

# EFFICACY OF “5Es” INSTRUCTIONAL STRATEGY AND DIAGNOSTIC REMEDIATION ON SENIOR SECONDARY SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT IN BIOLOGY IN ONDO STATE

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## Abstract

*The study investigates the efficacy of '5Es' instructional strategy and diagnostic remediation (DR) on senior secondary school students' academic achievement in Biology in Ondo State. The study adopted a quasi-experimental non-randomized pre-test, post-test, and control group design involving two experimental groups ('5Es' Instructional Strategy and Diagnostic Remediation); and the Conventional Group as the control). The sample consisted of 90 senior secondary school one students assigned to the treatment and the control groups. Data were collected using the Biology Achievement Test ( $r=0.79$ ), Data were analyzed using descriptive statistics to answer research questions and inferential statistics to test research hypotheses at the 0.05 alpha level. The findings revealed a significant difference in achievement between the experimental and the control group., ( $F_{cal} 4.982, p<0.05$ ); a significant difference was found in the achievement of male and female experimental groups in '5Es' Instructional Strategy ( $t_{cal} 3.164 p<0.05$ ); and Diagnostic Remediation ( $t_{cal} 2.392, p<0.05$ ). Based on findings, it was concluded that '5Es' Instructional Strategy and Diagnostic Remediation are more effective on students' academic achievement than the conventional method ('5Es' > DR > CR), hence, teachers should engage in using '5Es' Instructional Strategy and Diagnostic Remediation for teaching biology to help students learn more, retain more, and apply what is learnt.*

**Keywords:** Biology, '5Es' instructional strategy, diagnostic remediation, conventional method.

## Introduction

Education involves the activities and experiences put together to assist in the all-round development of the learners. Education makes learners think clearly and independently, gain an understanding of people, and of the society in which they live. It is a process of imparting knowledge, values, technological skills, and positive attitudes to the learners. This will make them responsible and be able to contribute positively to the development of the community. To fully realize the potential contributions of education to the achievement of the goals, the Federal Government of Nigeria took various measures to ensure proper implementation of the education policy at the secondary level of education. These measures included learner-centered educational activities for maximum self-development and fulfilment, activity-based practical teachings, support of experimental teachings, information technology, and relatedness of education to overall community needs (FRN, 2013). Generally, Education can be described as a conscious and systematic process of development of a whole human person, physically, socially, morally, intellectually, and emotionally. Thus, education viewed from this perspective requires an organized form of curriculum that enables the achievement of pre-set educational goals and targets. In a broad sense, Nwobodo (2012) described Education as all those experiences of the individual through which knowledge is acquired, the intellect is enlightened, or the will is strengthened. According to him, this form of Education is found in those activities that help to inform our worldviews, and help us to be integrated into our own community. The Nigerian revised National Policy on Education (FRN, 2008) stated that the need for scientific and technological progress of Nigeria as a nation necessitates the inculcation of the spirit of enquiry in the child through the exploration of nature and the local environment. In addition, the policy emphasizes the goals of science education to include the development of scientific literacy in the citizenry.

Science education is the foundation for sustainable national development by protecting human societies from ignorance, illiteracy, disease and poverty. Science education has been identified as one of the major bedrocks for the sustainable development of our country, which is seen as knowledge or ideas acquisition relevant to science (Nnamdi, 2014). Science education as a field of study is therefore in dire need of methods with qualities such as lesson clarity, promotion of self-activity, promotion of self-development, stimulation of interest and curiosity, and relying on the psychological process of teaching and learning to recommend to science teachers. The methods should encourage science teaching and learning that is better than it is now. Uza (2014), defined science as cumulative, verifiable, and communicative knowledge. According to Akase, Mwekaven, Awuhe, and Tombuwa (2015), pure science is the investigation of nature to satisfy the need to know, while applied science is the application of pure science to solve practical human needs. Science is the investigation of matter with a view to understanding and harnessing to serve human needs (Okoro, 2013). The methods of producing true knowledge were those which distinguished science from other kinds of knowledge; observation, accuracy, induction, proofs, deduction, etc. are the key terms of the debate. From the above definitions, science can be regarded as a way of thinking in the pursuit of understanding nature and a way of investigating a body of established knowledge.

Biology is concerned with the study of life and living organisms, including their structures, function, growth, evolution, distribution and taxonomy. The study of the origin of disease and plagues is also answerable by means of biology. For example, the etiology of cancer, infections, functional problems, the damage to fish, the pathologies of farm animals and plant trees, etc. can be understood by the study of Biology. Food resources and quality, factors that cause illness, plagues, sustainable exploitation of natural resources, the enhancement of useful species, the discovery and production of medicines, the study of the functions of living organisms and their inheritance, etc. are all fields of resources linked to biology.

Moreover, biology is a subject that engages the students in various process skills such as observation, clarifying, interpreting, predicting events, designing experiments, organizing information, and reporting adequately. One primary function of biology teaching is to help the students understand the subject, its concepts, principles, theories and laws. There is a need to continue to search for better ways of teaching the subject to improve students' academic achievement at both internal and external examinations and realize the nation's educational objectives. Research studies have pointed out some factors that may be responsible for low achievements of students in biology. The most common factors in the literature are teaching methods and strategies, students' negative attitude towards biology, large class size, lack of resources such as textbooks and other teaching and learning materials, difficult concepts, inadequate laboratory and teacher qualification among others (Irinoye, Bamidele, Adetunji, & Awodele, 2015).

Most exciting studies suggesting ways and means of addressing the problem of poor achievement among senior secondary school biology students tend to focus more on teaching methods than on students' learning. Biology scholars and researchers, concerned that science delivery in many schools is often too boring, have been trying out ways to help students understand biology better and reduce gender disparity in learning science. Therefore, in order to have a perspective that will lead to better results, science students at all levels should be given quality education through the use of viable, result-oriented modes of instruction that will provoke learners' interest, equip learners with the appropriate knowledge and attitude towards biology and science as a whole. Teachers should also make use of appropriate teaching and learning strategies that can help relate the novel abstract biology concepts to the concrete existing biology knowledge. Biology teachers must therefore make frantic efforts to create an ideal environment for teaching and learning to take place. This means teachers need to present ideas in ways that are authentic representations of the scientific concepts, yet simple enough to be meaningfully understood by the learners. Another major area of

concern is students' ability to solve real-life problems with knowledge gained in the classroom and also transfer procedures learned to the work environment. One of the major goals of science education according to the National Policy on Education (Federal Republic of Nigeria, 2015) is to enable students to become productive, well-rounded, self-reliant and self-regulated citizens who contribute to the well-being of themselves, their families, and the communities in which they live. It is therefore expected that science teachers should not only teach students mastery of knowledge for immediate use in the classroom but also teach students to transfer the acquired learning to other subject areas and novel situations; and further impress upon students to use the learned information outside of class in their everyday lives and in the future. Academic achievement is the extent to which learners have gained from a particular course of instruction. It is the measure of what a person has accomplished after exposure to an educational programme, as said by Lucy (2015). Achievement has to do with attainment of the set objectives in instruction. Udoguas cited in Neji and Joda (2016) asserted that academic achievement is the attainment of set objectives measured from the score obtained through a test. Thus, the success of science teaching and learning is dependent on the learners' ability to achieve and recall prescribed concepts meaningfully.

The conventional teaching method is an organized verbal presentation of subject matter where the presenter dominates the exercise for a long period with or without the students' involvement. The teacher controls the instructional process, the content is delivered to the entire class, and the teacher tends to emphasize factual knowledge. In other words, the teacher delivers the lecture content, and the students listen to the lecture. This method allows a great deal of information to be passed to the learner and favour handling of large classes. By this method, the teacher organizes resources, prepares an outline, and presents the lecture, while the students are made to listen. This method is not adequate to teach science today; many scholars and researchers have proposed

advanced ideas and virtual teaching scenarios or simulations that help to build a better understanding of science amongst students. Various innovative methods of teaching science abound (Edsys, 2018), and these include role play, visual class, '5Es' instructional strategy, diagnostic remediation, laboratory work, demonstration method, science games, and Hands-on learning, where students actively participate in experiencing scientific concepts rather than just having an audience view. This conventional teaching approach is one of the reasons discovered for poor performance, it is teacher-centered, which encourages rote learning or memorization (Adeyemi, 2008). It usually involves the teacher starting the lesson by introducing the topic or the concept, explaining it, and then giving some work or examples. This method of teaching has been criticized on the grounds that students are not able to think creatively, innovatively and critically since they perceivably receive what has been taught to them. Nebo (2012) stated that conventional method of teaching has failed to recognize the uniqueness of the inquiry-based nature of the learner's individuality thus failed to encourage creative thinking in the learner leading to poor achievement in students. Based on this, educators and scholars are challenged to seek for an intervention or innovative methods that would enhance the academic achievement of students in the school subjects in which learning experiences will be sequenced, students will have the opportunity to have a deeper understanding of the concepts, boredom will be removed, they will be actively involved in their learning, and individual differences will be considered.

The '5Es' learning cycle allows students and teachers to experience common activities, to use and build on prior knowledge and experience, to construct meaning and to continually assess their understanding of a concept. It is an inquiry-based teaching approach, a constructivist-oriented strategy where students are involved in experimenting, questioning, and investigating. This was credited to Rodger Bybee, who developed the '5Es' model (Bybee, Taylor, Gardner, Scotter, Powell, Westbrook, & Landes, 2006). The '5Es' learning cycle model sequences learning experiences so that students

have the opportunity to construct their understanding of a concept during the teaching and learning process (Bybee, 2002). The model leads students through five stages or phases of learning that are easily described using words that begin with the letter E: Engagement, Exploration, Explanation, Elaboration and Evaluation. In the Engagement phase, the teacher captures students' interest and makes them curious about the topic and concepts to be learnt. This phase provides an opportunity for the teacher to find out what students already know or think they know about the topic and concepts to be developed (Bybee, 2002). In the Exploration phase, students interact with materials and ideas through classroom and small group discussions (Llewellyn, 2005). This helps the students to acquire a common set of experiences so that they can compare results and ideas with their classmates. In the Explanation phase, students are provided an opportunity to connect their prior experiences with current learning and to make conceptual sense of the main ideas. This phase also provides the opportunity for the introduction of formal language, scientific terms, and content information that might make students' prior experiences easier to describe. In the Elaboration phase, students are provided with the opportunity to apply introduced concepts to new experiences (Llewellyn, 2005). This phase helps students to make conceptual connections between new and prior experiences, connect ideas and deepen their understanding of concepts and processes. The Evaluation phase which is centrally placed in the model, takes place virtually in every phase of the 5Es teaching cycle and provides a summative assessment of what students know (Bybee, 2002).

Diagnostic remediation is a process that enables a teacher to state the objectives of a concept to be taught, does a pre-assessment before teaching the concept, and thereafter carries out a diagnosis to the concept to enable the student to acquire optimal learning outcomes. Diagnostic remediation is concerned with the evaluation of students' learning difficulties during instruction. A diagnostic test is used to diagnose or to reveal an individual's weakness of a student in a given course of instruction and then suggest remedial measures. As a

doctor, diagnosis is supplemented by remedy; if not, it is worthless, and the same applies to the field of education. Students are the patients that must be diagnosed for the treatment of learning ailments. When a student is not doing well, there is a need to embark on a detailed diagnosis of the student's learning problem through diagnostic testing; this will enable the teacher to determine the nature and the cause of the student's learning difficulty with the purpose of correcting and remedying the difficulty involved.

Diagnostic remediation teaching is an individual difference instructional approach whereby weak students can be identified and helped by the teacher. If problems and difficulties are diagnosed from the product of students' performance through a survey test or from the teachers' observation and that if effective use of teachers' remediation on the students is accomplished, performance in biology will improve.

Gender refers to a social/cultural construction that assigns roles and values considered appropriate for each sex. Gender disparity as it exists in the schools either on the part of the students or the teacher has great influence on student attitudes towards any given subject (Nworgu, 2013). Gender differences in achievement have been examined for some time, resulting in a substantial body of literature. Mohammad (2015), Omwirhien (2015), Dorine, Peter and Philip (2018), and Ogundola, et.al, (2020). Some of these researchers pointed out that there is no significant gender difference in students' academic achievement in various subjects, while others found significant differences with either the males or the females performing better. So many factors contribute to the varied conclusions arrived at by all researchers. Some such factors include the campaign for, understanding, and implementation of gender equality in the study area. Another reason for the varied conclusions is the subject on which gender equality is being measured. For example, there has been global concern about gender differences in students' performance in basic science, and some research has been undertaken in many parts of the globe in this respect. Pulat, (2009) in

a study investigated the impact of '5Es' learning cycle on sixth-grade students' mathematics achievement and attitudes toward mathematics. The study was carried out in a public school in one of the towns of the Central Anatolia Region with 28 sixth-grade elementary school students. The study found that there was a statistically significant change in the mathematics achievement of sixth-grade students who participated in the instruction based on '5Es' learning cycle over three time periods (pre-intervention, post-intervention, and follow-up). Bunkure, (2012), in his own contribution, launched a study seeking to investigate the effects of constructivist instructional strategy using '5Es' teaching model on the academic achievement, retention, and attitude to physics among Science Secondary School Students of varied ability levels in Kano State. The results show that students exposed to the constructivist 5Es instructional strategy achieved, retained the learnt concepts, and developed a more positive attitude to physics than their counterparts exposed to the conventional method of teaching. It was also concluded that there was no significant difference in students' achievement with reference to gender.

In a related development, Shittu (2013), carried out a study on the effects of guided inquiry strategy on learning outcomes of low-achieving secondary school physics students using '5Es' teaching cycle model in Kaduna metropolis. He found that low ability students taught using inquiring method in physics concept achieved significantly higher than those taught using lecture method. Njoroge, Changeiywo, and Ndirangu, (2014) in a separate study investigated the effects of an inquiry-based teaching approach using '5Es' learning cycle on secondary school students' performance and motivation in Physics in Nyeri County, Kenya. The findings of the study showed that the Inquiry-Based Teaching (IBT) approach resulted in higher students' scores in achievement in Physics. Ado, (2014), in a related development, investigated the impact of constructivist teaching strategy using '5Es' teaching model on academic performance, retention, and attitude towards trigonometry among Senior School Students in Kaduna State. The results showed significant differences

The sample was made up of 90 SSS1 students. One research instrument was prepared for the study titled: Biology Achievement Test (BAT) as pre and post-tests. The Biology Achievement Test (BAT) consisted of two sections: A and B. Section A obtained demographic information of respondents, while Section B contained 40 multiple-choice objective items with four options each. The items were drawn from both WAEC and NECO past questions and covered two Biology Concepts-Photosynthesis and Cellular Respiration which were taught over a period of six weeks using the 5Es instructional strategy and Diagnostic Remediation for the experimental groups and the conventional method for the control group. Reliability of the instrument was established using the test-retest method yielding a reliability coefficient of 0.79. The results of the finding were analyzed using the mean, standard deviation and ANOVA statistic at 0.05 level of significance.

## Results

### Research Question

1. Will there be any difference in the students' mean achievement scores in the '5Es', DR and the Control group after treatment?

**Table 1: Summary of the descriptive statistics on students' mean achievement scores for the '5Es', DR and the control group after treatment.**

| Instructional Strategy | N  | Pre-test | S.D.  | Post-test | S.D.  | Mean Gain |
|------------------------|----|----------|-------|-----------|-------|-----------|
| '5Es'                  | 30 | 11.55    | 1.906 | 16.40     | 4.36  | 4.85      |
| DR                     | 30 | 11.47    | 3.082 | 15.90     | 3.540 | 4.43      |
| Control                | 30 | 11.07    | 3.028 | 13.73     | 3.279 | 2.66      |

The result in table 1 shows that there was a difference in the mean pretest and post-test scores of students in the three groups after the teaching which indicated that learning actually took place in all the three groups. Students' academic achievement scores increased across the three groups as indicated by the differences in their pre-test and posttest scores. However, students in the '5Es' group had the

highest mean post-test score of 16.40 while students in the DR group had post-test mean score of 15.90. Students in the conventional group however performed lesser than those in the '5Es' and DR groups with a mean post-test score of 13.73. It was also revealed from the table that the '5Es' group had the highest mean gain of 4.85, the DR group had 4.43 while the control group had the least mean gain of 2.66.

## Hypotheses

**Hypothesis one:** There is no significant difference in the mean achievement scores of students exposed to '5Es' DR and the conventional method.

**Table 2: Summary of ANOVA on the mean achievement scores of students exposed to 5Es, DR and the conventional method.**

| Variables      | Sum of Squares | df | Mean Square | F     | Sig   |
|----------------|----------------|----|-------------|-------|-------|
| Between Groups | 140.467        | 2  | 70.233      | 4.982 | 0.009 |
| Within Groups  | 1226.433       | 87 | 14.097      |       |       |
| Total          | 1366.900       | 89 |             |       |       |
| P < 0.05       |                |    |             |       |       |

The result in table 2 shows that the significant value is 0.009. This implies that a significant difference occurred between the mean achievement scores of students in the three groups.  $F_{cal} 4.982 p < 0.05$ . Hypothesis 1 which states that there is no significant difference in the mean achievement scores of students exposed to 5Es, DR and the control group is therefore rejected.

## Hypothesis 2

There is no significant difference in the mean achievement scores of male and female students when exposed to '5Es'.

in the mean scores of experimental and control groups in academic performance, retention ability, and attitude. The results also showed gender differences in academic performance. Betts, Hahn, & Zau, (2015) carried out a study to find out if diagnostic mathematics testing improves student learning. The authors of Betts et. al. study examined how both the voluntary use of mathematics diagnostic test (MDT) by separate teachers and compulsory testing by the San Diego Unified School District (SDUSD), California affect the mathematics achievement of students in California, USA. The authors found that mandatory use of MDT boosts students' scores from the 50<sup>th</sup> percentile to somewhere between the 54.6th and 57th percentile. Also, Ofem, Idika, & Ovat, (2017) examined the influence of diagnostic and feedback evaluation methods in improving secondary school students' achievement in mathematics. The result of the data analysis revealed that diagnostic and feedback evaluation methods enhance achievement in Mathematics. Ridgeway (2004) reported the outcome of her research using the interactive-lecture strategy and lecture-and-note method when teaching three units in evolution. She found no appreciable change in the mean achievement scores of students with varying ability levels between the experimental and the control groups.

## Theoretical Framework

This study is based on three theories. First is the Theory of Constructivism developed by John Dewey in the 1920s and 1930s, a philosophy of learning founded on the premise that by reflecting on our experiences we construct our own understanding of the world we live in. Constructivism is a philosophy about learning that proposes that learners build their own understanding of new ideas during teaching and learning. Constructivist theory is one of the contemporary learning theories that emerged from the philosophical basis that the teacher's role should be trainer, facilitator of the learning process, and creator of an educational environment. While the role of the learner is characterized by activity, positive innovation, leading to discovery of knowledge, self-understanding, through discussion with others, and keeping away from memorization (Abu-

Safar 2014). As a constructivist-based teaching and learning model, '5Es' model targets discovery and the connection of new concepts with students (Tuna and Kacar, 2013). The model is found to motivate students to be involved in a topic, to explore and to obtain more detailed information about their learning and to evaluate it. The '5Es' Instructional strategy /Learning cycle as a constructivist model motivates research-based learning, brainstorming, and creative thinking, complex for overcoming problems and difficulties and therefore can facilitate teaching and learning of difficult concepts in biology.

Second is the Theory of Lev Vygotsky's Social Constructivism, which states that children are drawn into cognitive activities when active participation in the learning is required. Social constructivists believe that the knowledge construction process is influenced by social interactions. Moreover, with respect to Vygotsky's theory, social interaction is essential for learners to internalize new or difficult understandings, problems, and processes. Notable among Lev Vygotsky's socio-cultural theories is the theory of the Zone of Proximal Development (ZPD), which is achieved by a student through the guidance of a teacher and peers Cope (2012).

The third is based on the theory of Gagne (1977) "Learning prerequisite". Gagne also maintains that learning should be sequenced in the order of "simple to complex" i.e., learners should have the necessary prerequisite to acquire new information. This also means that learning must follow a good sequencing such that a learner follows developmental tasks in stages till a final terminal behaviour is reached.

### **Statement of the Problem**

Biology is one of the key science subjects and it is central to many science- related courses such as medicine, pharmacy, nursing, and biochemistry to mention a few. Despite its importance, it is observed that students' performance in the subject is still not yet at its best. Students generally perceive the subject as conceptually difficult,

wide, and probably suitable for the talented ones. Over the years, it is observed that the teaching of science and particularly biology has been based on the lecture method, in which information is organized and presented to students, which can be boring, and this views science as a collection of an organized body of information about the natural world. This has failed to recognize the uniqueness of the inquiry- based nature of the learners, thus, failing to encourage creative, innovative, and critical thinking in learners. The results of students in this subject area as measured by their grades in the Senior School Certificate Examinations have not shown any significant improvement over the years. It is observed that Biology teachers show a near-empty knowledge of the '5Es' learning cycle and its application in teaching. This therefore calls for a change in the transmission method of presenting science to students to allow them to interact with the natural world to create knowledge. The situation therefore calls for educating science teachers on the procedures of the '5Es' learning cycle and its demonstration in science teaching and learning. This is an instructional strategy that has five different phases of Engagement, Exploration, Explanation, Elaboration and Evaluation. Observations in Nigerian schools have also revealed that it appears in teaching and learning of biology in schools, teachers have been testing students and moving to the next topic without any regard to whether students have understood the concept being taught. Scripts are marked, and scores awarded, but no conscious attempt is made to confirm whether students have learnt. What is done in the form of remediation is just general revision, giving of assignments without any attempt to diagnose the detailed areas of weakness and strength of the individual students, which could be used by the teacher to remediate the concept before moving to the next concept. These are considered, as problems that have necessitated this study. Therefore, the researcher investigated if learner-centered instructional strategies such as the '5Es' instructional strategy and diagnostic remediation will enhance students' academic achievement in biology, since a major concern of education has been to find ways in which students may learn most effectively and efficiently. This study, therefore, is designed to investigate the efficacy of '5Es'

instructional strategy and diagnostic remediation in enhancing students' academic achievement in secondary school biology in Ondo State.

### Purpose of the Study

The purpose of this study is to investigate;

- a. the efficacy of '5Es' instructional strategy and diagnostic remediation on students' academic achievement in senior secondary school biology
- b. the efficacy of '5Es' instructional strategy and diagnostic remediation on the academic achievement of male and female students.

### Research Question

1. Will there be any difference in the students' mean achievement scores in the '5Es', DR, and the control group after treatment?

### Hypotheses

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

- Ho1: There is no significant difference in the mean achievement scores of students exposed to '5Es', DR and the conventional method.
- Ho2: There is no significant difference in the mean achievement scores of male and female students when exposed to '5Es'.
- Ho3: There is no significant difference in the mean achievement scores of male and female students when exposed to DR.

### Methodology

The study employed a 3x2 pretest posttest control group quasi experimental design. This design consisted of two experimental groups (5Es instructional strategy and Diagnostic Remediation) and the control group. There were pretest and posttest. The population of the study consisted of all senior secondary school one (SSS1) Biology students in the 304 public secondary schools in Ondo State.

**Table 3: Summary of t-test on mean achievement scores of male and female students exposed to '5Es'.**

| Gender   | N  | Mean  | S.D.  | Df | t-cal | P     |
|----------|----|-------|-------|----|-------|-------|
| Male     | 15 | 18.60 | 4.102 | 28 | 3.164 | 0.004 |
| Female   | 15 | 14.20 | 3.489 |    |       |       |
| P < 0.05 |    |       |       |    |       |       |

The result in Table 3 shows that the t-cal value of 3.164 is significant because the p value (0.004) < 0.05, thus the null hypothesis is rejected. Hence, there is significant difference in the mean achievement scores of male and female students exposed to '5Es' instructional strategy in biology. The male students performed better than their female counterparts.

### Hypothesis 3

There is no significant difference in the mean achievement scores of male and female students when exposed to DR.

**Table 4: Summary of t-test on mean achievement scores of male and female students exposed to DR.**

| Gender   | N  | Mean  | S.D.  | Df | t-cal | P     |
|----------|----|-------|-------|----|-------|-------|
| Male     | 15 | 12.33 | 2.225 | 28 | 2.392 | 0.024 |
| Female   | 15 | 15.20 | 4.074 |    |       |       |
| P < 0.05 |    |       |       |    |       |       |

The result in Table 4 shows that the t-cal value of 2.392 is significant because the p value (0.024) < 0.05, thus the null hypothesis is rejected. Hence, there is significant difference in the mean achievement scores of male and female students exposed to diagnostic remediation in biology. The female students achieved better than their male counterparts. This shows the greater commitment of the females to experience the new technique of learning.

## Discussion of Findings

After the presentation and analysis of the above data on the efficacy of '5Es' instructional strategy and diagnostic remediation on senior secondary school students' academic achievement in biology in Ondo State, some findings were made. The findings revealed that there was a significant difference in the mean achievement scores of students when exposed to '5Es', DR, and the conventional method. The significant difference found was likely due to the use of '5Es' instructional strategy, an activity- oriented method, and diagnostic remediation- an individual difference instructional approach where students are actively involved in their learning. Since the '5Es' learning cycle was a student-centered and novel approach, students might believe the activities that were used in the '5Es' were interesting and useful. This also revealed that the strategy is good for teaching biology.

The result confirms earlier findings of Pulat (2009), Bunkure, 2012, Shitu 2013, Ado, (2014), and Njoroge, Changeiwo, and Ndirangu (2014), who found that students exposed to the inquiry method using '5Es' learning cycle performed significantly better in the experimental groups than those in the control group. The study contradicts that of Ridgeway (2004), who found no significant difference in the mean achievement scores of students in the experimental and control group when taught with '5Es' learning cycle using the inquiry method. This result is consistent with the findings by Betts, Hahn, & Zau (2015), who reported that if a student is given a mathematics diagnostic test (MDT) two years in a row, the achievement of the student a year after the first test is strengthened in the second year. This corroborates the findings of Ofem, Idika, & Ovat (2017), who reported in a study investigating the influence of diagnostic and feedback evaluation methods in secondary school students' achievement in mathematics, that the result of the data analysis revealed that diagnostic and feedback evaluation methods enhance achievement in mathematics. The findings show that there was a significant difference in the mean achievement scores of male and female students when exposed to '5Es'. A significant difference

was found in the mean achievement scores of male and female students in favour of the males, this shows the greater commitment of the males to experience the new techniques of learning and it implies that in respect to gender difference, there is significant difference between the male and the female students exposed to '5Es' instructional strategy. The study is in agreement with that of Omwirhiren (2015), Dorine, Peter and Philip (2018), Adodo and Olatunbosun (2019) and Ogundola, et al, (2020), who reported a significant difference in achievement based on gender in favour of the male students. The finding contradicts with the finding of Muhammad (2015) where it was found that there is significant difference with respect to gender in favour of female students. The findings also showed that a significant difference was found in the mean achievement scores of male and female students exposed to DR in favour of the females. The finding is in line with Muhammad (2015) where it was found that there is a significant difference with respect to gender in favour of female students. It contradicts the results from Omwirhiren (2015), Dorine, Peter and Philip (2018) and Ogundola, et al, (2020) who reported a significant difference in achievement based on gender in favour of the male students. Contrasting results from Ajayi and Ogbeba (2017) in separate studies reported that gender does not affect students' achievement in science.

## Conclusion

1. The '5Es' instructional strategy and diagnostic remediation had a significant effect on the students' academic achievement in biology. In other words, the more effective the instructional strategy employed by the teacher, the greater the impact on the students because it helps them to learn more, retain more and apply what is learnt.
2. A statistically significant difference was observed in the achievement between the experimental groups and the control group.
3. A significant difference was found in the achievement of male and female students taught using the '5Es' instructional strategy and diagnostic remediation.

## Recommendations

Based on the findings of this study, the following recommendations are made:

1. Innovative instructional strategies such as the 5Es instructional strategy and diagnostic remediation should be adopted in the teaching of biology in secondary schools. This is because these approaches reduce boredom, increase students' engagement, and make the learning process more interactive, meaningful, and student-centred.
2. Government, school administrators, and relevant educational stakeholders should organize regular seminars, workshops, and training programs for biology teachers. These programs should focus on equipping teachers with modern instructional skills and strategies, particularly the 5Es instructional strategy, diagnostic remediation, and other learner-centred approaches that enhance effective teaching and improve students' academic achievement.
3. Biology teaching should be structured in a way that promotes active student participation at all stages of the learning process. Students should not be passive recipients of information but active participants who engage in exploration, discussion, experimentation, and evaluation of concepts. This will help develop their critical thinking skills, improve understanding of abstract concepts, and increase overall academic achievement in Biology.

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