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# Efficacy of Science Writing Heuristic Instructional Approach on Senior Secondary School Students' Academic Achievement in Biology

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**ABSTRACT**

This research study investigated the efficacy of science writing heuristic (SWH) approach on students' achievement in biology. A non-equivalent control group quasi-experimental design was adopted for the study. A sample of 141 Senior Secondary year one students which comprises 57 males and 84 females drawn from four intact classes in two public co-educational secondary schools were used for the study. The experimental groups and control groups were taught using SWH approach and traditional laboratory (TL) approach respectively. Instrument used for collection of data was BAT (Biology Achievement Test) which was subjected to a reliability test using Kuder-Richardson's formula (KR-20) and a reliability index of 0.92 was obtained. Mean and standard deviation was used to answer the research questions while ANCOVA (Analysis of Covariance) was employed to test the hypothesis at 0.05 level of significance. The findings of this study revealed that the SWH approach was more efficacious in enhancing the achievement of students in Biology than the TL approach. The findings of this study also showed that the male students achieved slightly higher than the female students when taught with the SWH approach. Moreso, there was a significant interaction effect of gender and mode of instruction on achievement of students. It was recommended that Biology teachers should employ the use of SWH approach rather than the traditional laboratory approach in carrying out practical in biology to enhance students' achievement in Biology.

***Keywords:*** *Science Writing Heuristic Approach, Traditional Laboratory Approach, Achievement, Gender.*

## 1. INTRODUCTION

### *Research background and problem*

The technological development of a nation greatly depends on its level of education and scientific knowledge that has been acquired by her citizens. Through science and education, a society reproduces itself by passing on its quality and ideology to younger generations. Science, therefore, is receiving much emphasis in education because of its significance and relevance to life and society (Akinwumi & Falemu, 2020). Biology is a science subject that is essential for a nation's advancement. It is an integral part of science that encompasses the study of living organisms, their functions, structures and interrelationships. Biology is a science subject which aims at equipping students with appropriate scientific skills, attitudes, competences and ability to apply scientific knowledge to every challenge of life (Ezekiel, Yilshik & Joseph, 2021). Biology is a subject occupying a unique position in the secondary school core curriculum because of its importance; as the science of life.

In Nigeria, the secondary school Biology curriculum is structured to expose students to investigating natural phenomena further, deepen students' understanding and interest in biological sciences and encourage students' ability to apply scientific knowledge to solve everyday personal life problems, community, health and agriculture among others (Federal Ministry of Education, 2013). Biology is a foundational subject for many fields of study like Dentistry, Nursing, Public health, Genetics, Microbiology and Biochemistry which significantly contributes to the advancement in a nation's economy and technology. Bearing in mind these importance of Biology, students are expected to become responsible and contributing members of society. To attain this, the teaching approach implored by teachers in the learning of Biology should expose students to hands-on activities. Hence, students take responsibility and control of their acquisition of skills and knowledge which can be acquired through students' active involvement in Practical activities.

Practical activities through experiment and observation give students an understanding of how biological knowledge is generated. According to Ogundipe (2013), practical activities should engage students in hands-on and mind-on activities to help drive the lesson home. This implies that practical activities extend students' knowledge and understanding of Biology and enable them apply it in novel investigative situations. Practical activities offer a rich avenue for students to make meaning from observations and findings deduced from hands-on engagements (Taale et al., 2018). This in turn develops scientific thinking, basic manipulative and problem-solving skills in students. It is about engaging students in the reasoning processes, rather than merely memorizing concepts and doing experiments following teachers' instructions (Tseng, 2014).

Environmental and economic challenges of the modern world require the application of one's theoretical knowledge to solve real-life practical problems. Practical activity fosters the theory students must have learnt hence, prepare students for adult life. It enables students to appreciate how theories are generated from research and also do what real scientists do. Good research skills in students are formed through doing practical work. Nwagbo and Chukelu (2011) asserted that practical activities in biology provide opportunities for students to do science as opposed to learning about science. Despite the importance of practical activities, there are still challenges facing practical activities in Nigerian schools. According to Peter and Dickson (2014), some of the challenges faced in secondary schools include learners' poor understanding of practical concepts, inadequate practical guides and materials, poorly equipped laboratories, untrained laboratory technicians, inadequate allocation of time to practical, poor funds allocation for purchase and maintenance of laboratory equipment and so on. Based on these challenges, teachers' approaches to carrying out practical activities have been poor and not been yielding very good results. The above assertion about practical Biology shows that it could help in enhancing academic achievement in students.

Academic achievement in students is the extent to which students in a particular course of instruction have gained. It is the students' internalization of what has been taught and this can be demonstrated by the scores of students when tested. The expected outcome at the end of an examination which could be due to the use of effective instructional approaches in the process of teaching and learning is called achievement. Studies have shown that Biology teachers do not always employ effective instructional approaches in teaching the subject and this has constantly led to poor achievement in Biology (Okoyefi, 2014 & Enebechi, 2016). Statistics from the West African Examinations Council (WAEC, 2017, 2018, 2019) revealed that achievement in Biology in the May/June examinations has not been encouraging. Engaging students in real practical activities may enable students to experience firsthand science situations which could help enhance students' achievement in Biology. Niklas, Per & Johan (2023) stated that, the main purpose of practical activities is to promote conceptual knowledge and science learning in students to help them learn scientific concepts using scientific methods and research procedures. However, this may not be the case in most secondary schools because biology teachers usually employ the traditional laboratory approach.

The traditional laboratory approach is the most used approach in Nigeria for conducting Practical Biology. This approach entails students having to observe and follow instructions designed and given by their teachers. According to Maria, Salim, Marjan, Joe & Lisa (2013), the traditional laboratory approach will provide the students with all of the steps they need to take to complete the practical and this does not engage them in the experimental design process. Sheila, Gilbeth and Mageswary (2016) believes that SWH encourages students to be actively engaged in the laboratory activities such as utilizing investigative experiments which are likened to how scientists work rather than using the traditional discourse of confirmations of known facts. Some scientists use a traditional laboratory report format consisting of hypothesis, procedure, observations, results, and discussion when reporting the results of their research. However, this structure does not necessarily represent the actual process that real scientists go through in terms of the negotiations and debates that naturally occur during research; therefore, this type of approach may ignore or hinder students' from participating actively in science inquiry.

Researchers have tried to find a solution to the problem associated with students' passive participation in practical activities which leads to poor achievement by using different innovative methods and materials. Researchers such as Okoyefi (2014), Cengiz (2010), Bajon (2015) have tried the use of innovative strategies like the four mode application techniques, visual laboratory and mode of laboratory work on students respectively, yet poor achievement in practical biology still persist. This could be due to the fact that, these activity-based approaches used do not require that students be actively engaged in thinking through by posing their own questions, building up arguments for scientific claims and examining how their ideas have changed through reflective arguments. Therefore, the Science Writing Heuristic approach is another innovative approach to

science practicals that has been scarcely researched in Nigeria and could supply these requirements.

Hand and Keys of the University of Iowa was the first to develop Science Writing Heuristic (SWH) , an argument-based inquiry approach in 1999. SWH is a tool that helps in transforming students' thinking through the transformation of the science classroom. In the SWH approach, teachers tend to move away from the verification laboratories and memorization of facts towards the kind of activities, conversations and writing that real scientists do. The SWH approach, enables students to generate an argument as part of their work, and provides a structured framework for implementing inquiry-based activities through the use of reasoning and critical-thinking skills. According to Hand, (2008), students need these skills to negotiate meaning throughout the inquiry process so as to enable the students to construct rich understandings of the context. The author also stated that to bridge the gap between new learning and prior knowledge, it is important to write laboratory reports. The format of a traditional laboratory approach, requires students to fill in a standard report in which students complete sections which include; title of experiment, purpose of experiment, procedure for the experiment, data collected and discussion of results. This is likened to students' verifying science concepts which have been explained to them already. Whereas in SWH approach, it entails students being prompted to describe the experimental procedure by formulating their own research questions, reporting their findings, and setting up the claims and evidence gathered. The students then negotiate or analyze other sources of additional information and finally, they reflect the scientific topics based on their own ideas about.

In using the SWH student laboratory report template, it encourages students to use textbooks, internet and different resources to compare their findings with others (Hand, Wallace, Prain, & Collins, 1999). In the SWH argument-based inquiry approach, the learners engage in discussions or arguments on the things they observed and their findings from experimental data collected. It is such that students engage in critical thinking and evidence is transformed into knowledgeable claims which are parallel to the writing and reasoning of scientists. SWH approach could influence students' achievement due to the kind of activities involved in carrying out these practicals irrespective of the students' gender.

Researchers view issues on gender and academic achievement as very important. Gender is a social position and cultural construct which members of the society attach to being female or male. The concept of gender is the expectations held about the characteristics, attitudes and likely behaviour of both men and women (masculinity and femininity) in society (Ezeh, 2013). According to Okoyefi (2014), it is a social or cultural determinant that varies from place to place or culture to culture. Studies by Ogunleye and Babajide (2011) lend credence to significant gender effect in science achievement. In Nigeria, even within the science classroom, bias in gender status still prevails and persists. In the educational setting for instance, experience has shown that the curriculum, textbooks and the teaching materials tend to favour males and the females' intellectual potentials are ignored (Bajon, 2015). To account for differences in male and female students' achievement in science subjects, there are some identified factors by researchers. For instance, Idaa and Ugbede (2019) identified gender stereotyping that has brought discrimination in academic achievement which is a matter of great concern to educationists. Bajon (2015) examined the effect of mode of laboratory work on senior secondary school students' achievement in Biology and the results revealed that male students had higher mean achievement scores than their female counterparts. Also, a study by Ugwu and Nzewi (2015) on the effects of two instructional delivery approaches on students' achievement in Biology showed that male students achieved higher than the female students in Biology. Studies by Okoyefi (2014) and Rabacal (2016) revealed that there is no significant main influence of gender on students' achievement in Biology.

There are varied results on the issue of students' academic achievement and gender especially in Biology. Some researchers argue that they are of the view that female students perform better than males, while others disagree with this view, stating that gender has no significant influence on achievement of students. SWH is not a method that the students are used to; it may therefore excite them irrespective of gender. Hence, this study investigated gender differences in achievement using the SWH approach.

***Theoretical framework***

This research study is anchored on constructivist theory of cognitive development by Jean Piaget's (1965). This theory explains how a child constructs a mental model of the world. Piaget believes that children act like little scientists as they make observations, carry out experiments and engage in active roles during the process of learning science and the world around them. This enables children to build on existing knowledge and adapt previously held ideas to accommodate new information through their interaction with the world, therefore, continually adding new knowledge. Piaget observed that cognition develops stage by stage because people of the same age level have a similar line of thinking and reasoning.

Intellectual development theory of Piaget holds that active interaction of the child with his environment leads to cognitive development. This means that a child's own ability to interact with his physical and social environment forms the basis for learning. The author further stressed that for a child to learn and be actively involved and not passive, he must act on the objects in his environment. Children's active involvement may be in the form of visual observation, mental processes or through direct manipulation of objects. In the teaching and learning situation, the Piagetian theory places the learner as the primary agent while the teacher provides the individual with situations that encourage manipulation of objects.

Linking closely to constructivism, there is a need for a shift from a traditional laboratory approach where the students are passive learners to the SWH approach where students are active learners in a science laboratory. In a constructivist laboratory, the teacher facilitates and motivates while the student is an active learner who builds concepts, therefore, less emphasis is placed on the output from the teacher and more on the input of information in the student's mind. The SWH approach will expose students to asking questions, making observations and finding the answers to these questions. In summary, constructivism remains an underlying theory behind SWH approach because it engages students in constructing their own ideas, knowledge and active engagement in laboratory activities. Therefore, the outcome of this study validated the constructivism theory.

Hence, Piaget's cognitive theory supports the SWH approach because it enables students to think abstractly and creates room for direct manipulation with their environment and materials. The SWH approach is activity oriented, student- centered, and the teacher is a facilitator of learning, who guides the students through a series of activities expected to be carried out by the learner, making the learner very active in the learning process which possibly could enhance achievement. Therefore, this research study intends to investigate the efficacies of SWH on students' achievement in Biology.

***Research focus***

In an educational system, students' achievement is measured by their performance in examinations, that is, the marks that they obtained in the examination. The index of academic achievement is the total scores or marks that the students get in final examinations (Satyaprakasha & Sudhanshu, 2014). Ezenwosu and Nworgu (2013) described academic achievement as something students achieve at school, in class, in a laboratory or fieldwork. Academic achievement enables us to obtain information on the extent to which a student has attained the criterion performance. It also enables us to determine the relative position or rank of individual students with respect to their performance (Etuk, Koko & Eno, 2011). Students' high achievement in biology is important for the nation's technological and scientific development. When there is no sound knowledge of biology, technological and scientific breakthroughs may not be achieved. Research reports unfortunately, show that there is poor achievement of students in biology which comprises both theory and practical.

A number of factors such as the interaction between the teacher and student during the teaching and learning processes have been identified to lead to poor achievement of students in biology. Oloruntegbe (2010) stressed this point that interaction in the science classroom has always been a triple dynamic between the teacher, the instructional materials and the learner. The three variables interact harmoniously to produce the intended learning outcomes. In Nigeria, practical activity is carried out in secondary school as part of the curriculum. However, in most secondary schools, the traditional laboratory approach (TLA) is the most used approach in Nigeria as far as Practical Biology is concerned.

In TL Approach, the teacher designs instructions for students to observe and follow using the traditional laboratory report format which consist of hypothesis, procedure, observations, results and discussion. The TL approach to practical activities does not necessarily represent the actual process that scientists go through in terms of the negotiations and debates that naturally occur during research. Therefore, this approach tends to ignore students' active participation in scientific investigation. Nwagbo and Chukelu (2011) asserted that practical activities in biology provide opportunities for students to do science as opposed to learning about science. The TL approach may likely lead students into working on practical activities without much thought of the actions, hence resulting in poor achievement in biology at the end of their studies. This problem could be attributed to the way the instructional approach was employed during practical activity. Therefore, this study intends to investigate the efficacy of SWH approach on academic achievement of students' in Biology.

The SWH is an inquiry approach that is argument-based developed by Hand & Keys in which students are required to conduct inquiry investigations by posing their questions about the concept under review, constructing claims based on evidence, collecting data, finding out what experts say, and reflecting upon their arguments to determine how their ideas have changed. The SWH consists of two heuristic templates; one guiding students' practical activity and reasoning in writing while the other provides suggested steps for the teacher to enhance during practical activities. The teacher-designed template for activities to promote laboratory understanding according to Hands and Keys (1999) includes; exploration of pre-instruction understanding through individual or group concept mapping; pre-laboratory activities, including informal writing, making observations, posing questions and brainstorming; participation in laboratory activity; negotiation phase i- writing personal meanings for laboratory activity. Negotiation phase ii- sharing and comparing data interpretations in small groups; negotiation phase iii- comparing science ideas to textbooks for other printed resources; negotiation phase iv- individual reflection and writing; exploration of post-instruction understanding through concept mapping. These are the eight steps of the teacher's template while the seven steps of the student's template include: beginning ideas, tests, observations, claims, evidence, reading and reflection (Hand & Keys, 1999).

While the SWH recognizes the need for students to conduct laboratory investigations so as to develop their understanding of scientific procedures or methods, the teachers' template seeks to provide the pedagogical focus for this learning (Hand, 2008). According to Hasanceb and Kingir (2012), the teacher template can be used in designing an environment for students' learning while considering the exploration of prior learning, engagement in activities, small group class negotiations, individual negotiations through writing-to-learn and discussions. Whereas the students' template acts as a guide for engaging

students in activities or a tool for writing-to-learn. Hand (2008) emphasized that the SWH is based on the assumptions that science genres in school should reflect some of the characteristics of scientists' writing and be shaped as pedagogical tools to encourage students to 'unpack' scientific meaning and reasoning.

***Research Aims and Research Questions***

This research study examined the efficacy of the Science Writing Heuristic approach on academic achievement of students in Biology. The following questions were answered.

(i) What is the efficacy of the SWH approach and TL approach on mean achievement scores of students in Biology?

(ii) What is the influence of gender on mean achievement scores of students in Biology?

(iii) What is the interaction effect of mode of instruction and gender on mean achievement scores of students in Biology?

## 2. METHOD

***Ethical Approval Statement***

The researchers were granted permission to conduct this research by their University committee on research ethics. Besides, the students also filled consent forms before the commencement of the experiment.

***Research Design***

This study adopted a non-equivalent control group quasi-experimental design. It sought to determine the efficacy of SWH on students' achievement. According to Nworgu (2015) the design does not involve the random assignment of subjects to experimental groups. In this study, the use of intact classes was adopted to restrict disrupting normal class activities in the schools selected for the study. This design has been utilized by Ugwu et al (2015), Ezema et al. (2022) and Eze et al. (2021).

***Study Participants***

The sample size for this study comprised 141 students made up of 57 males and 84 females in four intact classes of SS1 students drawn from two public co-educational schools. Multi-stage sampling procedure was used to arrive at the sample size. Firstly, the researcher purposely selected two schools from 23 public co-educational schools in Nsukka Local Government Area. The criterion for selection includes location of school, schools with equipped laboratories and availability of qualified Biology teachers with minimum qualification of B.sc (Ed) in Biology. Secondly, simple random sampling technique (balloting without replacement) was used to draw two intact classes from each school. Finally, two intact classes were randomly assigned to the treatment and control groups respectively in each of the schools using simple balloting.

***Instrument validation and reliability***

The instrument for data collection was Biology Achievement Test (BAT) which contained 30 multiple choice objective tests with 4 options A,B,C,D, scored 1 mark each giving a total of 30 marks. Some questions were selected from the West Africa Examination Certificate objective questions paper while some were developed by the researcher from the topic food test and enzymes in Animal Nutrition. The BAT measured students' cognitive achievement in food tests and enzymes. The BAT was made available to the validators. Two experts from Science Education (Biology) and two experts from Measurement and Evaluation validated the instruments. The validators subjected the items to face validation to ensure the; suitability and clarity of the items and appropriateness of the items in relation to the purpose of the study. The table of specification was used to determine the content validity of the instrument which was also validated by the validators. The lesson notes were also vetted.

To test the reliability of BAT, it was trial tested by administering them to a sample of 22 students in one intact Biology class of SS 2 students at Obollo Community Secondary School, Obollo Afor, Udenu L.G.A. The students used for trial testing had covered the lessons on the topic chosen and were equivalent samples of the group for which the instrument was developed. The researcher marked, scored and recorded the scores in the scripts. The instrument's internal consistency had a reliability index of 0.92 which was analyzed using Kuder–Richardson Formula 20 (K-R20) reliability coefficient.

***Experimental procedure***

The research assistants used for this study especially for those in the experimental group were trained by the researcher. Ten research assistants were trained in all for the two schools and they include two regular biology teachers, six teaching practice students teaching Biology and two laboratory attendants. Two days training was organised for the research assistant used in this study. The researcher instructed the research assistants that SWH approach has both teacher and student templates, and these templates guide the teachers and students throughout the practical activity. The researcher trained teachers using the 8 steps of two SWH templates using the lesson notes. Two groups of SS1 students which are the SWH Approach group and the TL Approach group were used for this study indicating the experimental group and control group respectively.

BAT was administered to the students as a pre-test in the sampled schools so as to determine the baseline information on the

achievement of the students before the commencement of the study. After pre-test, both groups carried out practical on food tests and enzymes using SWH Approach and TL Approach respectively in normal lesson periods and their Biology teachers guided them. Study lasted for 4 weeks and a post test was administered to the students at the end after which the teachers collected the scripts, marked and handed over to the researcher for collation and analysis of data.

***Data Analysis Procedure***

Mean and standard deviation was used to answer the research questions while the hypothesis was tested at 0.05 level of significance using Analysis of Covariance (ANCOVA).

## 3. RESULTS

**Research Question One:** What is the efficacy of the SWH approach on the mean achievement scores of students in Biology?

**Table 1 Mean ($\bar{X}$) achievement scores and Standard Deviation (SD) scores of students taught using SWH approach and TL approach**

| APPROACH | n | PRETEST | | POSTTEST | | ADJUSTED MEAN |
|---|---|---|---|---|---|---|
| | | $\bar{X}_1$ | $SD_1$ | $\bar{X}_2$ | $SD_2$ | $\bar{X}$ |
| SWH | 73 | 10.27 | 2.90 | 19.45 | 5.16 | 19.44 |
| TL | 68 | 10.16 | 3.21 | 17.16 | 3.68 | 17.17 |

Results in Table 1 shows that students who were taught using SWH approach and TL approach respectively had mean achievement scores of ($M$ = 10.27, $SD$ = 2.90) and ($M$ = 10.16, $SD$ = 3.21) in the pretest. This suggests that at the start, the two groups had roughly comparable mean achievement scores. Whereas, after the instruction, the posttest mean achievement scores were ($M$ = 19.45, $SD$ = 5.16) and ($M$ = 17.16, $SD$ = 3.68) with adjusted mean scores of 19.44 and 17.17 respectively. Hence, students who were exposed to SWH approach, achieved higher than students exposed to TL approach.

**$Ho_1$:** There is no significant difference in the mean achievement scores of students exposed to Biology using SWH approach and TL approach respectively.

**Table 2 Analysis of Covariance of students' achievement scores by modes of instruction and gender**

| Sources of Variation | Sum of Squares | Df | Mean Square | F | Sig | Effect Size Delta (Δ) |
|---|---|---|---|---|---|---|
| Covariates | | | | | | |
| Pretest | 190.740 | 1 | 190.740 | 10.524 | .001 | |
| Main Effects (combined) | 229.113 | 2 | 114.556 | 6.321 | .002 | |
| Treatment | 177.854 | 1 | 177.854 | 9.813 | .002 | 1.74 |
| Gender | 51.259 | 1 | 51.259 | 2.828 | .095 | |
| Treatment*Gender | 125.191 | 1 | 125.191 | 6.907 | .010 | |
| Model | 545.045 | 4 | 136.261 | 7.518 | .000 | |
| Residual | 2464.927 | 136 | 18.124 | | | |
| Total | 3009.972 | 140 | 21.500 | | | |

Results in Table 2 showed that there is a significant main effect for SWH approach $F$ (1,136) = 9.813, $p$ = .002. This means that, there was significant difference in the mean achievement scores of students exposed to SWH approach and TL approach respectively, hence the null hypothesis was rejected. The adjusted mean for SWH approach was 19.44, while that for TL approach was 17.17. The difference was in favour of the SWH approach. The SWH approach, therefore, was superior to the TL approach in Biology. The effect size of 1.74 indicated that this difference was important (1.74 > 0.50).

**Research Question Two:** What is the influence of gender on the mean achievement scores of students in Biology?

**Table 3 Mean ($\bar{X}$) achievement and Standard Deviation (SD) scores of students according to gender**

| Gender | n | Pretest | | Posttest | | Adjusted Mean |
|---|---|---|---|---|---|---|
| | | $\bar{X}$ | SD | $\bar{X}$ | SD | $\bar{X}$ |
| Male | 57 | 10.44 | 3.06 | 19.14 | 4.43 | 19.08 |
| Female | 84 | 10.07 | 3.04 | 17.81 | 4.72 | 17.85 |

Table 3 shows that at pretest, the male and female students had mean achievement scores of ($M$ = 10.44, $SD$ = 3.06) and ($M$ = 10.07, $SD$ = 3.04) respectively. This suggests that at the start, both genders had roughly comparable mean achievement scores. Whereas, after the instruction, the posttest mean achievement scores were ($M$ = 19.14, $SD$ = 4.43) and ($M$ = 17.81, $SD$ = 4.72) with adjusted mean score of 19.08 and 17.85 for male and female students respectively. Therefore, male students achieved higher than their female counterparts.

**Ho$_2$**: There is no significant difference in the male and female students' mean achievement scores in Biology.

Results in Table 2 showed a non-significant main effect of gender $F$ (1,136) = 2.828, $p$ = .095. This means that there was no significant difference in the male and female students' mean achievement scores in Biology. HENCE, the null hypothesis was not rejected,

**Research Question Three:** What is the interaction effect of modes of instruction and gender on mean achievement scores of students in Biology?

**Table 4 Mean ($\bar{X}$) and standard deviation (SD) Achievement Scores by Modes of Instructional and gender**

| Modes of Instruction | SWH Approach | | | Tl Approach | | |
|---|---|---|---|---|---|---|
| | n | $\bar{X}$ | SD | n | $\bar{X}$ | SD |
| **Pretest** | | | | | | |
| Male | 29 | 10.00 | 3.02 | 28 | 10.89 | 3.10 |
| Female | 44 | 10.45 | 2.84 | 40 | 9.65 | 3.22 |
| **Posttest** | | | | | | |
| Male | 29 | 21.21(21.32) | 4.84 | 28 | 17.00(16.72) | 2.65 |
| Female | 44 | 18.30(18.22) | 5.09 | 40 | 17.28(17.47) | 4.28 |
| **Total** | | | | | | |
| Observed mean | | 19.45 | 5.16 | | 17.16 | 3.68 |
| Adjusted mean | | 19.44 | | | 17.17 | |

**Note:** The Adjusted means are written in parentheses

Results in table 4 show a mean (adjusted) score of 21.32 and 18.22 for male and female students exposed to SWH approach respectively. An adjusted mean score of 16.72 and 17.47 was obtained for male and female students exposed to TL approach respectively. No ordinal interaction effect between modes of instruction and influence of gender on students' achievement scores in Biology because at all levels of gender, the adjusted mean scores were higher for the SWH approach.

**Ho$_3$**: There is no significant interaction effect of modes of instruction and gender on students' mean achievement scores in Biology.

Findings in Table 2 indicate a significant interaction effect of modes of instruction and gender $F$ (1,136) = 6.907, $p$ = .010. Hence, the null hypothesis was rejected. The interaction effect of gender and modes of instruction on mean achievement scores of students in Biology was statistically significant.

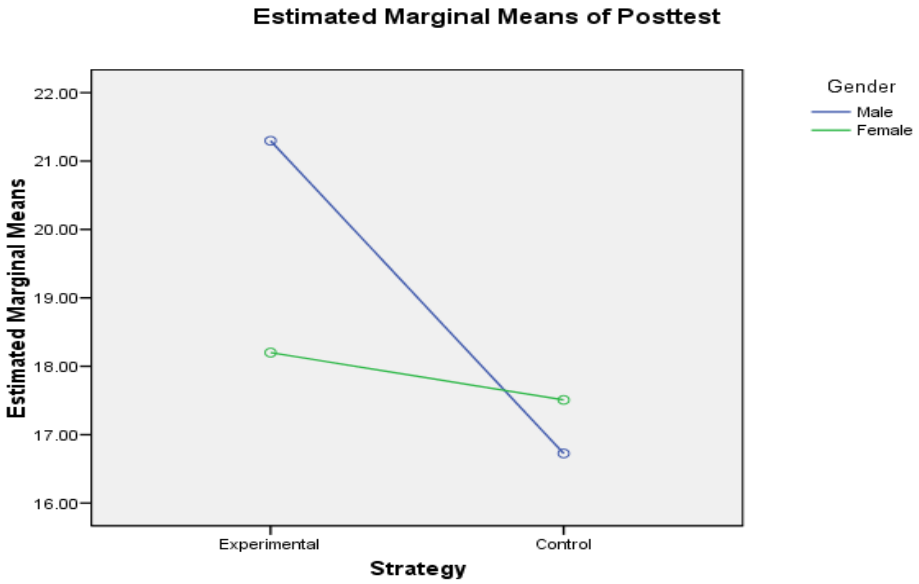


**Fig. 1**: Achievement score by mode of instruction and gender

The above figure indicated that the males taught with SWH approach had significantly higher mean achievement scores than the females. While in the TL approach, female students achieved higher than the males. The effect of modes of instruction and gender, therefore, was a case of disordinal interaction.

## 4. DISCUSSION OF THE FINDINGS

The study investigated the efficacies of SWH Approach and TL Approach on achievement of students in Biology. Students exposed to SWH approach achieved higher and had higher mean achievement scores than those in the TL approach group. Test of hypothesis also showed that mean achievement scores of students in Biology were significant. The type of instructional approach presented to the students, might have initiated the difference in the achievement scores of students. Learners in the SWH approach had equal chances of constructing their own knowledge and learning. This was made possible because the SWH approach had a student template with seven steps which required students' active participation through direct manipulation of equipment and materials. The SWH approach was activity based and student- centered, while the teacher was the facilitator in guiding them through their learning.

The SWH approach does not explicitly tell the students how to carry out the practical activity rather requires students to actively generate and answer questions while in the TL approach, the practical activities follow the teachers' agenda that does not permit more diverse data interpretation and questioning. In the TL approach, students carry out practical activities after the teacher must have demonstrated and this may not have given the students opportunity to critically think of how to construct their own knowledge individually. This probably made the result favour the students taught Biology using the SWH approach than students in the TL approach group.

The finding of this study corroborates the Constructivist theories which states that learning occurs through personal construction of ideas, views or knowledge. One of the constructivists believes that the learner must be actively engaged in the learning process. This means that, constructivist theory supports a learner-centered instructional approach that engages the learners during classroom sessions of which the SWH approach possesses this quality. For this reason, learners are responsible for their own learning and not viewed as passive recipients of knowledge. Hence, students are encouraged to use collaborative group work and guided inquiry laboratory activities to actively construct and negotiate knowledge while using the SWH approach because it is grounded on the constructivist philosophy.

The result of this study is in tandem with the findings of Kara and Kingir (2022) which showed that the SWH approach improved students' achievement in Elementary Science. According to Kingir (2011) and Erkol, Mustafa and Büyükkasap (2010) on the effectiveness of the SWH approach in teaching Chemistry and physics respectively, showed that the SWH approach was efficient in improving students' achievement. Munawaroh, Yuliani and Aisyah, (2020) supports this conclusion, finding Science Writing Heuristic approach superior to the Traditional laboratory approach hence, enhancing achievement of students in Chemistry. This finding is consistent with the result obtained in this study that showed that the SWH approach enhanced achievement of students in Biology more than the TL approach.

Furthermore, result also showed that males achieved higher than the females in their mean achievement score in Biology.

Despite the differences in their mean achievement scores, the test of hypotheses showed that male and female students' mean achievement scores in Biology was not significant. This could be because the instructional approach used may have given equal chances to both groups. SWH approach gives both genders equal opportunities of striving to achieve more during the learning process. In the SWH approach, individual students had access to an equal number of materials and apparatus used for the practicals. The students at some point had the opportunity to share ideas with their fellow students thereby helping them acquire more clarity and intelligence. The approach also ensured that the materials used were not gender biased. All these may have influenced the result of this study on gender and students' achievement in Biology.

The result of this research study agrees with the studies of Oludipe (2012) and Dania (2014) which also found no significant difference on influence of gender on academic achievement of male and female students. This result also supports the findings of Jacob and Linus (2017) which revealed that there was a significant interaction effect of modes of instruction on student achievement and gender. This shows that SWH is an effective instructional approach for enhancing achievement of students in Biology.

***Limitations of the Findings***

This study encountered difficulties that restricted the generalization of its conclusions. One of the major issues was the use of different Biology teachers to teach the topics, despite the fact that they were trained before the experiment commenced, because the teachers may not have the same cognitive and affective domain levels. This might have influenced the result of the study. The generality of the findings may be harmed by the non-randomization of subjects due to the use of quasi-experimental study. Although ANCOVA assisted in the homogenization of the groups, it was unable to eradicate the discrepancies.

***Conclusion and Recommendations***

The findings and discussions of this study revealed that; the nature of instructional approach used to teach students played a vital role in enhancing achievement of students. As seen in the study, SWH was able to enhance students' achievement and also streamlined gender differences in students' achievement in Biology because at all levels, SWH approach was superior to TL approach. It was also seen that the achievement of students was at par because the influence of gender on mean achievement scores of students when exposed to SWH approach was not significant. This shows that SWH is an effective instructional approach for teaching and learning of Biology. Based on the results of this research study, recommendations are made:

1. SWH approach should be adopted by biology teachers as an alternative approach to the traditional laboratory approach in carrying out practical biology.
2. Secondary school Curriculum developers such as the Nigerian Educational Research and Development Council (NERDC) should ensure that the infusion of the SWH approach into the Biology curriculum, as this will help enhance academic achievement of students in Biology.

**Conflict of Interest**

Authors of this manuscript have no conflict in interest

**Statement of Data Availability**

Data related to this research are available and can be made available on request.

## REFERENCES

[1] Akinwumi, I.O. & Falemu, F. A. (2020). Effects of Biology practicals on academic performance of secondary school students in Biology in Ikere Local Government Area of Ekiti State, Nigeria Aworeb - International Journal of Innovative Studies 1(3), 1-11

[2] Bajon, R. H. (2015). Effect of mode of laboratory work on senior secondary school students' achievement in Biology in Jalingo local government area. (Unpublished master's thesis). University of Nigeria, Nsukka.

[3] Cengiz, T. (2010). The effect of the virtual laboratory on students' achievement and attitude in chemistry. Journal of Educational Science, 2(1), 37-53.

[4] Dania, P.O. (2014). Effect of gender on students' academic achievement in secondary school social studies. Journal of Education and Practice, 5(21), 78-84

[5] Enebechi, R. I. (2016). Effects of two instructional scaffolding strategies on secondary school students' achievement and interest in Biology. (Unpublished Ph.D thesis). Department of Science Education: University of Nigeria, Nsukka.

[6] Ennis, R. H., Millman, J., & Tomka, T. N. (2005). Manual: Cornell critical thinking tests. Pacific Grove, CA: Midwest.

[7] Erkol, M., Mustafa, K. & Büyükkasap, E. (2010). The Effect of implementation of science writing heuristic on students' achievement and attitudes toward laboratory in introductory Physics laboratory. Procedia Social and Behavioral Sciences, 2, 2310–2314.

[8] Etuk, N., Koko, G. & Eno, U. (2011). Constructivist instructional strategy and pupils' achievement and attitude towards primary science. Bulgarian Journal of Science and Educational policy, 5(1), 225-230.

[9] Eze, K. O., Offorma, G. C., Ugwuanyi, C. S., & Okeke, C. I. O. (2021). Pre-reading activities and students' achievement in French Oracy: Implication for evaluation in library and information science. Library Philosophy and Practice (ejournal). 5952. https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=11426&context=libphilprac

[10] Ezeh, D. N. (2013). Science without women a paradox. 75th inaugural lecture. University of Nigeria, Nsukka: University of Nigeria senate ceremonial committee.

[11] Ezema, M. J., Ugwuanyi, C. S., Okeke, C. I., & Orji, E. I. (2022). Influence of cognitive ability on students' conceptual change in particulate nature of matter in physics. Journal of Turkish Science Education, 19(1), 194–217. https://doi.org/10.36681/tused.2022.118

[12] Ezenwosu, S. U. & Nworgu, L. N. (2013). Efficacy of peer tutoring and gender on students' achievement in Biology. International Journal of Scientific & Engineering Research, 4(12), 944-950.

[13] Ezekiel, D. P., Yilshik, O. M. & Joseph M. (2021). Biology Students' Questioning Behaviour in Relation to Their Achievement in Biology in Barkin Ladi, Local Government Area, Plateau State. Kashere Journal of Education, 2(2) 106-112.

[14] Federal Ministry of Education (2013). The senior secondary school Biology curriculum. Yaba: Lagos, NERDC Press.

[15] Hand, B. (2008). Science inquiry, argument and language: A Case for the Science Writing Heuristic. University of Iowa, USA. The Netherlands: Sense Publishers

[16] Hand, B. & Keys, C.W. (1999). Inquiry investigation: A new approach to laboratory reports. The Science Teacher, 66 (4), 27–29.

[17] Hand, B., Wallace, K.C., Prain, V. & Collins, S. (1999) Using the science writing heuristic as a tool for learning from laboratory investigations in secondary science. Journal of Research in Science Teaching, 36(10), 1065-1084.TO

[18] Hasanceb, F.Y &. Kingir, S. (2012). Overview of obstacles in the implementation of the argumentation based science inquiry approach and pedagogical suggestions. Mevlana International Journal of Education, 2(3), 79-94

[19] Idaa, A. J., & Ugbede, A. (2019). Gender discrimination and academic achievement of female students in some selected senior secondary schools in Karu Local Government Area, Nasarawa State, Nigeria. International Journal of Scientific Research & Engineering Trends, 5(3), 1099-1105.

[20] Jacob, F. & Linus, K.S. (2017). Effect of gender on senior secondary school students' academic achievement in geography in Ganye Education Zone, Nigeria. European Journal of Education Studies, 3(4).

[21] Kara, S. & Kingir, S. (2022). Implementation of the Model-Based Science Writing Heuristic Approach in Elementary School Science. International Journal of Science and Mathematics Education, 20, 683-703.

[22] Kingir, S. (2011). Using the science writing heuristic approach to promote student understanding in chemical changes and mixtures. (Unpublished Ph.D Thesis). Middle East Technical University

[23] Maria, B.P., Salim, S., Marjan, G. Z., Joe, S. & Lisa, S. (2013). An Inquiry-Based Approach to Laboratory Experiences: Investigating Students' Ways of Active Learning. International Journal of Innovation in Science and Mathematics Education, 21(5), 42-53.

[24] Munawaroh, H. S. H., Yuliani,G. & Aisyah, S.(2020). Implementation of Science Writing Heuristic Approach to Develop Chemistry Students' Argumentation Skill. DOI 10.2991/assehr.k.200513.033

[25] Niklas G., Per H. & Johan W. (2023). A systematic review of research on laboratory work in secondary school. Studies in Science Education, 59(2), 245-285, DOI: 10.1080/03057267.2022.2090125

[26] Nwagbo, C. & Chukelu, U. C. (2011) Effects of biology practical activities on students' process skill acquisition. Journal of the Science Teachers Association of Nigeria, 46(2).

[27] Nworgu, B. G. (2015). Educational research: Basic issues and methodology (3rd ed.). University Trust Publishers.

[28] Ogundipe, A. F. (2013). History and philosophy of Science. Ijebu-Ode: Lucky Odeni Publication. Press.

[29] Ogunleye, B.O. & Babajide, V.F. (2011). Commitment to science and gender as determinants of students achievement and practical skills in Physics. Unpublished Article

[30] Okoyefi, Q. O. (2014). Effect of four mode application techniques on achievement, retention and multiple intelligences of students with different learning styles in Biology. (Unpublished Ph.D Dissertation). University of Nigeria, Nsukka

[31] Oluruntegbe, K.O. (2010). Conflicts in science in the classroom: Documentation and management through phenomenological methodology. Educational Research and Reviews, 6(15), 828-834.

[32] Oludipe, D.I. (2012). Gender difference in Nigerian junior secondary students' academic achievement in Basic science. Journal of Educational and Social Research, 2(1).

[33] Piaget, J. (1965). Construction of reality in the child. London: Routledge & Kegan PaulPeter, K. & Dickson, K. R. (2014). Challenges facing laboratory practical approach in Physics instruction in Kenyan district secondary schools. International Journal of Advancements in Research & Technology, 3(8). Department of curriculum instruction and educational media, school of education, Moi University, Eldoret, Kenya.

[34] Rabacal, J.S. (2016). Test of science process skills of biology students towards developing of learning exercises. Asia Pacific Journal of Multidisciplinary Research, 4(4), 9-16

[35] Satyaprakasha, C.V. & Sudhanshu, Y. (2014). Effect of multimedia teaching on achievement in Biology. International Journal of Education and Psychological Research 3(1), 43-45

[36] Sheila, S., Gilbeth, A. J.& Mageswary, K. (2016). Effectiveness of green chemistry with science writing in enhancing understanding chemistry concepts. The Eurasia Proceedings of Educational & Social Sciences. International Conference on Research in Education and Science 5, 20-25

[37] Taale, K. D., Hanson, R., & Antwi, V. (2018). Investigating senior high school students' conceptions of introductory chemistry concepts. International Journal of Educational Administration, 3(1), 41-57.

[38] Tseng, C. (2014). The effects of the science writing heuristic (SWH) approach versus traditional instruction on yearly critical thinking gain scores in grade 5-8 classrooms. (Unpublished Ph.D Thesis). Graduate College of the University of Iowa.

[39] Ugwu, C. B. & Nzewi, U. M. (2015). Effects of two instructional delivery approaches on senior secondary school students' achievement and retention in Biology. (Unpublished M.Ed Thesis). University of Nigeria, Nsukka.

[40] WAEC (2017, 2018, 2019). West African Examination Council. May/June Chief Examiner's response retrieved 28/06/2023.