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EFFECT OF SOCRATIC TEACHING METHIOD ON SENIOR SECONDARY SCHOOL PHYSICS STUDENTS' ACADEMIC ACHIEVEMENT IN MACHINES AND WAVES IN ANAMBRA STATE, NIGERIA

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ABSTRACT

This study was conducted to find out the effect of Socratic method of teaching on senior secondary school students' academic achievement and retention in Anambra state, Nigeria. Three research questions were raised and three null hypotheses tested at 0.05 level of significance. Related empirical literatures were reviewed under ten sub-headings. The research design adopted was quasi-experiment design. The population for the study comprises 11,398 SS11 Physics students in 2020. The sample size was 253 students (intact classes). Multistage Sampling Technique and simple random sampling at three stages were used. Six schools in two education zones were selected. Mean and standard deviation were used to answer the four research questions, while Analysis of Covariance (ANCOVA) was used to test the null hypotheses. The findings showed among others, that there was significant difference ($p < 0.05$) in the achievement of secondary school students taught Physics using Socratic method (mean posttest score, 53.88) and lecture methods (mean posttest score, 28.84). Students taught Physics with Socratic Method performed better than their counterparts in lecture method, a significant effect of self-efficacy on students' academic achievement ($p < 0.05$). Students with high self-efficacy had significantly higher academic achievement (mean score 57.97) compared to students with low self-efficacy (mean achievement score, 32.69). It was concluded that teacher-student based teaching method such as Socratic teaching method enhance students' academic achievement in physics. Also, students' self-efficacy plays very important role in enhancing students' academic achievement in Physics. Based on the findings, it was recommended, that teachers should be encouraged to utilize teacher-student based teaching methods such as Socratic method to enhance students' academic achievement. Also, in-service training for physics teachers should focus on sensitizing teachers on the possible effect of self-efficacy on students' achievement. Students should as well be enlightened on the interaction effect of their own self efficacy and teaching method on their academic achievement in Physics.

KEYWORDS: Socratic method, secondary school, Students, Physics, Machine and Waves

INTRODUCTION

Since education is the primary vehicle for fostering both social and economic growth, nations from all over the world devote a lot of resources to improving their educational systems. The physical and financial efforts channeled towards education across the universe have practically expressed education as a world investment which it is assumed benefits are social and economic development, basically through the means of science and technology. This is so because science and technology education form the bedrock of sustainable development in any nation. According to Lutus (2010), the study of science is a component of education and is an intellectual and practical activity that involves the methodical investigation of the composition and behaviour of the physical and natural world through observation, inquiry, interaction, and experimentation. Through its procedural methods, the study of science contributes to technological advancements in all corners of the globe. Therefore, a lot of effort should be put into the study of science and scientific-related disciplines if any country hopes to grow technologically. More attention should be paid to physics education in particular, as it is crucial for the advancement of science and technology in both developed and developing nations (Okoronka, 2014). Basically, Physics education is a major factor in enhancing technological development of nations. Therefore, the expected outcome of the national investment into Physics education in particular and education in general is the academic achievement of students (Physics) across the nation (FRN, 2013).

Academic achievement is viewed as achieving at school: in a class, in a laboratory, in library or in fieldwork (Watabe, 2011). Abbing (2013) identified academic achievement to involve individual self-defining complete achievement in school. Thus, the quality of students' academic achievement within a nation is perceived as the benefit of the national investment in education because academic achievement determines the quality of educational outcome which directly influences the level of qualified and trained personalities in different professional fields leading to societal and technological advancement. However, in Nigeria, the national investment in education over the years as seen in the national budgets which range from 7%-8.28% of the total budget (National budget, 2014-2022) has not been justified by the under achievement of students over the years. This trend of under achievement can be seen in West Africa Examination Council (WAEC) results from 2014-2022, which showed 54.26%, 49.30%, 53.20%, 41.94%, 53.51%, 49.07%, 42.40%, 22.30%, and 40.78% failures in Physics. According to available statistics, except the year 2021 in which result showed low rate of failure (22.30%) in science subjects, others recorded high rates of failure. The high rates of failure is obviously not healthy in the pursuit of an advanced scientific and technological society. Hence, the need for underachievement in physics to be curbed. According to Mahmud (2011), academic achievement could be influenced by various factors which are categorized into teachers and students-based factors. The teacher-based factors include: mastery of the subject matter, applied teaching techniques, class size, adequacy of teaching materials and teaching methods used. While the students-based factors include: compromise of students, self-efficacy, motivation, interest in the subject matter, emotional wellbeing, personalities, readiness to learn and relationship with peers. Thus, to attain desired

academic achievement, Physics teachers should make a choice of teacher-student based teaching methods (socratic method) which will render students active rather than passive participants of the learning process as in lecture method.

According to Mohammed, Gayus, Oscar and Solomon (2008) one of the most prevalent teaching Methods in Nigeria secondary schools is the lecture method which predominantly involves the teacher talking to the students about the subject while the students listen most times passively.

Makinde (2005) stated that, lecture method is an oral presentation of information to students without an active involvement or effort on the part of the students. The teacher is actively involved and the learners are passively taking in the information (e.g. listening, writing). Lecture method perhaps may not be always suitable in teaching Physics abstract concepts because it probably promotes rote learning instead of the desired meaningful learning. According to Mayer (2011), rote learning takes place when individuals can actually recall knowledge for a short period of time, for the purpose of passing test but may not transfer knowledge to new situations, while meaningful learning occurs when students build the knowledge and cognitive processes needed for successful problem solving. Research result of Atherton (2016) indicate that meaningful processing strategies/ discourse pattern teaching methods (meaningful cognitive engagement) lead to greater achievement or achievement measures over the material studied than shallow strategies. Therefore, the persistent use of lecture method (swallow strategy) in teaching some topics of Physics may not give the desired learning outcome and may be part of the reason for the observed students' poor achievement in Physics. Thus, there is urgent need to explore viable meaningful teacher-student based approaches such as Socratic teaching Methods, in other to promote meaningful learning that can assist students process basic information into the long-term memory which could enhance their overall achievement in Physics.

According to Plato (1990), the Socratic method of teaching, also known as the questioning method, Elenchus, elenctic method, or Socratic debate, is a question-and-answer method in which the teacher asks a question, one student responds, the teacher reacts and asks another question, to which a second student responds, and so on. The method is thought to be particularly beneficial as a technique to direct developmental thinking, to encourage creativity, engage problem-solving, start discussions, and inspire quick recollection of prerequisites needed for the day's lesson (Fajemidagba, 2004). Fajemidagba further opined that educators can challenge students to consider both current and historical concerns by utilizing the Socratic Method in a range of topic areas and grade levels. The goal of the Socratic method is, firstly, to help students' process information and engage in deeper understanding of topics and that the teacher can easily know through the questions whether his students have given attention to something or not. Secondly, it keeps the students alert and therefore, keeps their attention intact. According to Copeland (2005), Socratic method is over 2400 years old and is reportedly founded on socrates' belief that lecture was not an effective Method of teaching all students. Results of studies conducted by Copeland (2005), York (2010), Croasmun (2010), Malacinski (2003) showed statistical significance when Socratic Method was applied for teaching in various fields of

study. Specifically, the work of Croasmum (2010) emphasized that the Socratic method is helping adult learners assimilate in science education by enhancing the learner's self-directedness, self-efficacy and the learner's autonomy. Croasmum's view is supported by Onaolapo (2015) who asserted that the goal of the Socratic method is to help students process information and engage in deeper understanding of topics. Most importantly, Socratic teaching engages students in dialogue and discussion that is collaborative and open-minded as opposed to debate, which is often competitive and individualized. Thus, this study investigated the effectiveness of socratic teaching method on the academic achievement of students in physics while considering self-efficacy as moderator variable.

According to Cheung (2015), a person's physiological state can increase or decrease confidence in their capacity to complete a task by acting as a mediating source and interacting with other sources. While excessive levels of stress and anxiety frequently cause a person to lose confidence in their abilities, cheerfulness and a good attitude will have a favourable impact on self-efficacy. Researchers appear to have reached a consensus that students' self-efficacy is positively correlated with their success in science (Chen & lai 2015; Merchant, Goetz, Keeney-Kennicutt, Kwok, Cifuentes & Davis, 2012). However, in the field of Physics education in particular, the literature is still inconclusive. While some researchers have found a strong predictive relationship between students' self-efficacy in Physics and Physics grade (Mahyuddin, Nooreen, & Maria, 2009; Marzano, 2012), others have reported a negative relationship between Physics self-efficacy and Physics achievement (Gungor, Eyilmaz & Fakioglu, 2007). Research works by Malacinski (2003) ; Abimbola (2004); Cavallo, Potter and Rozman (2004); Copeland (2005); confirmed that socratic teaching method and self-efficacy have significant effect/relationship on students' academic achievement and retention. On the other hand, research reports such as Faust and Paulson (2000) show no significant effect/ relationship between Socratic teaching method, interactive teaching method, self-efficacy and students' academic achievement. Therefore, this study considered self-efficacy as a moderating variable capable of influencing or interacting with the teaching method to affect students' academic achievement in Physics at the secondary school level.

The problem of this study put in question form is therefore: "Will the application of Socratic teaching methods (considering self-efficacy as a moderator variable) improve secondary school students' academic achievement in Physics in Anambra state?"

Research Question

1. What are the mean achievement scores of students taught Physics with Socratic Method and those taught Physics with Lecture Method?
2. What are the mean Physics achievement scores of High and low self-efficacy students taught with the different teaching Methods?
3. What kind of interaction effect exists between the teaching Methods and self-efficacy on students' Academic Achievement in Physics?

Hypotheses

The following null hypotheses tested at 0.05 level of significance guided in this study:

H₀₁: There is no significant difference in the academic achievement of students taught Physics with Socratic and lecture teaching methods.

H₀₂: There is no significant effect of self-efficacy on students' academic achievement in Physics when taught with Socratic teaching method.

H₀₃: There is no significant interaction effect of teaching Methods and self-efficacy on students' academic achievement in Physics.

METHODOLOGY

The design of the study was quasi-experimental design involving pre-test, post-test non-randomized control groups. Therefore, intact classes were used. The study was conducted in Awka and Nnewi Education Zones of Anambra State, Nigeria. The population is made up 11,398 SS 2 physics students in the two Education zone. The sample was made up of 169 SS2 physics students selected from six public secondary schools within the study area. Multistage sampling technique was used to select the sample. First – stage involved using simple random sampling (simple balloting) in selecting two education zones; Awka education zone (62 schools) and Nnewi education zone (50 schools), out of the six education zones of the study area. Second stage of sampling included using simple random sampling; simple balloting technique, in selecting four schools out of the total number of schools in the selected zones, two schools per zone. The instruments for data collection were the Physics Achievement Test (PAT) and Morgan-Jinks student efficacy scale. The PAT was adapted by the researcher from the WASSCE past questions between 2016– 2020. It contained 50 multiple choice test items with four options (A – D). The instrument was validated (face) by three experts because standardized items (past exam questions) were used. Reliability of the instrument was determined by administering it to 61 physics students from Ezi-Awka that was not part of the study. Kuder-Richardson formula 21 was used to analyze the data and a reliability coefficient index of 0.90 was obtained. Also, item analysis was conducted on the PAT to determine its facility and discrimination index on each item. The MJSES was also subjected to validation by three experts. Cronbach alpha was used to obtain a reliability index of 0.87 for MJSES.

RESULTS

Research Question One: this is answered using data analysis presented on table 1

Table 1: Descriptive Statistics of Students’ Pretest and Post test Scores

Independent Variables	n	PreTest Mean	S.D	PostTest Mean	S.D	Mean gain
Socratic TM	84	19.83	14.56	53.88	18.31	34.05
Lecture TM	85	19.84	10.54	28.84	10.20	9.00
Total	169					

Key: TM= Teaching Method, S.D= Standard Deviation.

Table 1 shows the descriptive statistical analysis of students’ scores taught Physics with two different teaching methods. From the table, students taught Physics using STM performed better (mean gain = 34.05) than those taught Physics with LTM (mean gain=9.00). The values of the posttest standard deviation are 18.31 and 10.20 for STM and LTM respectively are high and this suggests that, the scores are widely spread, i.e. the scores of students are generally far from the mean.

Research Question Two: This is answered using data analysis presented on table 2

Table 2: Descriptive Statistics of High and Low Self Efficacy Students’ Achievement

TEACHING STRATEGIES/METHOD	Academic Self Efficacy Level of Students	n	Mean	Std. Deviation
Socratic Teaching Method	High	51	65.25	11.45
	Low	33	36.30	11.83
Lecture Teaching Method	High	50	31.12	9.03
	Low	35	25.60	11.00
Total	High	101	57.97	20.22
	Low	68	32.69	12.62

Table 3 shows a descriptive statistics analysis of high and low academic self-efficacy students’ Academic Achievement scores taught Physics with the two different teaching methods. From the table, students categorized as high self-efficacy students performed better that those categorized in low self-efficacy across the two groups. This is evident in the average means obtained by the students in the different groups. For the group taught Physics using STM, the high self-efficacy students made a mean score of 65.25, while the low self-efficacy students made a mean score of 36.30, likewise the Control group taught with LTM also exhibited similar difference between the mean scores of high efficacy students and low efficacy students with mean scores of 31.12 and 25.60 respectively.

Research Question Three: This is answered using data analysis presented on table3

This question is answered based on graphical analysis of data on figure 1

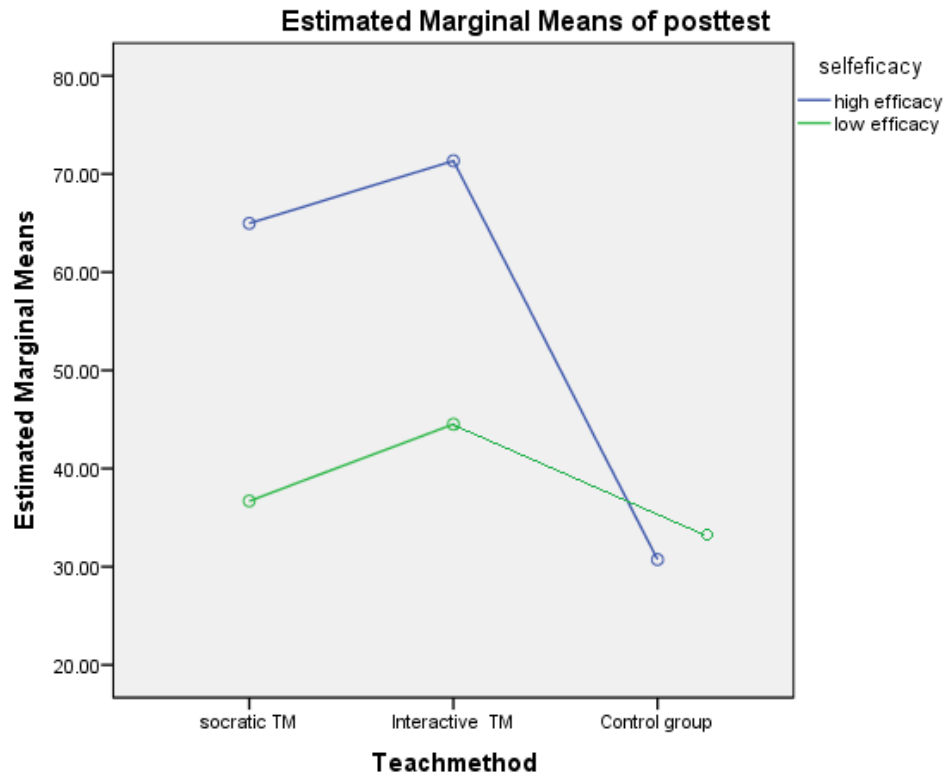


figure 1. Estimated Marginal Means of Posttest Scores

The crossed lines on the graph in Figure 2 suggest that there is an ordinal interaction effect of teaching methods and self-efficacy on students' academic achievement in Physics. The effect graph pattern suggests it is an ordinal interaction, which implies that the teaching Methods are effective in enhancing Physics students' academic achievement with high self-efficacy students but makes no difference in low self-efficacy students.

Hypotheses Testing

The three null hypotheses stated were tested in the order they were stated.

The first hypothesis H01 tested based on data analysis is presented on Table 3

Table 3: Two-Way ANCOVA of Students’ Academic Achievement Scores Taught Physics Using Socratic and Lecture Teaching Methods

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	46302.296 ^a	4	11575.574	112.681	.000	.734
Intercept	55416.559	1	55416.559	539.444	.000	.768
pretest	2325.049	1	2325.049	22.633	.000	.122
Teachmethod	20431.832	1	20431.832	198.891	.000	.550
selfeficacy	9847.513	1	9847.513	95.859	.000	.370
Teachmethod * selfeficacy	5856.688	1	5856.688	57.011	.000	.559
Error	16744.823	163	102.729			
Total	349570.000	169				
Corrected Total	63047.119	168				

a. R Squared = .734 (Adjusted R Squared = .728) * Significant P<0.05

Table 3 shows the result of two-way ANCOVA. Preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, equality of variances, outliers, and reliable measurement of the covariate.

The result on Table 3 shows that there is a significant difference effect of treatment on students’ academic achievement $F(1, 168) = 198.891, p=.000 < .05$, with a large effect size (partial eta squared = 0.559). according to guideline proposed by Cohen (2008), This implies that the treatment effect on the dependent variable is significantly large.

The second hypothesis H₀₂ tested based on data analysis is presented on Table 3

The result on Table4 shows that there is a significant effect of self-efficacy on Physics students’ academic achievement $F(1, 168) = 95.859, p=.000 < .05$, with a large effect size (partial eta squared = 0.370). According to guideline proposed by Cohen (2008). This implies that the moderator variable (self-efficacy) effect on the dependent variable is significantly large.

From Table 2, it is shown that students with high self-efficacy performed better than students with low self-efficacy judging by their mean scores 57.97 and 32.69 respectively.

The third hypothesis H₀₃ tested based on data analysis is presented on Table 3

The result in Table 3 shows that there is a significant interaction effect of teaching Methods and self-efficacy on students’ academic achievement in Physics $F(1, 168) = 57.011, p=.000 < .05$, with a mild effect size (partial eta squared = 0.259), according to guideline proposed by Cohen (2008). This implies that the moderator variable’s strength has effect on the independent variable which is significantly mild. The findings are summarized as follows:

1. There is a statistically significant difference effect of treatment on students' Academic achievement in Physics, $F(1, 168) = 198.891, p=.000 < .05$ which shows that, Socratic teaching method was significantly better than lecture Method.
2. Students' self-efficacy significantly had effect on students' academic achievement in Physics $F(1, 168) = 95.859, p=.000 < .05$ when they are taught physics using Socratic teaching method.
3. There is a significant interaction effect of teaching methods and self-efficacy on students' academic achievement in Physics $F(1, 167) = 57.011, p=.000 < .05$.

DISCUSSION

The finding of this study shows that Socratic teaching method is significantly more effective than the lecture method in enhancing physics students' academic achievement. The efficiency of this methods over lecture method, perhaps maybe due to the fact that the STM is student-teacher based teaching. According to Magaji (2017) the viable approach of Socratic teaching method may bring about the desired meaningful learning outcome and this opinion seems true as found in this study. The finding of STM being significantly effective than Lecture Method, agrees with the findings of Eze, Ezenwafor and Obidile (2017), Rajendra and Sudana (2018); Oyebola and Akinoso (2018) ; Hana (2018) ; Okwara, Anyagh and Ikyaan (2017) ; Adedamola (2018) ; Mallam, Ishaya, Mantu, and Oche (2019) who all found that the students taught with STM significantly performed better than the students in the control group (lecture method). The findings, however, contrasted with that of Smith, Knight, Guild and Su (2009); Sawsan, Izzat, Mohammed and Sharadgah (2013); Christopher (2014) who found that there is was no significant difference in performance of students taught with lecture method and Socratic method. Based on the findings of this study, Socratic can enable students visualize abstract concepts, organize their thinking about a given concept/topic, and learn a topic more meaningfully.

The findings of this study also revealed that students' self-efficacy had a significant effect on physics students' academic achievement; with high self-efficacy students performing significantly better than the low self-efficacy students when they are taught using Socratic teaching method. This result is in line with the findings of Wenslaus (2015); Connie (2016); Perez and Yan (2017); Ozan, Tahsin and Salih (2018) , Marcela and Lucia (2018), Asude and Aynur (2018). According to Bandura (1997), individuals who possess high self-efficacy are more likely to attempt challenging tasks, to persist longer at them, to exert more effort and to excel, unlike the low efficacy students who perceive challenging tasks too difficult to be demystified. Therefore, they are more likely to give up easily, exert less effort and to fail. On the other hand, the findings of this study contrasted with the findings of Muhammed Yusuf (2011), whose results of direct and indirect technique indicated no significant effects of self-efficacy beliefs on students' academic achievement. Nevertheless, this study was able to establish through the findings that high efficacy students perform better that low efficacy students when they are taught physics using Socratic teaching method.

The findings of this study, also, showed a significant interaction effect of teaching Method and self-efficacy on physics students' academic achievement. This is in line with Osman and Tien (2013);

Gamabri, Akawo, Gana and Ughovwa (2014); Rajendra and Sudana (2018); Okwara, Anyagh and Ikyaan (2017) ; Oyebola and Akinoso (2018) ; Hana (2018) ; Adedamola (2018) who found that there is a significant interaction effect of the moderator variable of self-efficacy and independent variable on the dependent variable. By this finding, it can be generalized that the teaching Method (Socratic method) or strategy used for instruction can be more or less effective if some other factors are not put into consideration. In this study, self-efficacy was carefully investigated and it was shown by the results that the self-efficacy in interaction with the teaching method actually played a critical role in enhancing students' academic achievement.

CONCLUSION

The study shows that Socratic had better significant effects on students' academic achievement in physics than lecture method. On the other hand, high self-efficacy level has significant effect on students' academic achievement in physics unlike low self-efficacy level when students are taught with Socratic teaching method. The study also indicated a significant interaction effect of teaching Method and self-efficacy on students' academic achievement in physics.

RECOMMENDATIONS

On the basis of the findings emanating from this study, the following recommendations are made:

1. Curriculum planners and professional bodies who are involved in training teachers , should encourage teachers to use Socratic method for teaching of Physics. The results of this study clearly showed that Socratic method enhanced students' academic achievements in physics.
2. In service training by professional bodies and government agencies/bodies for Physics teachers in form of seminars, workshops and conferences should focus on sensitizing teachers on the possible effect of self- efficacy on students' achievement. This should be done for teachers to know how to develop and sustain high self-efficacy in Physics students.
3. School management, teachers and parents should sensitize students on the Interactive effect of students' self-efficacy and teaching Method on their Academic Achievement. This will help the students build high self-efficacy in order to be successful in school.

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