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Effects of Concept Mapping Strategy on Secondary School Physics Students' Achievement in Jos, Plateau State, Nigeria

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Abstract. The study was motivated by the increasing poor performance of secondary school students in physics in external examinations which many researchers in physics education attributed it to defective teaching strategies. The study was specifically designed to achieve the following objectives: to determine the levels of achievement of students in physics before and after exposure to concept mapping strategy; to examine the interaction effects of gender; school type and motivation on students' achievement in physics. two research questions and four hypotheses were formulated to guide the study. The study adopted a quasi-experimental research design. Specifically, the study adopted the non-equivalent pretest-posttest control group design in which intact groups were assigned to experimental and control groups. A sample of 221 students were drawn from 2 secondary schools in Jos. The instrument used for data collection was Students Physics Concepts Achievement Test (SPCAT). The validity of the instruments was determined by three experts one in physics, one in test measurement and evaluation, and the other one in the area of physics education all from the University of Jos. The reliability of (SPCAT) was computed using k-R21 formula. The reliability index of (SPCAT) instrument stood at 0.83. The statistical techniques used in analyzing the data were the mean, standard deviation, simple percentages, pair t-test and independent t-test. The results of the study showed that concept mapping strategy improves students' achievement in physics. It was also found that concept mapping strategy was effective in enhancing students learning. There was significant difference in the post-test achievement mean scores of students in the experimental and control groups. It was found that no significant difference exist between the post-test achievement mean scores of male and female students exposed to concept mapping strategy. Furthermore, the findings showed that there was no significant difference between the post-test physics achievement mean scores of students in public and private schools exposed to concept mapping strategy. Based on the findings, it was recommended that concept mapping strategy should be employed by physics teachers to teach physics as doing so could help in promoting students' achievement in physics.

Keywords: Concept mapping, Physics and Achievement.

1. Introduction

Physics is one of the basic science subjects which deals with the study of matter and energy and how they interact. It is the study of matter and natural events, which is based mostly on empirical observations and quantitative measurements.

Physics has many contributions to the socio-economic development and transformation of

mankind. It helps in the scientific and technological development of any nation. Physics is crucial for effective living in this modern age of science and technology. The effects of physics can be felt in all areas of human activity. For example, the technological inventions like the scanning machines, X-ray machines, the production of drugs, camera, radio just to mention a few,are the many inventions and discoveries of man which require the knowledge of physics for their understanding. Most of the technology which mankind uses in daily life is related to physics. For example, television uses electromagnets to direct electrons on a screen to produce pictures, a cell phone uses microwaves, cars are built on the mechanical principles of physics and most modern homes use electricity to power appliances. An understanding of electromagnetism enables individuals to build electrical circuits and computers, Newton's first and second laws of motion enable people to put satellites into orbit, and erect safe buildings, the knowledge of the nature of light enable astronomers to determine the composition of stars without having to visit them.

Despite the significant place of physics in the technological development, researches over the years have shown that students' achievement in physics is low and even the few that enrolled perform poorly in physics examinations (Ogommuoh & Nzewi, 2003; Otuka, 2006). The poor achievement of students in physics is as a result of many challenges. Some of the challenges according to FME (2009) include dearth of qualified teachers, the use of ineffective teaching approaches, inadequate equipment in physics laboratories, and the nature of the subject matter that appears to be difficult.

These challenges have culminated in lack of interest in physics by students, declining popularity, and poor achievement in public examinations conducted by National Examinations Council (NECO) and the West African Examinations Council (WAEC).

Considering the hitherto effects of using ineffective teaching strategies on students' learning outcomes in physics, it becomes imperative to look for an appropriate modern teaching strategy that would enhance students 'achievement in physics. One of such modern teaching strategies is concept mapping. Concept mapping strategy is a graphical tool for organizing and representing knowledge. The concepts are usually enclosed in circles or boxes of some type and the relationship between the concepts are indicated by a connecting line and words linking the concepts.

The use of concept mapping strategy is relevant to the study of physics in the sense that it can help students to search for information to learn more about the subject. It could also be an aid to the teacher as one way to summarize understanding acquired by students after they have studied a unit or chapter in physics. Research results support the efficacy of using concept mapping strategy as a veritable tool in the classroom for enhancing meaningful learning, reasoning ability, long term retention of knowledge, reduction of anxiety, enhancement of attitudes and reading comprehension (Aiyede, 2010). Thus, the strategy plays a central role in students' meaningful learning and achievement.

Conventional teaching strategy have been widely reported in literature as the most frequently used method for teaching physics in Nigerian secondary schools. The conventional method of instruction is strictly teacher-centered and authoritarian in nature. In this type of learning environment, students' participation is minimal. The use of the conventional strategies has been found to have negative effects on most of the students (Gök & Silay, 2008).

Gender has continued to be an issue of great concern to science educators and researchers. Presently there is gender imbalance in the sciences, particularly in physics. The imbalance was widely reported to be in enrolment and achievement in physics. In line with this fact, researchers (Ogunleye, 2001; Malachy & Ononugbo, 2006; Simeon & Musa, 2010) remarked that girls under-achieve and are under-represented in the sciences, especially in physics. This is also evident from research reports (Okebukola, 2002; Longe & Adedeji, 2003; Yoloye, 2004; Eziirim, 2006), which

showed that gender has an impact on science education, physics inclusive. Also the fact that boys recorded higher percentage of credit passes than girls in physics in the West African Examinations Council ordinary level examinations between 2002 and 2009 is an evidence of gender inequality in physics (Ogunleye & Babajide, 2011). This gender imbalance could be noticed in both public and private schools in Plateau State.

In Nigeria today, schools are classified into public and private. Public schools are those owned by the government, while private schools are those owned by private organisations. Statistics collected from the Zonal Directorate of Education Jos (ZDE, 2013) showed the number of private schools in Jos. The statistics showed a total number of 146 public and private secondary schools, out of which 126 are private schools representing 86.3% and 20 are public schools representing 13.7% in Jos. This shows that private schools are more than public schools. No wonder Adebayo (2009) noted that a careful observation of the current trends in Nigeria in terms of parents' preferred choice of educational institutions for their children would reveal preference for private institutions as opposed to public institutions. The author attributed the development to the deterioration in academic achievement and wide-spread loss of confidence in public institutions. School type (Public and Private) became an issue in this study because of the increasing poor achievement of students in physics which this study may help to improve using concept mapping instructional strategy. Most researches conducted in Nigeria have tended to compare concept mapping strategy with other teaching methods like expository and guided discovery. Variables like students' attitude, cognitive ability and achievement were studied in physics using concept mapping strategy. However, these studies did not address the variables of, achievement, interaction effects of gender and school type in wave and simple harmonic motion concepts, hence the need to fill gaps in these areas.

2. Statement of the Problem

The teaching and learning of physics has been fraught with challenges which prevent many students from performing well in public examinations. Among the challenges according to Atadoga (2010) are the teacher factor, method factor, resource utilization, class size, language factor and workload. These challenges have negative consequences on students' enrollment, interest, attitudes and achievement in physics and physics related disciplines. The search for improvement and effectiveness in teaching and learning of physics in Nigerian secondary schools by individual researchers and collective efforts so far do not seem to have yielded the expected results. Students' performance and enrolment in physics are still reported to be very low (Otuka, 2006). This position is further clarified by theChief Examiner's Report of theWest African Examinations Council (2005-2006 & 2011) that generally, the overall performance of candidates in physics did not show any remarkable improvement over those of the previous years.The results also show that there is a deteriorating performance of candidates in science especially physics.

Many research studies in Nigeria have identifiedsome causes of students' poor performance in physics,such as, lack of resource utilization, poor teacher quality, large class size and defective methods of teaching (Achor, 2003; Ajiboye, 2005; Atadoga, 2010). This picture of physics education in Nigerian secondary schools is not desirable, considering the quest of the nation for technological development. The probable consequences of these challenges may be low rate of admission of students into science-based courses in Nigerian tertiary institutions and subsequently low manpower development, which will negatively affect the scientific and technological development of the country. In literature, various teaching methods such as, problem solving, discovery, discussion and concept mapping have been developed to take care of situations like this, but physics teachers rarely make use of some of them. This may be because of their ignorance or their choice to remain glued to the traditional methods such as in conventional methods which they feel are simple. Efforts in search of better teaching strategies yielded fruits in the discovery of

concept mapping strategy. The remarkable efficacy of the concept mapping instructional strategy in enhancing learning has been widely reported in science education literature (Canas & Novak, 2009).

To Aiyede (2010) Concept mapping instructional strategy helps teachers be more effective in their teaching. Although, studies showing the efficacy of concept mapping strategy abound, these studies are more in the other science subjects than physics. Moreover, the researchers are not aware of any study carried out in Jos that used concept mapping strategy to investigate students' achievement in physics. The researchers are not also aware of any study that incorporated concept mapping strategy in investigating students' achievement, interaction effects of gender and school type in simple harmonic motion and wave motion physics concepts in Jos, hence the need to investigate the effects of concept mapping strategy on secondary school physics students 'achievement in Jos, Plateau State. The broad question to be answered therefore is: To what extent will concept mapping instructional strategy improve physics students' achievement in secondary schools in Jos?

3. Purpose of the Study

The purpose of the study was to investigate the effects of concept mapping instructional strategy on secondary school physics students'achievement in Jos Plateau State.The specific objectives of this study are to:

- determine the levels of achievement of students in physics before and after exposure to concept mapping instructional strategy,
- find the influence of gender on students' achievement in physics when exposed to concept mapping strategy,
- find the influence of school type on students' achievement in physics before and after exposure to concept mapping instructional strategy,

4. Research Questions

The following research questions were answered in the course of the study:

- What are SS2 students' levels of achievement in physics before and after exposure to concept mapping strategy?
- What are SS 2 student's levels of achievement in physics before and after exposure to conventional strategy?

5. Hypotheses

For the purpose of this study, the following null hypotheses were tested at 0.05 level of significance:

- There is no significant difference between the post-test physics achievement mean scores of students in the experimental and control groups.
- There is no significant difference between the pre-test physics achievement mean gain scores of the experimental and control groups.
- There is no significant difference between the post-test physics achievement mean scores of male and female students exposed to concept mapping strategy.
- There is no significant difference between the post-test physics achievement mean scores of students exposed to concept mapping strategy in private and public schools.

6. Methodology

This study adopted a quasi-experimental research design. Specifically, the study adopted the non-equivalent pretest-posttest control group research design in which intact groups were assigned to one of experimental or control groups. The total population for the study was 1000 senior secondary schools student in Jos. Out of the study population a sample of 221 students from two senior secondary schools in Jos were selected to participate in the study.

7. Results

Research Question One: What are SS 2 students' levels of achievement in physics before and after exposure to concept mapping strategy?

To answer this research question, the students' physics concepts achievement test was administered to the experimental group. Their scores was then analysed using simple percentages. The results are presented in Table 1.

Table 1: Levels of SS2 Physics Students Achievement Beforeh and After Exposure to Concept Mapping Strategy

Achievement Levels	Range Scores in Percentage	Before		After	
		N	%	N	%
High	60 – 100	-	-	51	48.57
Average	50 – 59	3	2.86	23	21.91
Low	0 – 49	102	97.14	31	29.52

The analysis in Table 1 show that before students were exposed to concept mapping instructional strategy, 97.14% were at low achievement level (0-49%), 2.86% were at average achievement level (50- 59% and none of students were at high achievement level. After the exposure of students in the experimental group to concept mapping strategy, 48.57% of the students moved to high acievement level, 21.91% moved to low achievement level and 29.52% moved to average achievement level respectively. The result indicates that concept mapping strategy when use effectively improves students' achievement in physics.

Research Question Two: What are SS 2 students' levels of achievement in physics before and after exposure to conventional strategy?

To answer this research question, simply percentage was used to analyse the data. The results are presented in Table 2.

Table 2: Levels of SS2 Physics Students Achievement Before and After Exposure to Conventional Strategy

Achievement Levels	Range Scores in Percentage	Before		After	
		N	%	N	%
High	60 – 100	-	-	2	1.72
Average	50 – 59	-	-	8	6.90
Low	0 – 49	116	100	106	91.38

The analysis in Table 2 showed that before students were expose to conventional teaching strategy, none were at high achievement level (60-100), after the exposure to conventional strategy only 1.72% was at high achievement level, none were at average achievement level before exposure, after exposure to conventional strategy only 6.90% moved to average achievement level. Before exposure to conventional strategy all the students remain at low achievement level (0-49) and after the exposure 91.38% remained at the low achievement level. The result showed that the use of conventional strategy in teaching physics is not encouraging as its usage does not improve students' achievement significantly.

Hypotheses

Hypothesis One: There is no significant difference between the post-test physics achievement mean scores of students in the experimental and control groups.
This hypothesis was tested using t-test for independent sample and the result is presented in Table 3.

Table 3: t-test Analysis Results of Post-test Achievement Scores of Experimental and Control Groups

Group	N	□	SD	Df	P-value	sig(2tailed)
Experimental	105	53.50	13.15			
				219	.000	
Control	116	31.91	12.76			

Significance P < 0.05

The analysis in Table 3 show that the P-value 0.000 is less than $\alpha = 0.05$ level of significant at df = 219. Since the p-value is in the critical region of rejection($P< 0.05$) then the null hypothesis is not accepted meaning that there is a significant difference in the post-test achievement mean scores of students in the experimental and control groups. This difference in mean could be due to the effect of treatment on the experimental group.

Hypotheses Two: There is no significant difference between the pretest physics achievement mean gain scores of experimental and control groups.

This hypothesis was tested using t-test for independent sample and the result is presented in Table 4.

Table 4: Pre-test Analysis Results of Achievement Scores of Students in the Experimental and Control Groups

Group	Number N	Mean □	SD	Df	P-value Sig (2-tailed)
Experimental	105	22.15	9.84		
				219	0.38
Control	116	21.16	6.91		

Not significant P>0.05

The result in Table 4 show that P-value of 0.38is greater than $\alpha = 0.05$ at df = 219 and $\alpha= 0.05$ level of significance. Since the $P < 0.05$ then the decision was to accept the null hypothesis. This means that there is no significant difference between the pre-test achievement mean scores of experimental and control groups.

Hypothesis Three: There is no significant difference between the post-test physics achievement mean scores of male and female students exposed to concept mapping strategy.
This hypothesis was tested using t-test for independent sample and the result is presented in Table 5.

Table 5: t-test AnalysisResults of Post-test Achievement Scores of Experimental Group According to Gender

Gender	N	□	SD	Df	P-value sig(2tailed)
Male	48	51.94	13.89		
				103	0.35
Female	57	54.39	12.77		

Not significant P > 0.05

The analysis in Table 5 show that P > 0.05at df = 103. It then means that the P-value is in the critical region acceptance region($P> 0.05$) then the null hypothesis is accepted meaning that there is no significant difference between the post-test achievement mean scores of male and female students exposed to concept mapping.

Hypothesis Four: There is no significant difference between the post-test Achievement mean scores of students exposed to concept mapping strategy in private and public schools.
This hypothesis was tested using t-test for independent sample and the result is presented in Table 6.

Table 6: t-test Analysis Results of Post-test Achievement Scores of Experimental Group According to School Type

School Type	Test	N	□	SD	df	P-value sig(2tailed)

Private	Post-test	30	52.97	11.04		
					103	0.40
Public	Post-test	75	52.72	13.96		

Not significant P > 0.05

The analysis in Table 6 show that P- value of 0.40 is greater than $\alpha = 0.05$ at df = 103. Since the P-value is in the critical region of acceptance (P> 0.05) then the null hypothesis is accepted meaning that there is no significant difference between post-test physics achievement mean scores of students in public and private schools exposed to concept mapping.

8. **Discussion of Findings**

The study investigated the effects of concept mapping strategy on secondary school physics students' achievement in Jos, Plateau State, Nigeria. The results from research question 1 presented in Table 1 showed that before students were exposed to concepts mapping strategy 97.14% of the strudents were at low achievement level, (0 - 49%), 2.86% were at average achievement level and none of the students were at high achievement level. However, after exposure to concept mapping, 48.57% of the students moved to high achievement level, 21.91% moved to average achievment level while only 29.52% remained at low acheivment level. These results revealed that concept mapping when use effectively enhances students achievement in physics. The results also confirmed that students' achievement in physics improved significantly after being exposed to treatment. This finding is in line with that of Umaru (2008) who found that students who were exposed to concept mapping stratey achieved better in physics.

The analysis in Table 2 showed that before students were expose to conventional teaching strategy, none were at high achievement level (60-100), after the exposure to conventional strategy only 1.72% was at high achievement level, none were at average achievement level before exposure, after exposure to conventional strategy only 6.90% moved to average achievement level. Before exposure to conventional strategy all the students remain at low achievement level (0-49) and after the exposure 91.38% remained at the low achievement level. The result showed that the use of conventional strategy in teaching physics is not encouraging as its usage does not improve students' achievement significantly. This finding agrees with that of Gök and Silay (2008) who found that conventional strategies has negative influence on student achievement

The analysis in Table 3 hypothesis 1 indicated that P-value of 0.00 is less than $\alpha = 0.05$ at df = 219. This simply means that the P-value is in critical region of rejection (P < 0.05). By implication, the null hypothesis is rejected and the corresponding alternative hypothesis is accepted meaning there is a significant difference in the post test achievement mean scores of students in the experimental and control groups. This indicates that the use of concept mapping strategy on the treatment group help in improving the group achievement in physics than their counterpart in the control group. This difference could be as a result of the effect of treatment on the experimental group. This finding is in line with Cheema and Mirza (2013) where they found that students in experimental group gained significantly more than their counterparts in control group. Also this finding agrees with the finding of Simpson, Rotimi and Kenni (2011) where they found that the post-test mean scores of experimental group is higher than the post-test of the control group.

The findings from hypothesis 2 presented in Table 4 showed that the p-value of 0.38 for 2-tailed test at df = 219 and $\alpha = 0.05$ level of significance. Since the P<0.05 then the decision was to accepts the null hypothesis. This is an indication that there is no significant difference between the pre-test achievement mean scores of experimental and control groups. This finding showed that students were at the same level of achievement before they were exposed to concept mapping strategy.

Hypothesis 3 was tested and the result in Table 5 showed that the P-value of 0.35 for a 2-tailed

test at df = 103 is greater than α = 0.05 level of significance. Since the P-value is in the critical region of acceptance (P > 0.05) then the null hypothesis is accepted meaning that there is no significant difference between the post-test mean achievement scores of male and female students exposed to concept mapping strategy. This finding further confirmed that the use of concept mapping strategy on both the male and female students yielded no significant difference in achievement. This implies that their achievement in physics rely on the treatment received during instructions. This finding is contrary to the findings of Ukwungwu (2006) who found that the magnitude of the gender difference in performance in physics was 0.58 in the direction of males. This figure according to Ukwungwu corresponded with a correlation coefficient r = 0.28 which means that 7.8% of the variance in the students' performance in physics was accounted for by gender. The finding also disagreed with that of Cheema and Mirza (2013) where they found that the mean gain scores of male students was significantly greater than the mean gain scores of female students in general science.

The finding in Table 6 showed t-test analysis of hypothesis 4. The analysis revealed that the P-value of 0.40 is greater than α = 0.05 at df = 103. Since the P-value is in the critical region of acceptance (P > 0.05). By implication, the null hypothesis is accepted meaning that there is no significance difference between the post-test physics achievement mean scores of students in public and private schools exposed to concept mapping strategy. This could be as a result of the exposure of students to the same treatment. This finding is in agreement with findings of Ariyo and Ibeagha (2011) in which school type had both direct and indirect casual linkages in students' achievement in physics. The finding is also contrary to that of Olatoye and Agbatogun (2009) who found that public school students were lagging behind in their performance in sciences when they were compared with those in private schools.

9. Conclusion

The study investigated the effect of concept mapping instructional strategy on secondary school physics students' achievement in Jos Plateau State. This was prompted by the observed problem of defective methodology employed during instruction by teachers which result in low enrolment and poor performance of students in external examinations in physics. Furthermore, it provides evidence that the use of concept mapping instructional strategy promotes students' achievement in the classrooms. It also provides support for research studies that validate the use of concept mapping strategy to facilitate students' understanding and achievement towards physics.

10. Recommendations

In view of the findings of this study, the following recommendations are made:

- Concept mapping as an instructional strategy should be incorporated into the senior secondary physics curriculum as a medium of instruction in order to provide and direct the proper understanding of physics concepts by students.
- Re-training of physics teachers through series of workshops, seminars and symposium on how to incorporate effectively concept mapping instructional strategy during physics lessons should be done.
- Textbook being a primary tool to deliver concept of physics to the students lays a heavy responsibility on the textbook writers to develop a balanced textbook in terms of content, methodology, practical activities and assessment exercises. The textbook writers should include concept maps and concept mapping activities in the textbooks.

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