepts. Such a teacher must be ready to implement new teaching initiatives and to integrate advanced technologies in education, while being aware of the advantages and disadvantages that these innovations may bring to the teaching-learning process. Various methods and strategies of instruction, which are learner-centred, have evolved and these have the advantage of enhancing Physics learning in students over the expository method of instruction. One of such instructional strategies this study is concerned with is the hierarchical concept mapping with scaffolding aid which may be a more effective study strategy to improve secondary school students' knowledge and understanding of Physics concepts. Hierarchical concept mapping is the process of constructing a concept map for learning. A hierarchical concept map consists of propositions defined by concept nodes that are arranged in a hierarchical structure and connected by relation links. Between every two concept nodes there is a relation link which defines a proposition. Hierarchical concept mapping is a learning strategy that can be used to improve students' ability to learn autonomously and helps them become independent learners. Concept maps in the strategy represent a visual form of knowledge which makes learning meaningful to students. According to Tajeddin and Tabatabaei (2016) concept mapping enhances meaningful learning in students because it shows the relationship among concepts in a network in a hierarchical form. The duo studied the effect of concept map on reading comprehension and found out that the achievement mean of the experimental group exceeded the mean of the control group. Their findings also showed that the difference in the mean scores of the two groups in the reading comprehension test was significant. In another study undertaken earlier by Chang, Sung and Chen (2001), findings indicated that hierarchical concept mapping instructional strategy with scaffolding aid had more positive effects on students' learning of Biology concepts than those of 'construct-by-self' and 'paper-and-pencil' methods of hierarchical concept mapping.

Although hierarchical concept mapping instructional strategy is advantageous, Chang, Sung and Chen (2002) opined that students might feel frustrated when they are constructing concept maps on their own, which might decrease their motivation to learn. In order to solve that problem, Liu (2011) suggested the use of hierarchical concept mapping instructional strategy with scaffolding aid, because it is more beneficial than asking students to construct the whole concept map on their own. Scaffolding aid as described by Wood, Bruner and Ross (1976), consists of a teacher manipulating the elements task that are beyond the students' ability so that the student is able to focus on and achieve competence in the fundamentals within his/her capacity. Supplementing, Reiser (2004) saw scaffolding aid as a process by which a teacher provides assistance to a student, or a more knowledgeable student provides assistance to a less knowledgeable fellow student, altering the learning task so that the learner can solve problems or accomplish task that would ordinarily be impossible for him/her and to learn from the experience. A scaffold, which is an incomplete expert concept map with some blank nodes and links, is provided to the students by the teacher when he/she is using the hierarchical concept mapping instructional strategy with scaffolding aid. This implies that, rather than learn through completely constructing the map themselves, the students learn by constructing the concept map through filling in the blanks. Tajeddin and Tabatabaei (2016) remarked that the use of scaffolding aid in hierarchical concept mapping instructional strategy improves students'

achievement, motivates them towards learning and reduces cognitive loads.

It can be argued that schools are established with the aim of imparting knowledge and skills, and enhancing good academic performance to students who go through them. However, there are a number of observable problems plaguing the teaching and learning of Physics in Nigeria, especially at the secondary school level. These problems include poor methods of instruction used by Physics teachers as observed by Josiah, Larina (2015), Sule and Mankilik (2015), and which Agommuoh and Nzewi (2003) viewed as leading to students' poor achievement in Physics examinations. In spite of the varieties of instructional methods and strategies for teaching Physics, students at the secondary school level continue to exhibit poor performance in the subject. This has become a serious problem to the Nigerian society, considering the importance of Physics to national development. Research revealed that despite the huge resource invested by Nigerian stakeholders in the educational sector, mass failure in public examinations, especially in science and technology related areas which include physics is still being recorded every year (Joshua, Ekpoh, Edet, Joshua & Obo, 2004).

There are a number of observable problems plaguing the teaching and learning of Physics in Nigeria, especially at the secondary school level. Most worrisome is the problem of fluctuations and poor achievements of students in Physics which, perhaps, may be linked to the use of instructional strategies that are not learner-friendly in teaching Physics. Results of students in Senior School Certificate Examination (SSCE) Physics examinations, organized by West African Examination Council (WAEC) and National Examination Council (NECO), have attested to the fluctuations and poor achievements of students in subject. The situation of students' achievement in Physics in Jos, where this study was undertaken, is not too different from that of the national outlook. This fluctuations and not too impressive outcome have been attributed to ineffective methods of teaching Physics, such as the conventional lecture method, employed by teachers in the classroom and the lack of motivation that such methods present to the students, among others (WAEC, 2015 & NECO, 2009-2012). The role of the teacher in students' learning has been changing overtime and, currently, teacher-dominated learning strategies are being phased out as student's performance and achievement in physics continues to be poor. They are being replaced by the more advantageous learner-centred instructional methods. Hence, there is the need for Physics teachers to adopt learner-centred strategies, such as the hierarchical concept mapping instructional strategy with scaffolding aid, in teaching concepts. The aim of the study was to investigate the effects of hierarchical concept mapping strategy with scaffolding aid on students' achievement in senior secondary school Physics in Jos, Nigeria.

Specifically, the study sought to achieve the following two objectives:

1. To determine the level of students' achievement in secondary school Physics;
2. To find out if hierarchical concept mapping instructional strategy with scaffolding aid influences students' achievement in secondary school Physics.

This study provided answers to the following questions:

1. What is the level of senior school three (SS 3) students' achievement in Physic before exposure to hierarchical concept mapping instructional strategy with scaffolding aid?
2. What is the level of SS 3 students' achievement in Physics after exposure to hierarchical concept mapping instructional strategy with scaffolding aid?

The following null hypothesis was formulated and tested at 0.05level of significance: There is no statistical significant difference between the mean Physics achievement scores of senior school three (SS 3) students who were exposed to hierarchical concept mapping instructional strategy with scaffolding aid and those exposed to expository method of instruction.

Method

This study employed the quasi-experimental research design of the non-equivalent control group pretest-posttest type, because intact classes from two sampled educational secondary schools were used for the study. Purposive sampling technique was used to obtain the two schools for the intact classes in the study. The schools for the study were selected using the following criteria: The school must have (i) well-equipped Physics laboratory, (ii) at least one qualified Physics teacher with at least two years teaching experience, (iii) not less than 10 candidates currently being presented for Senior School Certificate Examination (SSCE) organized by West Africa Examination Council (WAEC) and National Examination Council (NECO). One of the two schools was randomly assigned to experimental group while the second was assigned to the control group. The experimental group was taught concept of electricity using hierarchical concept mapping strategy with scaffolding aid, while the control group was taught the same

concepts using the expository method of instruction. The instrument used for the study was a twenty-five-item multiple-choice Physics Achievement Test (PAT), which was developed from secondary school Physics curriculum and past SSCE organized by WAEC and NECO, using blue print. Face and content validity of PAT was obtained by giving it to three experts in the University of Jos. Thereafter, the reliability of PAT was obtained as 0.85 using Kuder-Richardson formula 20 (K-R 20) on the SPSS Software Version 25.

A total of sixty-three senior school three (SS 3) Physics students from the two sampled secondary schools in Jos, Nigeria formed the sample for the study. A week before treatment started, pretest was administered on both the experimental and control groups. Thereafter, treatment was carried out on the experimental group for a period of six weeks during which time the control group was merely, engaged using the expository method of instruction, on the same topic that the experimental group was treated. After the six weeks treatment, a post test was administered to all the students in both the experimental and control groups. The raised research questions were answered using the mean and standard deviation (descriptive statistics) while the formulated null hypothesis was tested using the One-way Analysis of Variance (ANOVA).

Results

Research Question One

What is the level of senior school three (SS 3) students' achievement in Physics before exposure to hierarchical concept mapping instructional strategy with scaffolding aid?

Table 1 shows the level of achievement of SS 3 students in Physics before exposure to treatment.

Table 1: Level of Achievement of SS 3 Students in Physics before Treatment

Group	N	Mean	Std Dev.	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Min.	Max.
Exp	33	38.5000	38.5000	2.55855	30.7300	41.2700	12.00	56.00
Control	30	38.7500	46393	2.74852	30.8143	42.1857	12.00	56.00
Total	**63**	**38.6250**	**13.11575**	**1.85485**	**32..5125**	**39.9675**	**12.00**	**56.00**

Table 1 indicated that the mean score; standard deviation of experimental group are (38.5000, 13.04461) as compared to those of the control group of (38.7500, 13.46393) respectively. This shows that before treatment, the Physics achievement mean scores of students exposed to hierarchical concept mapping instructional strategy with scaffolding aid and those exposed to expository method of teaching did not differ much.

Research Question Two

What is the level of SS 3 students' achievement in Physics after exposure to hierarchical concept mapping instructional strategy with scaffolding aid?

Table 2 shows the mean and standard deviation analysis performed on research question two.

Table 2: Level of Achievement of SS 3 Students in Physics after Treatment

Group	N	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Min.	Max.
Exp.	33	66.6154	9.03624	1.86827	52.5617	67.6691	36.00	72.00
Control	30	40.5000	11.41668	2.53454	33.2569	43.7431	16.00	56.00
Total	**63**	**53.5577**	**14.39932**	**2.03637**	**43.8278**	**52.0122**	**16.00**	**72.00**

From Table 2, the mean scores, standard deviation of experimental group and control group are; (66.6154, 9.03624) and (40.5000, 11.41668) respectively. This implies that there is a difference between Physics achievement mean scores of students who were exposed to hierarchical concept mapping instructional strategy with scaffolding aid and those exposed to expository method of teaching.

Hypothesis

There is no statistical significant difference between the mean Physics achievement scores of senior school three (SS 3) students who were exposed to hierarchical concept mapping instructional strategy with scaffolding aid and those exposed to expository method of instruction.

Table 3 provides the summary of analysis of variance on the formulated hypothesis.

Table 3: Analysis of Variance (ANOVA) of Pre-test and Post -test on Students' Achievement of Experimental and Control Groups

Source of variation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	16993.394	2	8496.697	92.38	.000
Within Groups	9197.451	60	91.975		
Total	26190.845	61			

$p<0.05$

in Table 3, the ANOVA reveals that there is a statistically significant difference of treatments given to students and their responds to hierarchical concept mapping instructional strategy with scaffolding aid and expository method of instruction, suggesting that students in the experimental group gained significantly more than their counterparts in the control group, that is F_c = 92.381, P=0.00 < 0.05. Therefore, the null hypothesis was rejected. This means that the hierarchical concept mapping instructional strategy with scaffolding aid had a greater impact in the teaching and learning of Physics than the expository method of instruction.

Discussion

Findings from tables 1 and 2 showed that before treatment, there was no much difference between the achievement mean score in Physics of students that were later exposed to hierarchical concept mapping instructional strategy with scaffolding aid and that of those exposed to expository method of teaching. This means that the entry behaviour of all the students was the same before the treatment. However, after the treatment, students who were exposed to hierarchical concept mapping instructional strategy with scaffolding aid had a higher achievement mean score (66.62) than their counterparts who were exposed to expository method of teaching (40.50).

The finding from table 3 showed a statistically significant difference of treatments given to students and their responds to the two methods of instruction. Students taught Physics using hierarchical concept mapping instructional strategy with scaffolding aid gained significantly more than their counterparts taught with expository method of instruction. The hierarchical concept mapping instructional strategy with scaffolding aid was found to be more effective in learning Physics concepts than the expository method of instruction. This can be attributed to the learner-centred nature of hierarchical concept mapping instructional strategy with scaffolding aid and its advantage of presenting visual form of knowledge to the learner This finding was in agreement to those of Chang, Sung, Chen (2001), Tajeddin and Tabatabaei (2016) who found out that concept mapping instructional strategy with scaffolding aid is more superior, in terms of their achievement, to expository method of instruction and other forms of hierarchical concept mapping instructional strategy.

The implication of the findings of this study is that concept mapping instructional strategy with scaffolding aid can enhance students' achievement when teachers use it in teaching Physics concepts. Consequently, the objectives of the Physics curriculum which includes provision of basic literacy in Physics for functional living in the society may be achieved.

Recommendations

The following recommendations were proffered based on the findings from the study:

1. Teachers should be encouraged to use hierarchical concept mapping instructional strategy with scaffolding aid in teaching secondary school Physics, amongst other learner-centred methods, since it is found to be effective in learning.
2. Teachers should be encouraged to attend periodic teacher-professional development programmes so as to build their capacity in the use of hierarchical concept mapping instructional strategy with scaffolding aid and other contemporary instructional methods of teaching.

Conclusion

The positive effect of teacher's use of hierarchical concept mapping instructional strategy with scaffolding aid on short-term learning was highly statistically significant. Hence, if the utilization of the instructional strategy is accorded crucial attention in the teaching and learning of Physics it may remedy the poor achievement in Physics.

References

Agommuoh, P. C., & Nzewi, U. M. (2003). Effect of videotaped instruction on secondar school students' achievement in Physics. *Journal of the Science Teachers Association of Nigeria, 38*(1 & 2), 88-93.

Boyo, A. (2010). *Identifying problems associated with studying Physics in Lagos state, Nigeria.* Retrieved from http://www.wepsd.org/posters/education/boyo-adenike-1.pdf

Chang, K. E., Sung, Y. T., & Chen, S. F. (2001).

Learning through computer-based concept mapping with scaffolding aid. *Journal of Computer Assisted Learning, 17*, 21-33.

Chang, K. E., Sung, Y. T., & Chen, I. D. (2002). The effect of concept mapping to enhance text comprehension and summarization. *The Journal of Experimental Education, 71*(1), 5-23.

Inyang, U. S., & Josiah, M. M. (2016). Students' gender and perceived difficulty of concepts in secondary school Physics in Jos metropolis, Nigeria. *IOSR Journal of Research and Method in Education, 6*(5), 1-5.

Josiah, M. M. (2012). School location versus academic achievement in Physics: Does computer-assisted instruction (CAI) has any effect? *Journal of Educational and Social Research, 2* (8), 162-168.

Josiah, M. M., & Larina, E. P. (2015). Physics education in Nigerian secondary schools: Problems and prospects. *International Journal of Research in Science, Technology and Mathematics Education, 3* (2), 115-123.

Josiah, M. M., & Mankilik, M. (2018). Influence of jigsaw cooperative learning on senior secondary two students' motivation towards learning Physics. *Journal of Educational Studies, 18* (2), 27-40.

Liu, P. L. (2011). A study on the use of computerized concept mapping to assist ESL learners' writing. *Computers & Education, 57*(4), 2548-2558.

Mankilik, M., & Usman, I.S. (2009). Evaluation of students' understanding and application of Physics concepts in Plateau state's Northern zone secondary schools. *FCT Education Secretariat Journal of Curriculum Studies & Instruction, 2*(1), 6 12.

National Examinations Council. (2009-2012). *Chief examiners' report SSCE (internal).* Abuja: Wins Image Limited.

Ogunleye, A. O. (2006). An investigation into the availability and extent of use of resources in the teaching of physics, in some Lagos state public and private schools. In U.

Nzem (Ed.). *Resources for Science, Technology and Mathematics Education. STAN Proceedings of 47th Annual Conference (pp. 283 – 290).* Ibadan: Heinemann Educational Books (Nig) Ltd.

Omosewo, E. O. (2009). *Factors influencing female students' choice of physics in selected secondary schools in Ilorin metropolis*. Retrieved from http://www.unilorin.edu.ng/unilorin/publication/omosewo/FACT

Reiser, B. J. (2004). Scaffolding Complex Learning: The mechanism of structuring and problematizing student work. *The Journal of the Learning Sciences, 13*(3), 273-304.

Sule, H., & Mankilik, M. (2015). Views of teachers and students on causes of students' mass failure in senior certificate Physics examination in Gombe, Nigeria. *International Journal of Research in Science, Technology and Mathematics Education, 3*(2), 238-253.

Tajeddin, Z., & Tabatabaei, S. (2016). Concept mapping as a reading strategy: Does it scaffold comprehension and recall? *The Reading Matrix: An International Online Journal, 16*(1), 194-208.

West African Examination Council (2015). *WAEC's e-learning tool kit.* Retrieved from www.waeconline.org.ng.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem-solving. *Journal of Child Psychology and Psychiatry, 17*(2), 89-100.