Innovations

Using self-regulated learning and Mind maps in enhancing students' achievement in senior secondary schools Physics in Delta Central Senatorial district

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Abstract

The study investigated the use of self-regulated learning and mind maps in enhancing students' achievement in Physics in Delta Central Senatorial District of Delta State. Three (3) research questions and hypotheses guided the study. The study adopted the quasi-experimental design, specifically the pre-test post-test control group design. The population of the study consisted of nineteen thousand, four hundred (19,400) SS II Physics students from one hundred and eighty-eight (188) secondary schools in Delta Central Senatorial District. The study sampled three hundred and six (306) SS II Physics students from six (6) intact classes from six (6) public mixed schools selected using random sampling techniques of "hat and draw" method with replacement. The instrument for data collection was Physics Achievement Test (PAT) which was face and content validated. A reliability of the PAT was established using Kuder-Richardson's formula 21 (K-R-21) which yielded coefficient of 0.86. PAT was used in collecting data to determine students' achievement. Data obtained were analyzed using descriptive statistics, independent samples t-test, and ANOVA. The results showed that: there was significant difference in the Physics mean achievement scores among students taught using self-regulated learning, mind maps and lecture method with students in the mind map group scoring the highest, followed by students in self-regulated learning and lecture method groups respectively; there was no significant difference in the mean achievement scores of male and female students taught Physics using self-regulated learning instructional strategy; there was no significant difference in the mean achievement

scores of male and female students taught Physics using mind maps instructional strategy. It was concluded among others that mind maps is the most effective strategy for teaching and learning of Physics while self-regulated learning strategy can be used as alternative. It was recommended that mindmaps strategy should be adopted by Physics teachers for teaching of Physics in secondary schools and that relevant agencies should train Physics teachers on the effective implementation of mindmaps.

***Keywords**: 1.Self-Regulated Learning, 2.Mindmaps, Students' Achievement, 3.Gender and lecture method*

Introduction:

A major developmental gap in Nigeria today is the abysmal technological advancement. This is evident in the nation's gross inadequacy of technological industries and the required knowledgeable manpower or human resources. The world today is driven by science and technology, which is reflected in diverse innovations in the different economic sectors of the globe. Physics is a fundamental science subject upon which technological advancement is hinged. The teaching and learning of Physics have consistently generated interest among scholars over the years because of its importance. The International Union of Pure and Applied Physics (IUPAP) defined Physics as the scientific study of matter and energy and their interactions with each other, which plays a key role in the future process of mankind (Abamba, 2021). According to Ike (2002), Physics deals with the study of physical principles and laws governing the universe with reference to the matter and energy. Physics is a basic science subject offered in senior secondary school in Nigeria and according to Feinstein (2011) and Kiboss (2011), Physics is important because it enables learners apply principles acquired through knowledge and skills to construct appropriate scientific devices from available resources. The importance of Physics for the growth and development of any nation in terms of science and technology cannot be over emphasized as it cuts across disciplines that have applications in many sectors of the economy, ranging from Energy, Information Technology, Agriculture, to Health, Architecture, Engineering, Geology, and Geophysics amongst others. Udoh (2012) asserted that learning of Physics provides students with the opportunity of thinking critically, reasoning analytically and acquisition of the spirit of enquiry.

Despite the glaring importance of Physics, a lot of students still perceive Physics to be difficult and are really not motivated to learn it leading to a corresponding persistent poor and fluctuating performance in the subject particularly in external examinations such as the West African Examination Council (WAEC). Some factors that have been identified to which the poor and fluctuating performance of students in Physics is attributed include students' poor attitude towards Physics, lack of qualified teachers, poor instructional strategies, poor infrastructure and non-availability of standard laboratory, poor utilization of instructional materials, lack of motivation and poor mathematical background. However, one common factor identified by researchers to which the poor achievement of students in Physics is attributed is the

application of inappropriate instructional or teaching strategies (Gambariet el 2012;Abamba, 2021, and Oladejo, Olosunde, Ojebisi, &Isola2011). Physics like any other science subject can be taught using different instructional or teaching strategies. Nwabufor (2005) asserted that lecture method is the predominant method of instruction in Nigeria secondary schools and judging by its characteristics, is arguably not considered an ideal method of teaching science subjects like Physics that is activity based. This is because it encourages regurgitation, which implies analyzing and processing information without comprehension. Selection of suitable teaching strategy is a basic condition for a successful teaching and learning process (Anis, 2016).In order to assuage this poor achievement of students in Physics therefore and ensure the attainment of the objectives of Physics education, teaching methods or instructional strategies that are learner-centred, in line with the principles of learning by doing and promote students active participation in the construction and organization of knowledge must be adopted. Teaching methods that are activity-based provides students with varieties of hands on activities, image formation, concept formation, creating puzzles that leads to concept formation culminating in students' motivation and facilitates comprehension. Dhindsa and Anderson (2011) asserted that there has been development of teaching approaches based on constructivist approach to teaching and learning in recent times. Such methods enable easy understanding of theories and concepts of Physics which may lead to high achievement in Physics. Teaching methods or strategies with these attributes amongst others are self-regulated learning and mindmaps.

Self-regulated learning (SRL) strategy is based on principle that, learning is an active and constructive process which enables learners to control their own learning. Self-regulated learning is an instructional strategy that avails students the opportunity to developing or setting their own goals for their learning and encourages students to be involved in the learning process such as goal setting, resource management, self-monitoring, and self-evaluation. Self-regulated learning emerged in the mid-1980s consequent upon the increased focus on self-regulation in the academic settings (Dinsmore, Alexander, &Loughlin, 2008). However, it has been argued that self-regulated learning is beynd the late 1980s and was introduce in education by Gardner in 1963(Zimmerman, 1990). Self-regulated learning process include goal setting, self-instruction, self-monitoring, and self-reinforcement. Zimmerman (2001) asserted that self-regulated learning strategy is the degree to which students are motivationally, meta-cognitively and behaviorally active in their learning process and in accomplishing their goals. According to Tang (2012), it is a process where learners monitor, control and regulate their motivation, cognition as well as guide their behaviour by their goals and contextual features in the environment. Self-regulated learning creates an environment where learners are not passive but active participant and are individuals that are resourceful as they are motivated by their goal.

Mindmapsare visual non-linear representation of ideas as well as their relationships to each other. It is graphical representation of ideas which consists of a central idea, primary branches, and secondary branches that describe a certain topic. Colours and pictures are also

incorporated in mindmaps to facilitate learning with arrows to show relations between concepts and for directionality. Mind map was invented by Tony Buzan in 1968 with the view of making note taking as brief and interesting as possible. He posited that mindmaps have many applications ranging from personal life, business, education, which includes note taking, and brain storming.Mindmapping strategy harnesses critical skills, images, logics, numbers, rhythm, and colour in a powerful manner (Akanbi, Olayinka, Omosewo, & Mohammed 2021). Mindmaps are spider like diagrams which radiates from the center. It is employed in representing knowledge in a network form and non-linear diagram. Mind maps, being characterized with the use of colours and images, are major reason why it attract students and motivates them to find out meaning associated with the colors thus, improves teaching and learning. This is because researches have shown that individuals have a recognition accuracy of images between 85 and 95 percent which buttressed the quote that a picture is worth a thousand words.

Mindmap instructional strategy has the capacity of transforming monotonous information into a colorful, pictorial and highly organized diagram that works in line with our brain's natural way of doing things (Parikh, 2015). Students usually lack motivation and interest to learn subjects they perceive to be difficult. However, studies show that students see mindmaps as an interesting, fun, and motivational approach to learning (Goodnough & Woods, 2002, and Abamba, et.al). Keleş (2012) noted that teachers are delighted in using mindmaps and believe the approach boost students' motivation and increase learning. Studies reveaed that mind maps are designed to function like the natural structure of brain and it enhances performance and creativity of students (Aliye, 2017&Buzan and Buzan, 2007). Jang and Wang (2019) asserted that mindmap is of great value in science education in the sense that it helps in improving classroom efficiency, stimulating students' interest and helping students increase thinking ability.

Gender is a factor that has been empirically reported to influence students' performance in science subjects. While some studies have proven that male students performed better than their female counterparts, others have shown that female students performed better than the male students. However, literature on the effect of self-regulated learning and mind maps on sex are scanty and the results of the available literature reviewed are mixed. This is one of the rational for this study which is to determine whether self-regulated learning and mind maps affect male and female students' achievement differently and to also provide more empirical evidences on the issue

However, selection of an appropriate and suitable teaching strategy is vital for its successful teaching and learning.It is imperative to state that several studies (Eyitayo and Mishack, 2017; Jaunine, 2013;Achufusi and Offiah, 2010; Nur, Maizatul, Fatin, Nor, and Jaysuman, 2019; and Kaptum, Peter, Stephen, 2018, Akanbi, Olayinka, Omosewo& Mohammed 2021,Abamba, Efe and Esiekpe2021, Adodo 2013 &Chrisantus 2010)have established the efficacy of self-regulated learning and mindmaps strategies in teaching/learning process but not much studies have been done on Physics, a key subject upon which scientific and technological development

of any nation is hinged. This study therefore, attempts to investigate the effect of self-regulated learning and mind maps instructional strategies can enhance Physics achievement in secondary schools.

Statement of Problem

The persistent poor and fluctuating achievements of students in Physics as reported by the West Africa Examination Council (WAEC) Chief Examiner from 2012-2019 is worrisome because it will in turn have a negative effect on other professions like Engineering, Geosciences, Pharmacy, Medicine, Astronomy and others in terms of manpower being that Physics is a key background subject. The abysmal achievements of students have been attributed to students' passive participation in the teaching and learning process due to the lecture method of teaching predominantly adopted by Physics teachers. There is therefore the need for to adopt of alternative teaching strategies such as self-regulated learning and mindmaps that promote and encourage students' active participation and increase creative thinking. The problem of study therefore, is to investigate the effects of self-regulated learning and mindmaps strategies will enhance students' achievements and close gender gap in senior secondary school Physics.

Research question

The research questions that guided the study are:

1. What is the difference in the mean achievement scores of students taught Physics using self-regulated learning, mind maps and lecture method?

2. What is the difference in the mean achievement scores of male and female students taught Physics using self-regulated learning strategy?

3. What is the difference in the mean achievement scores of male and female students taught Physics using mind maps strategy?

Hypotheses

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

1. There is no significant difference in the mean achievement scores of students taught Physics using self-regulated learning, mind maps and lecture method
2. There is no significant difference in the mean achievement scores of male and female students taught Physics using self-regulated learning strategy.
3. There is no significant difference in the mean achievement scores of male and female students taught Physics using mind maps strategy.

Methodology

A quasi-experimental design was employed in the study, specifically the pretest, posttest, control group design was adopted. Six (6) intact classes of three hundred and six (306) SS II Physics students from six (6) public mixed senior secondary schools which were randomly

selected from the eight (8) Local Government Areas in Delta Central Senatorial District were used for this study. Two schools each were randomly assigned to the three groups. Experimental group 1 comprised of 122 students (56 male & 66 female), Experimental group 2 comprised of 87 students (61 male & 26 female), while the Control group comprised of 97 students (42 male & 55 female).The instrument for the study was the Physics Achievement Test (PAT) which consisted of fifty (50) items of multiple choice objectives test to measure students' academic achievement in Physics based on the six week Physics SSII instructional units that was covered in (i) sources of light (ii) Transmission of light (iii) rectilinear propagation of light (iv) the pinhole camera (v) reflection of light at plane surfaces (vi) reflection of light at curved surfaces. PAT was content and face validated by experts in science education and measurement and evaluation. The reliability was established using the Kuder-Richardson's formula 21 (KR-21) and a reliability coefficient of 0.86 was obtained. The PAT was administered for pre and post-test to all three groups before and after treatment respectively. Date collected were analyzed using descriptive statistics, independent samples t-test and Analysis of Variance (ANOVA).

Treatment Procedure

Before the commencement of treatment, the research assistants in experimental group 1 and 2 were trained on how to teach students using self-regulated leaning and mind maps instructional strategies respectively. Each research assistant was trained individually for three days and in the course of training, the researcher made use of the self-regulated learning and mind maps intervention package. The essence of the training was to enable them to be conversant with the instructional strategies and to enable them apply the strategies accordingly in teaching. The training package consisted of information briefing and discussion that covered the purpose of the training, the concepts and usage of the instructional strategies (self-regulated learning and mind maps) and the lesson plans for both strategies. The trainees were requested to present a lesson using the strategy that they have been trained on while the researcher observes to ensure compliance and adherence to the procedures of the strategies.

The two research assistants in the control group were not trained since it is the conventional method. The researchers only explained the purpose of the study and provided the lesson plans in a lecture method format on the instructional units to the teachers for usage during the treatment.

The pre-test was administered to all the sampled SS II Physics before the actual commencement of treatment. The sampled students constitute Experimental Group 1, Experimental Group 2 and the Control Group. The pre-test is the 50 item Physics Achievement Test (PAT). This was done to determine the equivalence of the groups before treatment to be sure that any changes in achievement noticed later was due to the treatment. Their responses were collected, scored and the result was kept.

The treatment groups are; Experimental Group 1 which was taught using self-regulated learning instructional strategy and the Experimental Group 2 which was taught using mind

maps. The research assistant of Experimental Group 1 will incorporate the stages of self-regulated learning as specified in the lesson plan. The research assistant of Experimental Group 2 incorporated the processes of mind maps as specified in the lesson plan. The Control Group on the other hand did not receive any treatment but was taught using the traditional lecture method. However, the lecture method lesson plan with the same instructional contents/units as those using self-regulated learning and mind maps strategies was given to the teacher to ensure uniformity.

At the end of the treatment, students in experimental and control groups were post-tested with the Physics Achievement Test (PAT). The post-test questions were the same as the pre-test, only that the items were re-shuffled and re-numbered to avoid testing threat due to memorization of the pre-test. Thereafter, the scores from the ability test, pre-test and post-test were collated and analyzed.

Results

The result of the pretest scores was computed to determine the equivalence of the groups before instructions.

Table 1: Analysis of Variance (ANOVA) Comparison of Pretest Scores of Students taught Physics using Self-Regulated Learning, Mind Maps and Lecture Method

Source of Variation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	13132.602	2	1.799		
Within Groups	3478.052	303	5.820	0.309	.734
Total	16610.654	305			

The result of F (2,303) =0.309, p=0.734shows no significant difference between the groups, thus, establishing the equivalence of the groups before treatment.

In examining the effects of the methods on achievement, paired sample statistics was employed and the result is presented below.

Table 2. Paired Samples Statistics for pretest and posttest of the three groups

Variation		Mean	N	SD	SD Error mean
Lecture	Pre	16.0103	97	2.1481	0.21811
	Post	26.8041	97	3.484	0.3538
Mind Map	Pre	15.8391	87	2.5421	0.2725
	Post	41.9870	87	3.1732	0.3402
Self-Regulation	Pre	15.7541	122	2.5138	0.2276
	Post	39.9016	122	3.458	0.3131

The table shows mind map groups had higher effect on achievement, followed by self-regulated learning and lecture method in order of mean gain. However, to establish whether the effect was significant, the paired sample t-test was employed and the result is presented in table 3.

Table 3.Paired Sample t-test of the three groups

Groups	Mean	SD	Df	t-crit	P-value	Decision
Lecture	10.17943	3.8943	96	27.298	0.000	significant
Mind Map	26.1379	3.9596	86	61.571	0.000	significant
Self-regulation	24.1475	4.0343	121	66.113	0.000	significant

Table 3: Result shows that all three method had a significant effect on students' achievement in Physics.

Research Question 1:

What is the difference in the mean achievement scores of students taught Physics using self-regulated learning, mind maps and lecture method?

Table 1: Descriptive Statistics Showing the Achievement Scores of Students Taught Physics using Self-Regulated Learning, Mind Maps and Lecture method

Groups	N	TEST	$\overline{X}$	Mean Gain	SD
Self-Regulated Learning	122	Pretest	14.22	25.68	3.15
		Posttest	39.90		3.46
Mind Maps	87	Pretest	14.67	27.31	2.70
		Posttest	41.98		3.17
Lecture	97	Pretest	14.67	12.13	2.28
		Posttest	26.80		3.48

The result shows that the group exposed to mind mapping strategy achieved higher in post-test scores with a mean gain of 27.31, followed by the group exposed to self-regulated learning strategy with a mean gain of 25.68. The group exposed to lecture method had the lowest post-test score with a mean gain of 12.13.

Hypothesis 1:

In testing hypothesis 1, ANOVA was used and the result is presented below.

Table 4: Analysis of Variance (ANOVA) Comparison of Posttest Scores of Students taught Physics using Self-Regulated Learning, Mind Maps and Lecture Method

Source of Variation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	13132.602	2	6566.301		
Within Groups	3478.052	303	11.479	572.041	.000
Total	16610.654	305			

The result shows F (2, 303) = 527.041, P=0.000.This indicates that there is significant differences in the posttest mean achievement scores among students taught Physics using self-regulated learning, mind maps and lecture method. The Scheffe post-hoc test was employed to show the direction of the difference among the three groups and the result is presented below.

Table 5: Scheffe Post-Hoc Analysis Comparison of Self-Regulated Learning, Mind Maps and Lecture Method

I(Teaching Methods)	J(Teaching Methods)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Self-regulated learning	Lecture method	13.09752*	.46090	.000	11.9638	14.2313
	Mindmaps strategy	-2.07537*	.47542	.000	-3.2449	-.9059
Mindmaps strategy	Lecture method	15.17289*	.50028	.000	13.9423	16.4035
	Self-regulated learning	2.07537*	.47542	.000	.9059	3.2449
Lecture method	Mindmaps strategy	-15.17289*	.50028	.000	-16.4035	-13.9423
	Self-regulated learning	-13.09752*	.46090	.000	-14.2313	-11.9638

The Scheffe's post-hoc analysis shows that mind maps and self-regulated learning groups with mean difference (I–J) value of 15.17289and 13.09752 respectivelyachieved higher than the lecture group. The Scheffe's post-hoc analysis also revealed that mindmaps group achieved higher than the self-regulated learning group.

Research Question 2:

What is the difference in the mean achievement scores of male and female students taught Physics using self-regulated learning instructional strategy?

Table 2: Descriptive Statistics Showing the Posttest Achievement Scores of Male and Female students taught Physics using Self-Regulated Learning Instructional Strategy

Sex	N	$\bar{X}$	Mean Diff.	SD
Male	56	40.34	0.81	4.02
Female	66	39.53		2.87

The result shows a posttest mean achievement score of 40.34 with standard deviation of 4.02 for male students taught Physics using self-regulated learning strategy, while their female counterpart had a posttest mean achievement score of 39.53 with standard deviation of 2.87. The mean difference between both sexes is 0.81, in favour of the male students.

Hypothesis 2: In testing hypothesis 2, the independent t-test was employed and the result is presented below.

Table 6: Independent Samples t-test Comparison of Posttest Achievement Scores of Male and Female Students taught Physics using Self-Regulated Learning.

Sex	N	$\bar{X}$	SD	Df	t-cal	P-value	Decision
Male	56	40.34	4.02	120	1.29	.199	**H_{o2} is retained**
Female	66	39.53	2.87				

Result shows that $t\text{-}_{Cal}$ (1.29) is sig, P=0.199.This indicates that there is no significant difference in the posttest mean achievement of male and female students taught Physics using self-regulated learning.

Research Question 3:

What is the difference in the mean achievement scores of male and female students taught Physics using mind maps instructional strategy?

Table 3: Descriptive Statistics Showing the Posttest Achievement Scores of Male and Female Students taught Physics using Mind Maps Instructional Strategy

Sex	N	$\bar{X}$	Mean Diff.	SD
Male	61	42.03	0.19	3.15
Female	26	41.84		3.28

The results shows that at posttest, the male students exposed to mind maps had a mean scores of 42.03 with standard deviation of 3.15, while their female counterparts had a mean achievement score of 41.84 with standard deviation of 3.28. The mean difference is 0.19, in favour of the male students.

Hypothesis 3:

In testing hypothesis 3, the independent t-test for male and female students on mindmap is presented below.

Table 7: Independent Samples t-test Comparison of Posttest Achievement Scores of Male and Female Students taught Physics using Mind Maps Instructional Strategy

Sex	N	$\bar{X}$	SD	Df	t-cal	P-value	Decision
Male	61	42.03	3.15	85	.250	.803	H_{o3} is retained
Female	26	41.84	3.28				

Result shows thatt-$_{Cal}$ (0.250) is not sig; P=0.803.This indicates that there is no significant difference in the posttest mean scores of male and female students taught Physics using mindmaps strategy.

Discussion of findings

The effective implementation of any model cum strategy in the teaching learning process has mostly yielded positive results on achievement. Results of the study revealed a significant difference in pre-test and post-test scores of students under self-regulated learning, mindmapping strategy and lecture method. By implication, all three methods of teaching enhanced students' achievement in Physicsbut to varying degrees. The Scheffe's post-hoc test also indicated that students taught Physics with mindmaps and self-regulated learning achieved higher than lecture method group with mindmap group achieving the highest. The findings agrees with Abamba, Efe and Esiekpe (2021), Akanbi, Olayinka,Omosewo and Mohammed (2021), Jibrin, shehui, and Abdullahi(2021), Adodo (2013) who reported that students under to mindmapping strategy outperformed those under other methods. Also the findings of superiority of self-regulated learning over the lecture method is in consonance with the findings of Nwafor, Obodo, and Okafor (2015), and Kaptum, Peter, and Stephen (2018) who reported that self-regulated learning strategy enhanced students' achievement than lecture method.The study also shows a no significant difference in the posttest achievement scores of male and female students taught Physics using self-regulated learning and mindmaps strategy. In other words, self-regulated learning and mindmaps enhanced both male and female students' achievement equally. These findings corroborates that of Jirgba and Bur (2019*),* Nwafor, Obodo and Okafor (2015) and Yukselturk and Bulut (2009), Katcha, Orji, Francisca, Zainab, &Babagana (2018), Bello and Oluwatosin (2014), Kanelechi and Amadi (2018) and Akanbi, Olayinka, Omosewo, and Mohammed (2021)who in their different studies reported a no significant difference in the achievement of male and female Physics students taught with self-regulated learning and mindmaps instructional strategy.

Conclusion

From the study, it was concluded that mindmapping strategy is most effective in enhancing sstudents' achievement in secondary school Physics as students in this group had the highest mean scores. The study also concluded that self-regulated learning and mindmaps strategies are not sex biased as data on analysis showed the two strategies did not significantly favour either male or female students.

Recommendations

The following necessary recommendations were proffered based on the findings of the study:

1. Physics teachers should adopt mindmaps as an instructional strategy in teaching Physics at the secondary level to assuaging the issue of low achievement in Physics.
2. Self-regulated strategy should be used as alternative when it is not possible to use mind maps instructional strategy as statistics revealed the students taught with Self-regulated strategy outperformed their counterpart taught with lecture method.
3. Government agencies and professional associations, whose responsibilities are to design and revise the curriculum for secondary schools, should incorporate and emphasize, through conferences, seminars and workshops on the use mind maps instructional strategy in Physics curriculum.

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