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EFFECTS OF VISUAL IMAGERY AND MIND MAPPING STRATEGIES ON PHYSICS STUDENTS' MATHEMATICAL SKILLS IN MECHANICS IN EKITI STATE, NIGERIA

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ABSTRACT

The study examined the effects of visual imagery and mind mapping strategies on physics students' mathematical skills in mechanics in Ekiti state, Nigeria. The study adopted a pretest-posttest control group quasi experimental research design. Eight senior secondary schools were be purposively selected for the experimental groups, while four schools were purposively selected for the control group. This made a total of twelve schools that were selected from twelve local government areas across all the three senatorial districts of Ekiti state for the study. A total number of two hundred and forty six physics students from the selected schools were used. The instrument that the researcher used for the study was self-designed instruments titled: Mechanics Mathematical Skills Test (MST). The data collected were analysed using descriptive statistics (mean, standard deviation) as well as inferential statistics such as Analysis of Covariate (ANCOVA) which was used to determine the significant mean and interaction effects to the variables of the study. Estimated Marginal Mean (EMM) was used to determine the performance of each group. Bonferroni pair wise Analysis and Scheffe Post-hoc analysis were also employed to trace the source of observed significance among the groups.The finding of the study revealed that there was significant effect of treatment on students' mathematical skills. The result further showed that those exposed to visual imagery had the highest mathematical skill mean score, closely followed by those exposed to mind mapping while those taught with conventional method of teaching had the least. Also, the finding of the study showed that there was no significant main effect of school location on students' mathematical skills. However, the

finding showed that there was significant interaction effects of treatment and school location on students' mathematical skills.

Keywords: mind-mapping; visual imagery; mathematical skills; mechanics; physics.

Introduction

The contributions of physics cut across human endeavour such as medicine, pharmacy, agriculture, petroleum engineering, geology, industries and computer. The feats of Physics being the bedrock of scientific and technological revolutions are in every facet of human endeavour (Awodun, Oni & Aladejana, 2014). It could be rightly said that every sector of the society now depends on Physics for proper functioning. Despite these importance of Physics to mankind and the efforts of researchers to improve on its teaching and learning, performance of students in the subject still fluctuates in Ekiti (Aladejana, 2021). The table below sheds more light.

Table 1 Performance of Students in Physics in the West African Senior School Certificate Examination(WASSCE) 2010-2019 in Ekiti State

Year	No of candidates	Credit (1-6) %	Pass (7-8) %	Fail (9) %	Total failure (7-9) %
2010	5765	49.77	31.66	13.30	44.95
2011	7317	83.31	9.08	1.44	10.51
2012	5155	68.17	22.87	7.53	30.40
2013	4964	56.29	28.22	13.65	41.88
2014	5862	55.61	29.56	14.82	44.39
2015	6069	47.17	33.37	19.46	52.83
2016	5231	79.77	12.83	7.40	20.33
2017	5250	51.89	34.65	13.47	48.11
2018	4989	86.63	6.84	6.53	13.37
2019	67.53	67.53	18.97	13.50	32.47

Source: Planning, Research and Statistics Dept, Ministry of Education, Science and Technology, Ado-Ekiti, Ekiti State, Nigeria.

Table 1 indicated fluctuations in the performance of students within the years 2010 and 2019. The failure rate was as high as 52.83 % in 2015 and this has affected the number of students from studying Physics and Physics related courses at the higher level of education in the country. Students are required to score more than 50% (C6) to show that they possess solid foundation in Physics before moving to tertiary institutions to study Physics-related courses that would assist in the development of the world technologically

Dissecting the causes of the failure, West African Examination Council Chief Examiners(2016) reported that many students were having challenges with mathematical skills under mechanics. In line with this, reports of many researches established the prediction of Physics performance by the mathematical skills (Awodun & Ojo,2013; Oyedeji,2011; Wang & Santos, 2003; Delialighi & Asker,1999). To buttress this, Awodun and Ojo(2013) stated further that proficiency in the use of mathematical skills is the topmost factor for good performance in physics and it accounts for a high proportion of about 86% which make them to be highly germane in Physics students' performance. Hence, failure rate in physics performance could be attributed to poor mathematical skills.

Therefore, mathematical skills, according to Trumbley & Weiss (2011) are the multifacet constructs that display the ability to exercise, discover, manipulate and evaluate relationship. Various researchers had classified mathematical skills into various but interrelated categories, for instance, Soleymani & Rekabdar, (2016) and Alacaci & Erbar, (2010) classified them into: measuration; application; analysis, reasoning, problem solving; proportionality; etc while Odili cited by Oyedeji(2011) categorized mathematical skills into: computational skills; algebraic process skills; geomentry skills; measuration skills; table and graph interpretation; probability and statistics skills but Awodun & Ojo (2013) found that those highlighted skills Odili contribute to the prediction of performance in Physics in that descending order.

In another vein, school location determines to a large extent the level of students' achievement(Aladejana, Asubiojo & Ajayi, 2018; Titus, Dada & 2016). In a research work, Ella & Ita (2017) examined correlational relationship between school location and students' academic performances in English language in secondary schools. They used survey research design. The population of the study consisted of all the 836 senior secondary two (SS2) students of the 2016/17 academic session in all the 46 public and private secondary schools in Ogoja Local Government Area.Two hundred students (124 representing 62% were males; while 76 students representing 38% were females) was drawn for the study through stratified random sampling. The instrument used was achievement test tagged English Language Achievement Test (ELAT) carved from 2015 English Language Mock Examination in Calabar Education zone. Independent t-test was used to analyse the data. He found that there was a significant difference in students' academic performance in English language on the basis of school location. In another work, Isa (2018) examined the effect of school location on mathematics students' performance in Gaya Zonal Education Area of Kano State, Nigeria. He adopted expost facto research design. Sample of two hundred and eighty four students was selected through random sampling studens' out of a population of six hundred and sixty nine students. He discovered significance difference between them in favour of urban students irrespective of sex.

Towards improving the mathemathematical skills, mind mapping and visual imagery are of immense benefits to mathematical skills because it utilizes both parts of the brain (Brinkmann, 2003). Al-kamli(2019) define*s "mind mapping strategy as a visual organizer where students organize their ideas as well as organizing grammatical and lexical knowledge needed for expressing those ideas"* while Kozhevmkov, Hegarty,M. and Mayer (2002) describes visual imagery as the representation of the visible diagram of an object , such as shape, etc. Similarly, in their work, enhancement of mathematical reasoning ability of junior high school students by applying mind mapping strategy, Ayal, Kusuma, Sabandar & Dahlan(2016) revealed that mind mapping strategy enhance mathematical reasoning ability.

Statemement of Problem

Despite efforts made by stakeholders in education towards improvement of performance of students in Physics in senior secondary schools certificate examinations(SSCE), it is disheartening that the failure rate of Physics students are still above 30% in many years in Ekiti state which contradicts the motto of Ekiti State (fountain of knowledge). This calls for urgent action! Researchers had attributed this problems to the lack of proficiency in the area of mathematical skills in Physics which are traceable to inadequate instructional strategies. To solve the problem, various researchers had recommended innovative strategies such as mind mapping and visual imagery strategies but the literature is relatively devoid of researches on the effects of mind mapping and visual imagery strategies on Physics students' mathematical skills Physics in Ekiti State Senior secondary schools.It is against this backdrop that there is need for research on effects of mind mapping and visual imagery strategies on Physics students' mathematical skills.

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

1. There is no significant main effect of the treatment on students mathematical skills in mechanics;
2. There is no significant effect of school location on students mathematical skills in mechanics;
3. There is no significant interaction effects of treatment and school location on students' mathematical skills in mechanics.

Research Design

The study adopted a 2X1X1 pretest-posttest control group quasi experimental research design.

Selection of Participants

Eight senior secondary schools were purposively selected for the experimental groups, while four schools were randomly selected for the control group. This made a total of twelve schools that were selected from twelve local government areas across all the three senatorial districts of Ekiti state for the study. A total number of two hundred and forty six physics students from the selected schools were used.

Research Instruments

The instrument that the researcher used for the study was self-designed instruments titled Mathematical Skills Test (MST). The instrument contained section A and section B. the section A consisted of bio-data of the respondents such as the name of school and location of school. The Section B of Mathematical Skills Test consisted of 50 items multiple choice questions with four options (A-D) with instructions to select any the correct option.

Method of Data Analysis

The data collected were analysed using descriptive statistics (mean, standard deviation) as well as inferential statistics such as Analysis of Covariate (ANCOVA) which was used to determine the significant mean and interaction effects to the variables of the study.

Testing of Hypotheses

Hypothesis 1: There is no significant main effect of treatment on students' mathematical skills

Table 2: Summary of ANCOVA of Effect of Treatment on students' Mathematical Skills

Variable	Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta^2
Mathematical skills	Corrected Model	2587.009	3	862.336	1334.087	.000	.943
	Intercept	574.715	1	574.715	889.118	.000	.786
	Covariate (Pretest-mathematical skills)	635.026	1	635.026	982.423	.000	.802
	Group	2005.645	2	1002.823	1551.427	.000	.928
	Error	156.426	242	.646			
	Total	43361.000	246				
	Corrected Total	2743.435	245				

***p<0.05**

Table 2 above shows that there is significant main effect of treatment on students' mathematical skills ($F_{(2,242)}$ = 1551.427; $p<0.05$; η^2=.94). Hence, Ho_1 is rejected. Therefore, there is significant effect of treatment on students' mathematical skills.

Table 3: Estimated Marginal Means across the Groups on Mathematical Skills

Variables	Group	N	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
Mathematical skills	Visual imagery	97	15.593	.082	15.432	15.754
	Mind mapping	70	13.528	.096	13.337	13.718
	Control	79	8.880	.091	8.702	9.058

Table 3 above shows that those exposed to visual imagery had the highest mathematical skill mean score (15.593), closely followed by those exposed to mind mapping (13.528) while those taught with conventional method of teaching had the least (8.880).

Table 3 below reveals the pairwise comparison of the three groups.

Table 4: Scheffe's Post Hoc Pairwise Comparison on Mathematical Skills

Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
Mathematical skills	Visual imagery	Mind mapping	2.066*	.127	.000	1.761	2.371
		Control	6.713*	.122	.000	6.419	7.007
	Mind mapping	Visual imagery	-2.066*	.127	.000	-2.371	-1.761
		Control	4.647*	.133	.000	4.328	4.967
	Control	Visual imagery	-6.713*	.122	.000	-7.007	-6.419
		Mind mapping	-4.647*	.133	.000	-4.967	-4.328

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Table 4 above shows that the main effects exposed by Table 1 is as a result of the significant difference between mathematical skills of students exposed to: visual imagery and mind mapping; visual imagery and conventional and mind mapping and conventional

Hypothesis 2: There is no significant effect of school location on students' mathematical skills

Table 5: Summary of ANCOVA of Effect of School Location on students' Mathematical Skills

Variable	Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta^2
Mathematical skills	Corrected Model	613.291	2	306.645	34.981	.000	.224
	Intercept	698.473	1	698.473	79.680	.000	.247
	Covariate (Pretest-mathematical skills)	541.384	1	541.384	61.759	.000	.203
	School location	31.927	1	31.927	3.642	.058	.015
	Error	2130.144	243	8.766			
	Total	43361.000	246				
	Corrected Total	2743.435	245				

p>0.05

Table 5 shows that there is no significant main effect of school location on students' mathematical skills ($F_{(1,243)}$ = 3.642; p>0.05; η^2=.015). Therefore, $Ho3_a$ is not rejected.

Table 6: Estimated Marginal Means across School Location on Mathematical Skills

Variables	School Location	N	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
Mathematical skills	Rural	123	12.487	.268	11.959	13.015
	Urban	123	13.212	.268	12.685	13.740

Table 6 shows that urban students had slightly higher mathematical skills mean score of 13.212 while their rural counterparts had 12.487.

Hypothesis 3: There is no significant interaction effects of treatment and school location on students' mathematical skills

Table 7: Summary of ANCOVA of Interaction Effect of Treatment and School Location on Students' Mathematical Skills

Variable	Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta^2
Mathematical skills	Corrected Model	2615.328[a]	6	435.888	813.206	.000	.953
	Intercept	490.669	1	490.669	915.407	.000	.793
	Covariate (Pretest-mathematical skills)	523.533	1	523.533	976.718	.000	.803
	Group	1994.579	2	997.289	1860.573	.000	.940
	School location	14.307	1	14.307	26.692	.000	.100
	Group * School location	15.383	2	7.691	14.349*	.000	.107
	Error	128.107	239	.536			
	Total	43361.000	246				
	Corrected Total	2743.435	245				

***p<0.05**

Table 7 shows that there is significant interaction effect of treatment and school location on students' mathematical skills ($F_{(2,239)} = 14.349$; $p<0.05$; $\eta^2=.107$). Therefore, $Ho5_a$ is rejected.

Table 8: Estimated Marginal Means showing interaction of Treatment and School Location on Mathematical Skills

Variable	Treatment	Gender	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
Mathematical skills	Visual imagery	Rural	15.639	.116	15.410	15.868
		Urban	15.563	.097	15.372	15.754
	Mind mapping	Rural	13.352	.116	13.124	13.581
		Urban	13.814	.149	13.522	14.107
	Control	Rural	8.314	.118	8.082	8.546
		Urban	9.435	.116	9.207	9.663

Table 8 showed that there is mean difference between rural and urban students' mathematical skills when various treatment was administered to them with (means for visual imagery: rural = 15.639, urban= 15.563; means for mind mapping: rural = 13.352, urban= 13.814; and means for control: rural=8.314; urban = 9.435) respectively.

Discussion of Findings

The study is on the effects of mind mapping and visual imagery strategies on Physics students' mathematical skills in mechanics in senior secondary schools in Ekiti state, Nigeria. The descriptive analysis of the study pointed out homogeneity in the mathematical skills test by the respondents as there was marginal difference

in the mean scores of rural and urban students taught mechanics using mind mapping and visual imagery instructional strategies

The finding of the hypothesis one revealed that there is significant effect of treatment on students' mathematical skills. The result further showed that those exposed to visual imagery had the highest mathematical skill mean score (15.593), closely followed by those exposed to mind mapping (13.528) while those taught with conventional method of teaching had the least (8.880).

Also, the finding of the hypothesis two showed that there was no significant main effect of school location on students' mathematical skills.This finding is in disagreement with the submissions of Aladejana, Asubiojo & Ajayi (2018) and Titus, Dada & Adu (2016) that school location had effect on students' mathematical skills. Further analysis of result showed that urban students had slightly higher mathematical skills mean score of 13.212 while their rural counterparts had 12.487. This finding is in tandem with the finding of Isa (2018) that there was significance difference between them in favour of urban students. However, the finding contradicted the finding of Ella & Ita (2017) there was a significant difference in students' academic performance in English language on the basis of school location.

Moreso, the finding of hypothesis three showed that there is significant interaction effect of treatment and school location on students' mathematical skills

Recommendations

Based on the findings made so far, the following recommendations are therefore made:
(i) Mind mapping and visual imagery instructional strategies should be used in teaching mathematical skills;
(ii) Workshops, seminars and conferences should be organized for educational stakeholders on how best to use mind mapping and visual imagery strategies;
(iii) Curriculum planners should include the use of mind mapping and visual imagery strategies in the curriculum for secondary schools;
(iv) Parents should encourage their children to equally make use of mind mapping and visual imagery as learning strategies;
(v) Government should provide neccessary facilities that will aid the use of the strategies.

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