



Effects of 5e-Cyclic and Mental Models Instructional Strategies on Junior Secondary School Students' Learning Outcomes in Basic Science in Ondo State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The study investigated the effects of 5e-cyclic and mental models instructional strategies on junior secondary school students' academic performance and self-efficacy in Basic Science. The study adopted non-equivalent, pretest-posttest control group quasi-experimental research design. The population for the study comprised all junior secondary school students in Ondo State, Nigeria. The sample size consisted of 95 junior secondary school two (JSII) students in three intact classes. The three (3) classes were assigned randomly to two experimental groups (5e-cyclic-model and mental-model instructional strategies) and one control group (teacher expository method). Two instruments were used for data collection namely: Basic Science Concept Test (BSCT) and Basic Science Self-Efficacy Rating Scale (BSSERS). Data collected were analysed using analysis of covariance (ANCOVA). The results showed that there was a significant effect of treatments on the academic performance of students taught with 5e-cyclic-model and mental-model instructional strategies and teacher expository method with students taught using 5e-cyclic-model and mental model showing better performance than teacher expository. Also, significant effect of treatment was found in the self-efficacy of students taught with 5e-cyclic-model and mental-model with students from both techniques performed better than teacher expository. The study concluded that 5e-cyclic and mental models instructional strategies had improved the academic performance and

self-efficacy of students in Basic Science. Therefore, it was recommended that teachers should use 5e-cyclic model and mental model instructional strategies to teach Basic Science concepts because the instructional strategies have been demonstrated to be more effective as a teaching-learning strategies for Basic Science than teacher expository method.

Keywords: 5e-cyclic model; mental model; teacher expository method; academic performance; self-efficacy.

1. INTRODUCTION

Science is one of the most powerful tools that man has ever devised for exploring new worlds. Science is the intensive human effort to understand the natural world's past and how it operates, using verifiable physical evidence as the foundation of knowledge [1]. It is conducted out by formulating and testing hypotheses based on observational evidence; experiments are useful when they are used, but their primary purpose is to make observation easier under controlled conditions. Science education was integrated into the Nigerian school curriculum in acknowledgment of the relevance of science. Science education is an important aspect of a child's basic education because it prepares them to live in a world where science and technology are increasingly shaping their lives [2]. According to Agboola and Oloyede [3], one of the purposes of scientific education is to enhance students' enthusiasm in science and technology. Science education is one of the most significant disciplines in schools because of its value to students' lives. It allows students to develop lifelong abilities such as problem solving and critical thinking, which help them to produce ideas, weigh options wisely, and even comprehend the information that informs public policy.

However, at the higher basic level, Basic Science (formerly known as Integrated Science) was introduced as the basic foundation for the other sciences. It is a subject that introduces students to the world of science after they have learned the principles of science in elementary school [4]. Afuwape [5], described Basic Science as a weapon for understanding, embracing and propelling science at the grass root. It is characterized as a style of teaching science in which concepts and principles are presented in such a way that they show the basic unity of scientific thought while avoiding an overemphasis on scientific domain distinctions [6]. Basic Science has several aims, one of which is to serve as a basis for higher-level science education or scientific literacy. Despite

the importance of Basic Science to a country's progress and socioeconomic development, students' interest and proficiency in the subject is waning in Nigerian classrooms. Several researches have shown that Nigerian science classrooms are compounded with lot of challenges; prominent among which are poor teaching strategies adopted by teachers [7,8]; students' lack of interest in the sciences [9]; gender [10]; availability and usability of science laboratory equipment's [11]; students' anxiety [12]; students' self-efficacy [13] and the abstract nature of science [14].

According to Holbrook [15], students pursue science to improve factual knowledge and talents as well as to pass subject knowledge tests. In order to get a meaningful understanding and assimilation of facts, individualized learning also needs learners' devotion and interest, as well as active participation in the learning process. This implies that learning could be meaningful and effective when students reflect on what is taught; develop interest on the subject matter and construct new knowledge based on their understanding of the concepts. Moreover, many factors influence students' science performance and one of the most essential is self-efficacy [16]. Self-efficacy is a person's belief in his or her ability to manage and achieve the concrete plan needed to reach certain objectives. Self-efficacy refers to a person's belief in their ability to achieve high levels of performance, fulfill targets or milestones, and complete tough tasks [17]. In a nutshell, the belief in one's ability to execute tough tasks and that one's skill can grow with effort is known as self-efficacy [18]. Most students believe that if they have strong self-efficacy, they will have a higher chance of success in science projects and courses [19]. Students with strong science self-efficacy set more ambitious objectives for themselves and work harder to accomplish them than students with low science self-efficacy. As a result, a combination of self-efficacy and drive appears to be a strong predictor of academic accomplishment in science, and its complexity warrants more investigation.

Learners use a variety of methods to acquire information and knowledge. Models of instruction were created to teach students tools that will help them think clearly and rationally, as well as develop social skills and dedication. They teach students how to learn by assisting them in acquiring information, ideas, skills, values, and methods of thinking and expressing oneself [20]. Each of the models has a set of general strategies. A model can give a teacher structure and direction, but it cannot provide all of the actions that a teacher takes, because of this premise, the model differs from normal teaching methodologies. All instructional scenarios are regarded to be applicable to general teaching approaches. However, these teaching styles are not appropriate for all teaching circumstances. Teaching models are tools that can assist skilled teachers teach more successfully by making their lessons more methodical and efficient, but they are not a replacement for good teaching skills.

Hence, 5E-cyclic model is a constructivist paradigm that allows students to acquire a new concept thoroughly from a previously learned concept. As a very frequently used model in constructivist learning approach, 5E learning cycle model's name comes from the number of its phases and the initials of each phase. These five phases are:

- Engage/Enter
- Explore
- Explain
- Elaborate
- Evaluate

1. Engage/Enter: The purpose of this phase is to get students' attention on the topic. Asking specific questions, providing a scenario, exhibiting an event, showing a picture, or initiating a debate can all help students focus on the tasks at hand and establish connections to previous knowledge and experience.
2. Exploration: The explore phase is the one in which pupils engage in the most activities. In this phase, students work in groups to address the problem by collaborating, talking, and experimenting. Meanwhile, teachers should just provide guidance to pupils rather than participating fully in their work. If a teacher notices a student's error while guiding, he or she should not correct it immediately, but rather give pointers or demonstrate how pupils might fix themselves.

3. Explanation: In the explain phase, students explain scientifically the results of their observations and data. In the explanation phase, a representative from each group explains the outcomes of their work and invites their peers to debate it. Teachers become active in correcting mistakes and filling in the gaps in students' findings, the explain phase is a teacher-centered phase in the 5E paradigm.
4. Elaboration: Students can put their new information to use in this phase by suggesting solutions, creating new challenges, making decisions, and/or introducing logical consequences.
5. Evaluation: The assessment phase is crucial in establishing whether students grasp the concept in a scientific context and can apply it to the circumstance.

According to O'Brien [21], the 5E teaching cycle is an instructional paradigm for developing a sequence of experientially rich lessons that are conceptually connected and developmentally scheduled to enable the continuous, progressive refining of student understanding over time. The 5E paradigm focuses on pupils discovering new concepts and associating them with prior knowledge. Students create their own knowledge about a specific problem with the help of planned and implemented learning-teaching activities. It is a style of teaching and learning that is consistent with inquiry's preferred status and moves away from a teacher-centered approach toward a student-centered approach. It has been discovered to result in much improved scientific conceptions of states of matter and solubility [22], and photosynthesis and respiration in plants [23]. It was also discovered that exposing students to 5E model learning activities improved their scientific performance and positive attitudes regarding learning activities [24]. Furthermore, teaching students within the 5E framework improved their mathematical thinking, understanding, and also the permanence of knowledge in trigonometry [25]. It effects on students' learning outcomes in Basic Science deserved investigation.

A mental model is a cognitive construct that describes a person's knowledge of a certain issue in the universe. Mental models are ways for codifying reality in terms of one's understanding of it, or cognitive representations of reality. Mental models, according to Van Merrinboer and Kirschner (2017), are mental representations of how a knowledge field is

organized. It is a summary of someone's perspective on how something works in the real world. Johnson-Laird and Byrne [26] define mental models as mental representations of real and imagined events. Furthermore, a mental model is an internal process that cannot be directly observed. It is revealed by an explanation in one or more languages that incorporates texts, visuals, photos, equations, and other elements. One of these languages is concept mapping.

Concept maps are visual aids for organizing and presenting information [27]. They depict concepts, which are commonly represented by circles or boxes, as well as relationships between concepts, which are represented by connecting lines and arrows. These maps are classified as chain or sequential maps, cyclical maps, or hierarchical maps based on their structure. In order to grasp phenomena or complicated reality, a model-centered learning strategy delivers learning circumstances that demand the development and manipulation of mental models. A student could also use common observations of specific features of reality that are pertinent to the phenomenon in the actual world. When these observations are made on a regular basis and properly analyzed, they can assist to add new knowledge and concepts to the mental model and structure them in a comprehensive manner. Nevertheless, the expository instruction of teaching science subjects like Basic Science has been criticized as being teacher-centered; incapable of enhancing conceptual changes and conceptual understanding of emerging concepts in Basic Science. Two instructional models that have been adjudged to enhance students learning outcomes in Mathematics, Chemistry, and Biology are 5E-cyclic and Mental models. The extent to which these models could enhance students learning outcomes in Basic Science incite investigation, hence this study.

1.1 Purpose of the Study

The purpose of this study was to see how the 5E-Cyclic-model and Mental-model instructional techniques affected junior secondary school students' academic performance and self-efficacy in Basic Science concepts in Ondo State. Specifically, The study sought to:

- i. investigate the effects of 5E-Cyclic and Mental models instructional strategies on junior secondary

- school students' academic performance in Basic Science; and
- ii. determine the effects of 5E-Cyclic and Mental models instructional strategies on junior secondary school students' academic self-efficacy in Basic Science.

1.2 Hypotheses

The following hypotheses were formulated to guide the study;

- H₀₁:** There is no significant main effect of 5E-cyclic and mental models instructional strategies on junior secondary school students' academic performance in Basic Science concepts.
- H₀₂:** There is no significant main effect of 5E-cyclic and mental models instructional strategies on junior secondary school students' academic self-efficacy in Basic Science concepts.

2. RESEARCH DESIGN

The study employed non-equivalent pre-test, post-test, control group quasi-experimental research design as described by Campbell and Stanley (2015), to verify the effects of 5E-cyclic model and Mental Model Instructional Strategies on students' academic performance and self-efficacy of Basic Science concepts. This study used a non-equivalent pre-test, post-test design since secondary schools have intact classes, and randomising students into groups for experimental purposes is simply not allowed to avoid class disintegration. This is to ensure that the experiment has a high level of internal validity. Measurements were taken before and after the treatment was introduced, according to the pre-test and post-test. The pre-test aids in determining the differences between the experimental and control groups in order to set a baseline for the treatment's effect.

The design is represented schematically as follows:

O ₁	X ₁	O ₂	-	Experimental Group A
O ₃	X ₂	O ₄	-	Experimental Group B
O ₅	X ₃	O ₆	-	Control Group C

Where,

O_1 ; O_3 and O_5 are the pre-test scores of the experimental groups A; B and control group C; while O_2 ; O_4 and O_6 are their respective post-test scores for experimental groups A; B and control group C.

X_1 = 5E-cyclic-model Instructional Strategy (5EIS)
 X_2 = Mental-model Instructional Strategy (MIS)
 X_3 = Expository Method (EM)

2.1 Population, Sample and Sampling Techniques

The population for the study comprised all the Junior Secondary School Two (JSSII) Students in Ondo State. The sample consisted of 95 Basic Science students in their intact classes in three selected secondary schools in Ondo North Senatorial District of Ondo State. The three schools were chosen using a simple random sampling procedure. The experimental groups A and B, as well as the control group C, were assigned to the three schools at random. The schools were in a semi-urban setting in Nigeria's southwestern region. The majority of the residents in this area work in trade and agriculture, with only a small number working as civil servants. The usage of this location is justified by the fact that it contains a mix of literate and neoliterate residents, the children of whom are utilised as samples in the selected schools.

2.2 Research Instruments

Two research instruments were used for data collection, they are: Basic Science Concepts Test (BSCT) and Basic Science Self-Efficacy Rating Scale (BSSERS).

2.2.1 Basic Science Concepts Test (BSCT)

Basic Science Concepts Test (BSCT) it is a self-designed instrument that was used for pre-test and post-test to measure student's knowledge in Basic Science concepts. BSCT has section A and section B. The section A contained student's demographic information and the section B comprised 25 items 4-option structured conceptual multiple-choice questions drawn from the physical concepts of Light Energy, Magnetism, Force, Satellite and Radioactivity in Basic Science. The detail of item specification for BSCT based on topics selected is presented in Table 1.

2.2.2 Basic Science Self-Efficacy Rating Scale (BSSERS)

Basic Science Self-Efficacy Rating Scale (BSSERS) adapted from (Dullas, 2018), was modified and was used to assess the students' self-efficacy in Basic Science, before and after the treatment. BSSERS had two sections; section A contained demographic information and section B comprised 40-item self-expressing scale. Item 1-10 Perceived Control in Basic Science; item 11-20 Competence in Basic Science; item 21-30 Persistence in Basic Science and item 31-40 Self-Regulated Learning in Basic Science. Each item was rated on 4-point Likert scale: Strongly Agree (SA) = 4; Agree (A) = 3; Disagree (D) = 2; and Strongly Disagree (DS) = 1.

2.3 Validation of the Instruments

The validity of the drafted Basic Science Concepts Test (BSCT) and Basic Science Self-Efficacy Rating Scale (BSSERS) were submitted to experienced Basic Science teachers in junior secondary schools, the supervisor and experts in test development for face and content validity. They were requested to check for the appropriateness of the items and content coverage considering the grade level of the students and the objectives of the study. Based on their comments and suggestion, which included revising some of the items and dropping some, the number of items was reduced in BSCT from 35 to 30 items and BSSERS from 60 to 40 items. To further strengthen the validity of the BSCT, items analysis was carried out on the BSCT. The 30 remaining BSCT were trial tested on a sample of some selected Basic Science students in a school in the study area not selected for the study. Items analysis were carried out on the data obtained from the pilot study to determine the Difficulty Index (F.I) and Discrimination Index (D.I) of each of the item in the BSCT. For the purpose of this work items with difficulty indices below 0.30 were deleted for being difficult and those above 0.70 were also deleted for being too simple (Mahjabeen, Alam, Hassan, Zafar, Butt, Konain; & Rizvi, 2018). With respect to the discriminating powers or item efficiency, only items with discriminatory indices above 0.21 were accepted test items in assessing students' performance (Mahjabeen, et al. 2018). These further reduced the number of items from 30 to 25 items in the final form of BSCT.

Table 1. Table of Specification for BSCT Based on Revised Bloom Taxonomy

Contents	Remember (44%)	Understand (28%)	Apply (28%)	Total (100%)
Light Energy (28%)	2,7,11	8,10	9,23	7
Magnetism (24%)	6,12,22	13,21	14	6
Radioactivity (16%)	19,20	1,18	-	4
Force (16%)	3		4,16,17	4
Satellite (16%)	5,25	15	24	4
Total (100%)	11	7	7	25

Source: Researcher, 2021

Thereafter, the reliability co-efficient of BSCT was determined using test-retest method while that of BSSERS was determined using Cronbach's Alpha reliability index. For the BSCT, test-retest method was used to generate two set of scores for the students. For test-retest measurements, the second test which was a reshuffled version of the first, was administered two weeks after the first to the same set of students in the study area not selected for the main study, and the data obtained was analysed using Pearson Product Moment Correlation and the reliability coefficient was found to be 0.73. For the BSSERS, adapted from (Dullas, 2018), the instrument was administered on twenty (20) students sample, different from the schools selected for the study. The Cronbach's Alpha reliability index of SIS was 0.94 was obtained. These observations showed that these instruments were reliable and capable of measuring the intended events with consistency.

2.4 Procedure for Data Collection

This was accomplished in stages. In the initial phase, the researcher went to the selected schools to get permission to use the students and some of the school's facilities. This was followed by the administration of the BSCT and BSSERS as a pre-test to students in the two experimental groups and the control group to determine equivalence in ability and self-efficacy. In the second phase, the treatments were introduced to the experimental groups and control group. Students in experimental group A were taught using the 5E-cyclic model while those in experimental group B were taught using the Mental model and control group C were taught using Expository method. Four physical concepts (Light Energy, Magnetism,

Radioactivity, Force and Satellite) were taught concurrently in the three schools using the appropriate treatment in each school for a period of eight weeks. In the third phase, the BSCT and BSSERS were re-administered to the three groups as post-test. The pre-test and post-test were scored to generate quantitative data which were analyzed using mean and analysis of covariance (ANCOVA). ANCOVA was considered most appropriate since the subjects were treated in their intact class setting.

3. RESULTS AND DISCUSSION

3.1 Hypothesis One (Ho₁)

There is no significant main effect of 5E-cyclic and Mental models instructional strategies on junior secondary school students' academic performance in Basic Science in Ondo State.

The descriptive analysis of mean was employed to fulfill the first component of the objectives, which concerned assessing the impacts of 5E-cyclic and Mental models instructional strategies on students' academic performance in Basic Science. Table 1 showed that 30 students exposed to 5E-cyclic strategy recorded the post-test mean Basic Science performance score of $\bar{X} = 56.80$, the 31 students exposed to Mental model strategy recorded post-test mean Basic Science performance score of $\bar{X} = 54.45$, while the 34 students exposed to expository method recorded post-test mean performance score of $\bar{X} = 39.65$. The result from Table 2 revealed that students taught with 5E-cyclic strategy had highest mean performance scores and followed by students taught with mental model strategy.

Table 2. Descriptive Statistics of the Effect of Instructional Strategies (Treatments) on Junior Secondary School Students' Academic Performance in Basic Science

Instructional Strategy	N	Mean	Standard Deviation
5E-cyclic strategy	30	56.80	15.381
Mental model strategy	31	54.45	13.092
Expository method	34	39.65	13.443
Total	95	49.89	15.849

Table 3. Analysis of Covariance of the Effect of 5ECMIS and MMIS on Junior Secondary School Students' Academic Performance in Basic Science

Source	Type III Sum of Square	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected model	12580.770 ^a	3	4193.590	34.598	.000	.533
Intercepted	7049.141	1	7049.141	58.156	.000	.390
Pre-test	6936.065	1	6936.065	57.223	.000	.386
Treatment Groups	6643.184	2	3321.592	27.403	.000	.376
Error	11030.177	91	121.211			
Total	260112.000	95				
Corrected Total	23610.947	94				

a. R Squared = .533 (Adjusted R Squared = .517)

Table 4. Post-Hoc Test of Pair-wise Comparisons of Basic Science Post-test Scores of Students on Treatments

(I) Strategy	(J) Strategy	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
5CMIS	MMIS	1.372	2.823	1.000	-5.513	8.256
	TEM	18.161*	2.761	.000	11.427	24.895
MMIS	5CMIS	-1.372	2.823	1.000	-8.256	5.513
	TEM	16.789*	2.747	.000	10.090	23.488
TEM	5CMIS	-18.161*	2.761	.000	-24.895	-11.427
	MMIS	-16.789*	2.747	.000	-23.488	-10.090

Based on Estimated Marginal Means. *. The mean difference is significant at the .05 level

The results of a one-way between-group analysis of covariance were presented in Table 3 to determine the significant main effect of 5E-cyclic and mental models teaching strategies on junior secondary school students' academic performance in Basic Science in Ondo State. The post-test mean Basic Science performance scores of the students following exposure to the different levels of instructional strategy demonstrated a significant difference $F(2, 91) = 27.403$, $p < 0.05$, partial $\eta^2 = 0.376$. (5E-cyclic, Mental model & Teacher expository method). The findings also demonstrated that instructional technique alone accounted for 37.6% of the variation in students' academic achievement in Basic science. The null hypothesis (H_{01}) was

therefore rejected. As a result, the major effect of 5E-cyclic and mental models instructional strategies on junior secondary school students' academic performance in Basic Science in Ondo State was shown to be considerable.

The results of post-hoc test for the groups is presented in The Table 4.

Table 4 showed the results of the Bonferroni-corrected post-hoc comparisons conducted to determine where the differences exist among the three groups in this study. It can be observed from the table 4 that students exposed to 5CMIS is statistically significant different from those exposed to TEM ($p < 0.05$). Also, there is

statistically significant different between the students exposed to MMIS and TEM ($p < 0.05$). Conversely, there is no statistically significant different between students exposed to 5CMIS and MMIS ($p > 0.05$).

3.2 Hypothesis Three (Ho₂)

There is no significant main effect of 5E-cyclic and Mental models instructional strategies on junior secondary school students' self-efficacy in Basic Science in Ondo State.

In order to realize the third objective which bothers on examining the effects of 5E-cyclic and Mental models instructional strategies on students' self-efficacy in Basic Science, descriptive analysis of mean and standard deviation were used. According to the table, 30 students who were exposed to the 5E-cyclic strategy had a post-test mean Basic Science self-efficacy score of $\bar{X} = 80.97$; 31 students who were exposed to the Mental model strategy had a post-test mean Basic Science self-efficacy score of $\bar{X} = 79.71$; and 34 students who were exposed to the expository method had a post-test mean self-efficacy score of $\bar{X} = 78.56$.

Table 6 showed the result of A-one-way between-group analysis of covariance conducted to examine the significant main effect of 5E-cyclic and mental models instructional strategies on junior secondary school students' self-efficacy in

Basic Science in Ondo State. The post-test mean Basic Science self-efficacy scores of the students following exposure to the three levels of instructional strategy demonstrated a significant difference $F_{(2, 91)} = 26.625$, $p < 0.05$, partial $\eta^2 = 0.369$. (5E-cyclic, Mental model & Teacher expository method). Furthermore, the results demonstrated that instructional technique alone accounted for 36.9% of the variation in students' self-efficacy in Basic Science. As a result, the null hypothesis (Ho₁) was rejected. Therefore, this result concluded that there is significant main effect of 5E-cyclic and mental models instructional strategies on junior secondary school students' self-efficacy in Basic Science in Ondo State.

The results of post-hoc test for the groups is presented in the table 6.

Table 7 showed the results of the Bonferroni-corrected post-hoc comparisons conducted to examine where the differences exist among the three groups in this study. It can be observed from the table 4.4c that students exposed to 5CMIS was statistically significant different from those exposed to TEM ($p < 0.05$). Also, there was statistically significant different between the students exposed to MMIS and TEM ($p < 0.05$). Conversely, there was no statistically significant different between students exposed to 5CMIS and MMIS ($p > 0.05$).

Table 5. Descriptive Statistics of the Effects of Instructional Strategies (Treatment) on Junior Secondary School Students' Self-Efficacy in

Instructional Strategy	N	Mean	Standard Deviation
5E-cyclic strategy	30	80.97	10.280
Mental model strategy	31	79.71	11.883
Expository method	34	78.56	12.585
Total	95	79.69	11.587

Table 6. Analysis of Covariance of the Effects of 5CMIS and MMIS on Junior Secondary School Students' Self-Efficacy in Basic Science

Source	Type III Sum of Square	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	11722.226 ^a	3	3907.409	395.997	.000	.929
Intercept	212.807	1	212.807	21.567	.000	.192
Pre-test	11629.814	1	11629.814	1178.625	.000	.928
Treatment Groups	525.431	2	262.715	26.625	.000	.369
Error	897.922	91	9.867			
Total	615989.000	95				
Corrected Total	12620.147	94				

a. R Squared = .929 (Adjusted R Squared = .927)

Table 7. Post-Hoc Test of Pairwise Comparisons of Basic Science Self-Efficacy Post-Test Scores of Students on Treatments

(I) Strategy	(J) Strategy	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
5CMIS	MMIS	-1.726	.809	.107	-3.700	.248
	TEM	3.873*	.788	.000	1.951	5.795
MMIS	5CMIS	1.726	.809	.107	-.248	3.700
	TEM	5.599*	.791	.000	3.670	7.528
TEM	5CMIS	-3.873*	.788	.000	-5.795	-1.951
	MMIS	-5.599*	.791	.000	-7.528	-3.670

Based on Estimated Marginal Means. *. The mean difference is significant at the .05 level

4. DISCUSSION OF FINDINGS

This study investigated the effects of 5e-cyclic and mental models instructional strategies on junior secondary school students' learning outcomes in Basic Science compared with the conventional expository method. The discussion of the findings was presented according to the two hypotheses, which were tested to give direction to this study.

The findings of hypothesis one showed that there was significant main effect of 5e-cyclic and mental models instructional strategies on junior secondary school students' academic performance in Basic Science. The performance of students in 5E-cyclic and mental models instructional strategies over teacher expository method could be attributed to the fact that 5e-cyclic and mental model encourage students to be active participants in construction of their own knowledge, provides opportunity for students to share ideas and expanding their existing knowledge by building on other peoples' contributions. Further analysis revealed that there was statistically significant difference between the academic performance of students exposed to 5e-cyclic learning strategy and teacher expository method. It also showed that there was statistically significant difference between the academic performance of students exposed to mental model and teacher expository method. However, there was no significant difference between the academic performance of students exposed to 5E-cyclic learning strategy and mental model learning strategy.

The finding is in conformity with Tuna and Kacar [24], who discovered that students who participated in a learning cycle had superior academic achievement and trigonometry

knowledge retention than those in the control group. In addition, the study agreed with Akinwumi and Bello [8], who asserted that students who are exposed to 5e-cyclic learning strategy scored significantly higher in physics test than those who were not exposed to learning cycle strategy. In the same vain, the findings agreed with Gambari (2010) who stated that the students taught using instructional model performed significantly better than their counterparts taught using the conventional method. Similarly, Majid and Prahani (2017) found that due to the dynamic nature of atomic structure models, students' learning outcomes (perception and imagination) are likely to alter.

Likewise, the findings of hypothesis two revealed that there was a substantial main effect of 5e-cyclic and mental models instructional strategies on junior secondary school students' self-efficacy in Basic Science in Ondo State when compare with expository method. The significant self-efficacy performance of students' in 5e-cyclic and mental models instructional strategies over expository method it is possible that this is due to the fact that these two instructions gives an opportunity to students to be positive independence, intuitive in reasoning and thinking. Further analysis revealed that there was statistically significant difference between the self-efficacy of students exposed to 5e-cyclic learning strategy and teacher expository method. It also showed that there was statistically significant difference between the self-efficacy of students exposed to mental model and teacher expository method. However, there was no significant difference between the self-efficacy of students exposed to 5E-cyclic learning strategy and mental model learning strategy. This discovery showed more light on earlier discoveries of Tuna and

Kacar [24]; Cheema and Mirza (2013); Ado (2014); Njoroge, Changeiywo, and Ndirangu, (2014); and Seven, Tiryaki and Ceylan (2017) who opined that constructivist teaching strategy is best among the teaching strategies that improve students' science learning outcomes.

5. CONCLUSION AND RECOMMENDATIONS

The study concluded based on the findings of this investigation, that 5e-cyclic and mental models instructional strategies were effective in enhancing students' academic performance and self-efficacy in Basic Science than the expository presentation approach.

Based on the conclusions of this study, the following recommendations were considered relevant:

- Basic Science teachers and educators should adopt 5e-cyclic and mental models strategies as purposeful and efficient instructional strategies and resources in teaching basic concepts so that students could reap the full benefits of active classroom participation.
- Education stakeholders should organize conferences, seminars and workshops for basic science teachers to acquaint them with the use of 5e-cyclic and mental models to improve the process and product of learning science in secondary schools.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Animola OV, Bello TO. Comparative effectiveness of mastery and peer-to-peer learning strategies in improving junior secondary students' learning outcomes in basic science. *Asian Journal of Advanced Research and Reports*. 2019;3(4):1-12. Available:<https://doi.org/10.9734/ajarr/2019/v3i430092>
2. International Council for Science. *Science Education and Capacity Building for Sustainable development*; 2002. Available: <http://www.icu.org/library/WSSD-Rep/Vol15.pdf>.
3. Agboola OS, Oloyede EO. Effects of concept mapping and peer tutoring instructional strategies on learning outcomes of students in chemistry. *Journal of Educational and Social Research*. 2013;3(1):141-150.
4. Odetoyinbo BB. Teacher and factors as correlates of achievement in integrated science. *Journal of Science Teacher Association of Nigeria*. 2004;39(1&2):16-21.
5. Afuwape MO. Integration in science teaching-learning: Problems and prospects. *An International Journal of Science and Technology*. 2012;1(3):126-133
6. Maduabum MA. Strategies of improving the access of girls and women in Science Technology and Mathematics (STM). *Journal of Science Education*. 2011;1(1):11-12.
7. Agboola OS, Olajide SO. Influence of students' feedback on the quality of science teaching among undergraduates in South-West Nigerian Universities. *Journal of Emerging Trends in Educational Research and Policy Studies*. 2015;6(7):229-235.
8. Akinwumi MO, Bello TO. Relative effectiveness of learning-cycle model and inquiry-teaching approaches in improving students' learning outcomes in physics. *Journal of Education and Human Development*. 2015;4(3):169-180.
9. Okigbo EC, Okeke SOC. Effects of games and analogies on students' interest in mathematics. *Journal of Science Teachers Association of Nigeria*. 2010;46(1):20-30.
10. Oluwatosin OB, Bello TO. Comparative effect of mastery learning and mind mapping approaches in improving secondary school students' learning outcomes in physics. *Science Journal of Education*, 2015;4(4):86-92. Available:<https://doi.org/10.11648/j.ijeeedu.20150404.11>
11. Bello TO. Effects of availability and utilization of physics laboratory equipment on students' academic achievement in senior secondary schools' physics. *World Journal of Education*. 2012;2(5):1-7.
12. Jegede SA. Students' anxiety towards the learning of chemistry in some Nigerian

- secondary schools. *Educ. Res. Rev.* 2010;2(7):193-197.
13. Aslam S, Ali MS. Effect of self-efficacy on students' achievement in science: A case of secondary school students in Pakistan. *European Journal of Education Studies.* 2017;3(11):220-235. Available:<https://doi.org/10.5281/zenodo.1050292>
 14. Alebiosu KA, Bilesanmi-Awoderu JB, Oludipe OS. Effectiveness of learning cycle models on Nigerian senior secondary students' anxiety towards chemistry. *British Journal of Education, Society and Behavioural Science.* 2017;21(1):1-13.
 15. Holbrook J. Enhancing scientific and technological literacy(STL): A major focus for science teaching at school. *Journal of Science Teacher Association of Nigeria.* 2011;46(1):9-34.
 16. Bandura A. *Self-efficacy: The exercise of control.* W. H. Freeman and Company; 1997.
 17. Gaumer Erickson AS, Soukup JH, Noonan PM, McGurn L. *Self-efficacy Formative Questionnaire Technical Report;* 2018. Available:<http://www.researchcollaboration.org/uploads/SelfEfficacyQuestionnaireInfo.pdf>
 18. Gaumer Erickson A, Noonan P. *College and career competency (CCC) framework needs assessment.* Lawrence, KS: University of Kansas, center for research on learning; 2016. Available:<http://resources.cccframework.org>
 19. Kupermintz H. Affective and conative factors as aptitude resources in high school science achievement. *Educational Assessment.* 2002;8:123-137.
 20. Eggen P, Kauchak D. *Strategies and models for teachers teaching content and thinking skills (6th ed.).* Boston Pearson; 2012.
 21. O'Brien T. *5E (2) Guidelines for designing research-informed science lesson sequences.* NSTA press; 2013.
 22. Eren C, Omer G. Facilitating conceptual change in understanding state of matter and solubility concepts by using 5e learning cycle model. *Hacettepe University Journal of Education.* 2009;36:41-50.
 23. Balci S, Cakiroglu J, Tekkaya C. Engagement, exploration, explanation, extension and evaluation (5E) learning cycle and conceptual change text as learning tools. *Biochemistry and Molecular Biology Education.* 2006;34:199-203.
 24. Liu TC, Peng H, Wu WH, Lin MS. The effect of mobile natural-science learning based on the 5e learning cycle: A case study. *Educational Technology and Society.* 2009;12(4):344-358.
 25. Tuna A, Kacar A. The effect of 5e learning cycle model in teaching trigonometry on students' academic achievement and the permanence of their knowledge. *International Journal on New Trends in Education and Their Implications.* 2013;4(1):73-87.
 26. Johnson-Laird PN, Byrne RMJ. *Conditionals: A theory of meaning, pragmatics and inference.* *Psychological Review.* 2002;109:646-678.
 27. Ifenthaler D. Scope of graphical indices in educational diagnostics. In N. M. Seel, D. Ifenthaler, & P. N. Pirnay-Dummer (Eds.), *Computer-based diagnostics and systematic analysis of knowledge* 2010:213-234. Springer. Available:<https://doi.org/10.1007/978-1-4419-5662-0>
 28. Aigboimian DO. *Science for all: Implication for the Teacher and National Development.* Ambik Press; 2002.
 29. Bandura A. Guide for constructing self-efficacy scales. In F. Pajares & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents (5th ed., pp. 307-337).* Greenwich, CT: Information Age Publishing; 2006.
 30. Catherine A. Investigating the relationship between science self-efficacy beliefs, gender, and academic achievement, among high school students in Kenya. *Journal of Education and Practice.* 2017;8(8):146-153.
 31. Federal Republic of Nigeria. *National policy on education (7th ed.).* NERDC Press; 2014.
 32. Ginsburg HP, Pappas S. SES, ethnic and gender differences in young children's informal addition and subtraction: A clinical interview investigation. *Applied Developmental Psychology.* 2004;25:171-192.
 33. Gonzalez A, Fernandez MVC, Paoloni PV. Hope and anxiety in physics class: exploring their motivational antecedents and influence on metacognition and performance. *Journal of Research in Science Teaching.* 2017;54(5):558-585.

34. Mallow JV. A science anxiety program. American Journal of Physics. 1978;46:862-870.
35. Mallow JV. Science anxiety: Fear of science and how to overcome it (Revised Eds.). Clearwater: H & H Publications; 1986.
36. Mallow JV. Science anxiety: Research and action. In JJ. Mintzes & W. H. Leonard (Eds.), Handbook of College Science Teaching. National Science Teacher Association Press. 2006:3-14.
37. Maloney EA, Schaeffer MW, Beilock SL. Mathematics anxiety and stereotype threat: Shared mechanisms, negative consequences and promising interventions. Research in Mathematics Education. 2013;15(2):115-128.
38. Nwagbo CR. Level of scientific literacy of secondary school science students: implications for sustainable development in Nigeria. 43rd Annual Conference Proceedings of the Science Teachers' Association of Nigeria. Heinemann Educational Books (Nig); 2002.
39. Nwaiwu NE, Audu B. Influencing factor in female engineering and technical education in Nigeria knowledge review. A Multidisciplinary Journal. 2005;10(1): 8-11.
40. Okeke EAC. Women in science /technology and mathematics education in Nigeria. Keynote Address at the 42nd Annual Conference of STAN; 2001.
41. Taber KS. Learning from experience and teaching by example: reflecting upon personal learning experience to inform teaching practice. Journal of Cambridge Student. 2009;4(1):82-91.
42. Van Merriënboer JJG, Kirschner PA. Ten steps to complex learning: A systematic approach to four-component instructional design. Routledge; 2017.
43. Zeldin AL, Pajares F. Against the odds: Self-efficacy beliefs of women in mathematical, scientific and technological careers. American Educational Research Journal. 2000;37:215–246.

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