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Effect Of Using Science Wriing Heuristics During Instruciton On Students' Acheivement In Biology

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Abstract: ***The study is concerned with the effect of science writing heuristics during instruction on students' achievement in biology. Three hypotheses guided the study. Quasi-experimental research design was used, specifically the non-equivalent control group design. The population of the study comprised 1, 946 senior secondary school year two (SS2) biology students in Oshimilli North Local Government Area of Delta State, Nigeria. A sample of 201 SS 2 biology students was involved. The instruments for data collection was Biology Achievement Test (BAT) validated by two lecturers in Science Education Department and Educational Foundations of Nnamdi Azikiwe University, Awka. The reliability of the instruments was established using Kudder-Richardson Formula 20 which yielded coefficient of internal consistency of 0.91 for BAT. Data were collected by administering the instruments before as pretest and posttest after six weeks. The data obtained were analyzed using mean and Analysis of Covariance (ANCOVA). The finding of the study showed that the effects of SWH approach on was significant compared to the use of conventional method. The researcher recommended among others that school administrators should organize seminars and workshops for biology teachers to acquaint them with science writing heuristic approach.***

Keywords: Science writing heuristics, achievement, biology, germination, adaptation in xerophytes

I. INTRODUCTION

Scientific literacy is considered as an important part of science education because it enables each student to become a scientifically literate person and make informed decisions (Akinsayo, Ajayi & Salomi, 2014). Students who are science literate, can communicate their ideas orally or in writing. To be science literate individuals, need to have a substantial background in science literacy and content knowledge in order to provide solutions to scientific issues (Balgopal & Wallace, 2013). In addition, students can use scientific evidence to draw inferences to establish critical thinking skills. Students can evaluate scientific evidence, make claims, understand the development of scientific knowledge, and make real life connections through extension of scientific concepts. Metz (2012) noted that as an important part of science literacy, writing in science classrooms can effectively assist all students to understand questions, claims, scientific reasoning, evidence, and claims-evidence relationship in science. Thus, science literacy serves as a foundation to effective learning for all the science related subjects in secondary schools including biology.

The poor academic achievement of secondary school students in biology as indicated in the annual report of the West Africa Examination Council (WAEC) reveals poor achievement in biology education (Bella, 2014). According to Osuafor and Okonkwo (2013), statistics from May/June 2007 – 2012 WAEC examinations revealed that the percentages of candidates who passed WASCE at credit level and above (grade 1-6) in biology were as follows; 15.79 in 2007, 31.29 in

2008, 31.39 in 2009, 38.75 in 2010, 36.56 in 2011 and 31.81 in 2012.

The WAEC chief examiner's report shows that from 2010 to 2018 certain weaknesses were exhibited by biology students. Among the common weakness were wrong spelling of technical terms, not attempting compulsory questions, lack of sequence in life cycles of insects and animals, (example life cycle of toads and metamorphosis in butterfly), inability to define test cross correctly, poor understanding of sexual reproduction in organism like flowering plants, poor attempt in answering questions requiring detailed explanations, poor response to the questions on adaptation in xerophytes. Other weaknesses include: drawing flowering plant instead of the transverse section of a stem, inability to give detailed description of terms relating to germination of seeds, inability to compare succession and competition, draw according to specification, classify organisms, understand what observable difference means, relate differences in a tabular form, march structures with function correctly and poor grammatical expressions.

The poor achievement in biology and these identified weaknesses may be attributed to lack of effective teaching method or to the use of conventional teaching methods, non-availability of modern laboratory and learners' background knowledge. Conventional teaching methods are teacher-centered and include the use of lectures and discussions, while the problem solving element is presented by and/or discussed with the teacher, the syllabus, the teaching materials and the student assessments are determined by the teacher and transmitted to students in various lectures. In teaching biology practical, teachers often adopt demonstration method which involves teacher modelling the experiment for the students. The students are thereafter divided into groups with group leaders who carry out the experiment on behalf of their group. Although the students did not individually carry out the experiments on their own, they are evaluated individually. This approach reduces the involvement of the students but could affect students' achievement and acquisition of science process skills effectively. There is need for more innovative methods of teaching that could positively enhance students' achievement. One of such teaching method is the science writing heuristics.

Science writing heuristics (SWH) simply means teaching science and reporting scientific evidence through discovery (Erduran, 2014). SWH is used in the teaching of practical orientated topics in science; the students are put in place of independent discoverers with no help or guidance provided by the teachers. The method requires the teacher to set experimental problems for students' and then stands aside while the students' discover the answers. Science writing heuristics (SWH) is a relatively new teaching approach in Nigeria. This approach can also help in the enhancement of scientific literacy in students' and teaching of biology and other science subjects in secondary schools.

In the Science writing heuristics classroom, the lesson begins with the students carrying out the experiments, using the questions and instructions (hints on the topic) on the SWH students' template as a guide, students' record their observations and findings, compares their report with that of their classmates and exchange ideas. The students' reports are analysed by the teacher to find out areas where the students' are having difficulties in understanding the concept being taught. From the teacher's observation of the students' difficulties, the teacher begins the lesson, making sure that emphases are made on the areas where students' are having difficulties.

According to Drobitsky (2015), the SWH process begins with a discourse between the students and the teacher at the students' current level of understanding. This provides an avenue for scaffolding of knowledge by students and enabling the teacher to better address the students' specific learning style and pre-knowledge. With carefully planned and guided prompting, students' questioning will occur naturally, leading students to want to find out or discover knowledge for themselves. If necessary, the teacher uses prompts to redirect students when they begin to go astray from the desired topic under discussion. Once the students have decided what they plan to investigate and frame their own questions, they will be more motivated to continue.

This process of experimentation helps the students to feel that they themselves are in control of their learning and are learning what they want to know. This active engagement in the learning process leads to increased conceptual understanding and acquisition of science process skill. As results of the experiments are been discussed and compared between students, there is an opportunity to shape students' understanding of the science concepts been taught. The mental processes occur in a students' mind as the student discusses and work out his or her reasoning as a result of the communication of ideas (Drobitsky, 2015).

Science writing heuristics incorporates writing as a learning tool than just a reporting tool, when utilizing this type of writing (writing-to-learn), students generate and clarify their understanding of scientific concepts for themselves rather than simply communicating with a teacher for evaluation (McDermitt, 2010). The active engagement in writing enables metacognition and increases conceptual understanding. These activities often require that students write for a specific audience, this may be their classmates, students in another content course or even younger students. Writing to an audience other than their teacher forces the students to express their thoughts clearly and coherently (Balgopal & Wallace, 2013).

SWH is used in the teaching of practical orientated topics in science, the students are put in place of independent discoverers, thus, no help or guidance is provided by the teachers. According to Kingir (2011) heuristics method of teaching are methods which involve the teacher placing the students as far as possible in the attitude of the discoverer, methods which involve students finding out facts by themselves instead of being told about things. There are several gains to the use of science writing heuristics teaching approach in secondary school, SWH can help a student to solve problem by using scientific attitude, demonstrate the experiment, illustrates the results of the experiment, acquire knowledge about new science concepts, think independently, collects and analyze data for information and acquire basic and integrated science process skill. According to Drobitsky (2015) when students are required to list, describe or define, processes involved in writing, they are focused on concepts in

isolation. However, when performing analytical tasks such as explaining real-world applications of scientific concepts, learners connect these into an integrated web of meaning.

When the students are involved in this type of discourse, they compare their findings with that of their peers. They can persuade others that what they are stating is factual and accurate. To think things through clearly, to examine what evidence supports a conclusion derived from experiments, based upon the students' generated hypothesis is a highly desirable skill that will aid in scientific knowledge and the acquisition of science process skills necessary for secondary school students to function as scientifically literate individuals (Kingir, 2011).

The conventional teaching method (traditional laboratory method) on the other hand do not reinforce science skills (measuring, using equipment, safety etc.) or teach the students how to work together for a common goal, without additional guiding questions. This format is not designed for the student to generate meaning of what occurred nor are the students expected to use their evidence to make a claim. The conventional laboratory write-up may require the students to make sense of their results, but more from the perspective of whether their result supported their hypothesis. The traditional laboratory write-up is compartmentalized: purpose, hypothesis, experimental design, data, and conclusion; the conclusion answering the question of whether their hypothesis was correct or not. This fails to make the laboratory experience personal for the students.

SWH, on the other hand, joins the discrete parts of the laboratory experiences together and makes the experience more personal and therefore a meaningful experiment. Instead of answering section headings (purpose, hypothesis, design, data, conclusion), the students develop their reports themselves (Drobitsky, 2015). Gunel (2006) describes SWH as a tool that helps students construct a conceptual understanding of science topics through laboratory activities that are guided by templates; one template guides the teacher and the other guides the students (see Appendices H and I, page). Studies have shown that when students utilize SWH effectively, their construction of scientific meanings and conceptual understanding is improved (Gunel, Hand & Dermott, 2009, Handelsman, Miller & Fund, 2007).

The SWH process has several qualities which are supported by educational work and research based data. SWH uses collaborative learning and thus, has been found to support student achievement and acquisition of science process skills. The National Science Teachers' Association (NSTA) recognizes the importance of social collaboration as they report that they expect science teachers to provide regular opportunities for students to collaborate effectively with others in carrying out complex tasks, share the work of the task, assume different roles at different times, and contribute and respond to ideas (NSTA, 2007). SWH arranges for students to interact frequently in smaller and more intimate groups. Having knowledge of the social and cognitive behaviours of the adolescent, the teacher can utilize SWH to assist these delicate students to work with their peers to build positive relationships and attitudes about learning science and acquisition of science process skills.

Writing to learn can also benefit students when they peer-review and edit each other's work, solve problems and clarify ideas to see what happens after carrying out an experiment. Editing another student's work is shown to improve a student's own writing skills. If the reader is unclear about something, they ask for clarification. The readers are free to make comments and suggestions, this process supports students, especially those with weaker writing skills, in creating a well-written and well-understood final report (Ende, 2012).

Biological science programs should aim at producing graduate and students who are able to think like a scientist, that is, students and graduates who are able to solve problems in multiple contexts and effectively integrate information into meaningful scientific concepts. This scientific literacy and science process skills should be impacted in the students as early as possible. A more effective way to help students master science concepts and acquire science process skills and better prepare them for careers in science would be through explicit instruction of science process skills, helping students acquire mastery and use of these skills early in the college curriculum and thereby augmenting their content acquisition and interdisciplinary ways of perception (Coil, Wenderoth, Cunningham, & Dirks, 2010). Thus, in this study science writing heuristics was used as a teaching approach and a tool for enhancing students' acquisition of science process skills in biology.

PURPOSE OF THE STUDY

The purpose of this study is to investigate the effect of using science wring heuristics during instruction on students' achievement in biology. Specifically, the study investigated the:

- ✓ Effect of science writing heuristics on students' achievement in biology when compared to those taught using conventional method.
- ✓ Effect due to gender on students' achievement in biology.
- ✓ Interaction effect of instructional methods and gender on students' achievement in biology.

HYPOTHESES

The following null hypotheses were tested at 0.05 level of significance:

- ✓ There is no significant difference in the mean achievement scores of students taught biology using Science writing heuristics (SWH) and those taught using conventional method.
- ✓ There is no significant difference between the mean achievement scores of male and female students.
- ✓ There is no significant interaction effect of teaching methods and gender on the students' achievement in biology.

II. METHOD

The design adopted for the study was quasi-experimental. Specifically, the study used pretest posttest non-equivalent

control group design. The design is represented summarily as follows:

E	O1	X	O2
C	O1	~X	O2

Figure 1: Design of the Study

Where
E = Experimental Group
C = Control group
0_1 = Pre-test
0_2 = Post-test
X = Treatment with SWH
~X = Treatment with Conventional method
---- = non-equivalence of the two groups

The study was carried out in Oshimili North Local Government Area of Delta State, Nigeria. The population of the study comprised 1,946 senior secondary school year two (SS 2) biology students in 11 secondary schools in Oshimili North Local Government Area in Delta state. (Source: Ministry of Education, Asaba, 2017). The sample for the study is 207 SS2 students obtained using a multi-stage procedure. The instruments for the study were Biology Achievement Test (BAT). . BAT is a 25-item multiple choice objective test (see Appendix B, p. 67 for details on BAT) based on 4 concepts in S.S 2 biology curriculum. The questions were taken from standardized West Africa Examination (WAEC) past questions using a table of specifications (see Appendix C, p. 70 for table of specification). Lesson plan was developed for the experimental and control group teachers by the researcher in the content areas taught (see Appendix F, p. 77 for lesson plans).

Since the Biology Achievement Test (BAT) questions were guided by a table of specification and obtained from an question from a formal examination body WAEC, the instrument was given to a lecturers in the Department of Science Education for face validation. The corrections and suggestions of the validators were incorporated into the final production of the instrument. The reliability of the BAT was established using Kudder-Richardon 20 (KR-20) formula. The rationale behind the use of KR-20 method is that it is appropriate for objective test items that are dichotomously scored. KR-20 was chosen because the difficulty levels of the question items is heterogeneous. Thus, the students will face varied level of challenges in attempting the questions. The instrument was administered to 40 biology students outside the area of study and the obtained scores were tested for reliability using the KR-20 formula. The coefficient of internal consistency obtained for BAT is 0.91.

Before the experiment, the treatment and control groups were given pre-test. This was done through the help of the regular classroom biology teachers who were trained as research assistants. In week one, the students were exposed to the topic: stages of development of a toad. The students were provided with SWH students' templates, live specimen of tadpoles and a toad. Before the lesson, the students were requested to locate pool of stagnant waters and ensure they observe the water for stages in the development of a toad. During the treatment, the students were taken to the laboratory and were requested to solve problems in the template relative to experiments on the stages of the development of a toad. Students were requested to brain storm and try to report exactly what they observe both in the habitat and from the laboratory specimen. After writing their reports, students were requested to exchange their templates with other students so as to compare and learn from each other. Thereafter, the teacher gave explanations on the stages of the development of a toad. After explanation, the teacher inspected the students' SWH reports and from the weakness observed, the teacher gave a summary on the important points of the lesson highlighting the areas where the students showed weaknesses. The same procedure was followed in the second week in teaching germination of seeds, organs of reproduction in flowering plants in the third week and adaptation in xerophytes in the third week.

The control group was taught the same concepts using conventional teaching method. The students were taught with the teacher modelling the experiment for the students after which the students were grouped together with a group head. The group head conducted the experiment on behalf of the students and all the students wrote their individual reports. They were all given posttest after the experiment. The generated scores were then collated for analysis. The hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. ANCOVA was used to take care of the initial differences among the groups. In that case pretest scores were used as covariate measures. The decision for the hypotheses was that whenever the Pvalue was less than 0.05, the null hypothesis was rejected; otherwise, the null hypothesis was not rejected.

III. RESULTS

Source of variation	SS	Df	MS	F	Sig.	Decision
Corrected Model	32868.826[a]	4	8217.206	163.337	.000	
Intercept	51810.552	1	51810.552	1029.863	.000	
Pretest	2.025	1	2.025	.040	.841	
Gender	41.222	1	41.222	.819	.366	NS
Method	32766.762	1	32766.762	651.321	.000	S
Method*Gender	1.080	1	1.080	.021	.884	NS
Error	10162.256	202	50.308			
Total	507845.000	207				
Corrected Total	43031.082	206				

Table 1: ANCOVA on Effect of SWH on Achievement of Students in Biology and those taught using Conventional Method

HYPOTHESIS 1: There is no significant difference in the mean achievement scores of students taught biology using Science writing heuristics (SWH) and those taught using conventional method.

Table 1 shows that there was significant mean effect of the treatment on the achievement scores of the students, F (1, 206) = 651.321, P = 0.000 <0.05. Thus, the null hypothesis was rejected. Therefore, the observed difference in the mean achievement scores of the students taught using SWH and those taught using conventional method is significant and in favour of SWH as can be seen in the mean scores.

Source of Variation	N	Pretest Mean	Posttest Mean	Gained Mean	Pretest SD	Posttest SD
SWH	101	20.35	60.29	39.94	7.32	7.55
Conventional	106	20.71	35.09	14.38	7.35	6.55

Table 2: Pretest and Posttest Mean Achievement Scores of Students taught Biology using SWH and those taught Conventional Method

Table 1 shows that the group taught using science writing heuristics (SWH) had gained mean achievement score of 39.94 and the group taught using conventional method had mean gain score of 14.38. The spread of scores was higher in the group taught with SWH than the group taught using conventional method.

HYPOTHESIS 2: There is no significant difference between the mean achievement scores of male and female students.

Table 1 also shows that there was no significant mean effect of the treatment on the achievement scores of the male and female students, F (1, 206) = .819, P = 0.366 >0.05. Thus, null hypothesis was not rejected. Therefore, there is no significant difference between the mean achievement scores of male and female students. Thus, any observed mean difference in table 3 was by chance.

Group	Gender	N	Pretest mean	Posttest mean	Gained Mean	Pretest SD	Posttest SD
SWH	Male	50	21.18	59.78	38.60	7.18	7.57
	Female	51	19.50	60.80	41.30	7.44	7.58
Conventional	Male	56	21.27	35.49	14.22	7.61	6.58
	Female	50	20.18	34.73	14.55	7.13	6.56

Table 3: Pretest and Posttest Mean of Achievement Scores of Male and Female Students in Biology

Table 3 shows that male students taught using science writing heuristics (SWH) had gained mean achievement score of 38.60 and females had mean gained score of 41.30. Male students taught using conventional method had gained mean achievement score of 14.22 and females had mean gained score of 14.55. The use of SWH increased the spread of scores among the females than it did among the male students in the SWH group but the reverse was the case of students in the conventional group.

HYPOTHESIS 3: There is no significant interaction effect of teaching methods and gender on the students' achievement in biology.

Table 1 further reveals that there was no significant interaction between gender and teaching methods as on achievement scores of students, F (1, 206) = 0.021, P= 0.884 > 0.05. Therefore, the null hypothesis was not rejected. There is no significant interaction effect of teaching methods and gender on the students' achievement in biology.

IV. DISCUSSION

The findings of this study revealed that SWH significantly enhanced the achievement of students in biology when compared to the conventional method using their pretest posttest scores. The significant difference in the gain in mean score of both groups in favour of SWH can be explained from the continuous interaction with the learning material inherent in SWH especially the use of students' templates. The heuristic templates which were designed around some questions prompted the students to utilize scientific thinking and reasoning through critically analyzing their prior knowledge, negotiating their own meaning of scientific concepts, developing links between claims and evidence, and constructing explanations that are based on relationships or generalizations observed.

This interaction helped the students to develop a deeper understanding of the big ideas of science contents through the phases of the students' template/plan. Also the templates used by students required the students to solve a number of problems experimentally; the experiment starting with questions in other to find answer and a writing task, which often follows a continuous cycle of negotiating and clarifying meanings and explanations with their peers and teachers. This experience allowed the students to also compare their ideas with others and considering how their ideas changed in the process gave them a proper understanding of the concepts taught.

The collaborative nature found in the use of SWH is not common with the conventional method. The students do not engage much often in the experiment themselves and are not challenged by experimental tasks like in the use of SWH. In science writing heuristics group, the lessons began with the students carrying out the experiments, using the questions and instructions (hints on the topic) on the SWH students' template as a guide, students' record their observations and findings, compared their report with that of their classmates and exchanged ideas. This as Drobitsky (2015) noted provides an avenue for scaffolding of knowledge by students and enabling the teacher to better address the students' specific learning style and previous knowledge. With the carefully planned and guided prompting in the students' templates, students' questioning occurring naturally, lead students to want to find out or discover knowledge for themselves. Also, the experimentation made students to see themselves as being in control of their learning and are learning what they want to know. Drobitsky (2015) reported that the mental processes going on in students' mind as the students discussed and worked out their reasoning results in the communication of ideas. The active engagement in writing enables metacognition and increases conceptual understanding (McDermitt, 2010).

Writing to learn through the use of SWH templates also benefit students when they peer-review and edit each other's work, solve problems and clarify ideas to see what happens after carrying out an experiment. Editing another student's work helped to improve a student's own writing skills. It was observed that when a student is unclear about something, they ask for clarification. They are free to make comments and suggestions. This process Ende (2012) noted supports students, especially those with weaker writing skills, in creating a well-written and well-understood final report. SWH joins the discrete parts of the laboratory experiences together and made the experience more personal for each student and therefore a meaningful experiment. Instead of answering section headings (purpose, hypothesis, design, data, conclusion), the students develop their reports themselves.

The findings of this study supports the findings of Amal, Sozan, and Olfat (2015) who reported that students taught using SWH performed better than those taught using the

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conventional method and concluded from their study that SWH is effective. The findings of this study also supported that of Brian (2004) who investigated using Science Writing Heuristic to enhance learning outcomes from laboratory activities in seventh-grade science. Brian indicated those students who used the Science Writing Heuristic performed better as a group than students who did not, and that students who completed a textbook explanation as a write-up performed better as a group than those who completed a more traditional write-up format. The findings of the study however contradict that of Lori (2013) who investigated the effect of incorporating the science writing heuristic approach to inquiry activities in a high school science classroom. Lori reported that the results from the data that was analyzed in regards to quiz scores and lab scores did not demonstrate that the SWH approach had an impact on student grades. The findings of the study also contradicted that of Arnold (2011) who conducted a study on investigating the impact of the science writing heuristic on student learning in high school chemistry. Arnold found no difference in the achievement of student in both the traditional and SWH groups. It is therefore recommended that, school administrators should organize seminars and workshop for biology teachers to acquaint them with science writing heuristic instructional approach since it is not a common method of instruction in the area studied.

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