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Teachers' Use Of Science Writing Heuristics in Biology Instruction and Its Effect of Students' Acquisition of Science Process Skills

IREDE Elohor Anthonia[1], OKOLI, Josephine Nwanneka[2]
1 – Ugbolu secondary school, Ugbolu, Oshimilli North Local Government Area, Delta state Nigeria,
2 - Department of Science Education, Nnamdi Azikiwe University, Awka, Nigeria,

Abstract: *The study investigated the effect of science writing heuristics on students' acquisition of science process skills. Four research questions and five hypotheses guided the study. The quasi-experimental design was used, specifically the pretest posttest 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 of Delta State. A sample of 201 senior Secondary School year two (SS 2) biology students was used in the study. The instrument for data collection was Science Process Skills Acquisition Test (SPSAT). SPSAT was validated by two lecturers in Science Education department and Educational Foundation of Nnamdi Azikiwe University, Awka and one experienced biology teacher. The reliability of the instruments was established using Kudder-Richardson formula 20 to be 0.83. Data were collected by administering the instruments as pretest and posttest after six weeks. The data obtained was analyzed using mean, standard deviation and Analysis of Covariance (ANCOVA). The results of the study revealed that there is significant difference in the mean scores of students in the science process skills of observing, experimenting, inferring, classifying and communicating, those taught biology using science writing heuristics (SWH) teaching approach and those taught using the conventional method in favour of SWH. There was also a significant difference in the mean scores of students in the science process skills of those taught biology using science writing heuristics (SWH) teaching approach and those taught using the conventional method in favour of SWH. However, there was also no significant interaction effect of gender and teaching method on the mean scores of students in the science process skills of observing, experimenting, inferring, classifying and communicating. The researcher recommended that school administrators should organize seminars and workshop for biology teacher to acquaint them with science writing heuristic instructional approach.*

Keywords: *Science writing heuristics, science process skills, biology, development in toad, germination*

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I. Introduction

The explosion of knowledge and the nature of learning, combined with the growing power of technology present learners with new and constantly changing situations. With the increasingly diverse knowledge explosion and fast developing technological innovations, there is need for secondary school students to acquire science process skills that will enable them function effectively in the larger society. Most graduates of the education system are aware of scientific processes but lack the ability to apply them in situations of everyday living (Karamustafaoglu, 2011). For this reason, science students are expected to acquire both science process skills to be able to function effectively in the modern age of science and technology.

Science process skills (SPS) are a set of broadly transferable abilities that reflect what scientists do (Mei, Kaling, Xingi & Khoon, 2007). Science process skills (SPS) are the skills used by scientists to create scientific knowledge, think about a problem and make conclusions about the problem (Karsili and Sahin, 2009). According to National Policy on Education, science education programmes will be designed to enable the learner to acquire problemsolving and decision making skills and to discover the relationship of science with health,agriculture, industry and other aspects of daily life (FRN, 2004). They have been described as mental and physical abilities and competencies which serve as tools needed for the effective study of science and technology as well as problem solving, individual and societal development (Akinbobola & Ado, 2007). Science process skills are categorized into basic science process skills and integrated science process skills (Mei et al., 2007). The basic science process skills include observing, inferring, experimenting, communicating, classifying and predicting.

Over the years, biology teachers have been faced with the problem of helping students improve achievement and acquire science process skills, of which acquisition of science process skills is the major goal of teaching science (Ali, Toriman, & Gasim, 2014). According to Lenor (2015), no two students enter a classroom with identical abilities, experiences and needs. Learning style, language proficiency, background knowledge, readiness to learn and other factors can vary within a single class group. Regardless of the learners' individual differences, students are expected to master the same concepts, principles and skills. To cater for the different learning abilities of the students, teachers are expected to be well equipped in the pedagogical content knowledge as well as strategies of passing scientific knowledge and science process skills to the learners. One pedagogical approach that could boost on students' acquisition of science process skills is the use of science writing heuristics.

SWH is a teaching approach that provides learners with an experimental (heuristic) template, or plan, to guide their science laboratory activities using experiments, arguments, negotiation and writing. This heuristic template, or plan, is designed around some questions. The questions prompt the learner to utilize scientific thinking and reasoning through critically analyzing their prior knowledge. This is followed by students negotiating their own meaning of scientific concepts, developing links between claims and evidence, and constructing explanations and generalizations based on relationships observed (Arnold, 2011). In this approach, the students are placed in the position of independent discoverers and students must make a claim (inference) about what was learned through the laboratory activity and provide evidence to support that claim. The successful implementation of the SWH teaching approach requires a student-centered learning environment (Greenbowe, Poock, Burke & Hand, 2007).

SWH provides learners with a experimental template to guide their science activities and reasoning in writing, as well as provides teachers with a template of suggested strategies that could enhance students' learning from laboratory activities (Drobitsky, 2015). It is a bridge between informal, expressive writing modes that foster personally constructed science understandings and more formal public writing modes that focus on organized forms of reasoning in science. The template for student thinking, prompts learners to generate questions, claims and evidence, for making an argument based on valid reasoning.

Science process skills can be developed by using SWH, inquiry, or investigative approach of teaching and learning science that gives students opportunities to practice these skills. Acquisition of science process skills can have a profound impact on student success in secondary science classes. Evidence shows that new students who participated in a course in which they were explicitly taught science process skills, out-performed students who did not participate in the program in subsequent introductory biology courses (Dirks & Cunningham, 2006).

Similarly, students in a molecular biology course who practiced data analysis, diagrammatic visualization, and other analytical reasoning skills had improved test scores compared with those in a control course. Explicit instruction in generating and interpreting scientific data and experiential research projects that promoted science process skills also benefited students' learning and reinforcement of course content (Yeoman & Zamorski, 2008). According to Kingir (2011), the SWH approach is grounded on the constructivist philosophy because it encourages students to use guided inquiry laboratory activities and collaborative group work to actively negotiate and construct knowledge. SWH is not just a tool used for writing the laboratory reports but rather an argument-based inquiry because it successfully integrates inquiry activities, collaborative group work, meaning making via argumentation and writing-to-learn strategies.

SWH helps students develop a deeper understanding of the big ideas of science contents through the phases of the students' template/plan. The template requires the student to solve a number of problems experimentally; the experiment starts with questions in order 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. Comparing their ideas with those of others, and considering how their ideas have changed through this process. Thus, the emphasis of the SWH focuses on the collaborative nature of scientific activities or scientific arguments. According to McDermott (2010), SWH incorporates writing as a learning tool rather 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 and also develop science process skills in the course of the experiments. SWH approach to learning is important and has been part of the emphasis for constructivist like Bruner.

Constructivist theory was propounded by Bruner in 1966. Bruner's constructivist theory states that, learning is an active process in which learners construct new ideas or concepts based upon their past knowledge. The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure to do so. Cognitive structure means an organization of experiences which allows the individual to go beyond the information given. Bruner (1966) argued that as far as instruction is concerned, the instructor should try and encourage students to discover principles by themselves. The instructor and students should engage in an active discussion. The task of the instructor is to translate information to be learned into a format appropriate to the learners' current state of understanding. Curriculum should be organized in a spiral manner so that the student continually builds upon what they have already learned.

Bruner (1966) states that a theory of instruction should address four major aspects in learning: (1) predisposition of the learner towards learning, (2) the ways in which the structure of knowledge can be organized so that it can be most readily grasped by the learner, (3) the most effective sequences in which to present the learning material, and (4) the nature and placing of rewards and punishments. Effective methods for structuring knowledge should result in simplifying, generating new propositions, and increasing the manipulation of information. According to the constructivist view, the characteristics of individuals influence their learning as much as the teacher and school. This idea highlights the importance of students' prior knowledge for their subsequent learning. Students' prior conceptions originate from previous classes and personal experiences acquired from observation, experiments, television, internet and social settings. These conceptions may facilitate or hinder their further learning.

Implicit in Bruner's constructivist theory is that it supports SWH teaching approach which encourages students to be actively involved in their learning by experimenting and connecting prior experiences with new information. The learners choose information that allows them to construct hypotheses and make decisions, which gives the needed cognitive structure. Cognitive structure provides meaning and organization for their learning experiences and allows the individual to gain more than just the basic knowledge or vocabulary for the answering test questions and also master the use of science process skills. Furthermore, in the constructivist classroom, students work primarily in groups so that learning the required knowledge is interactive and dynamic. This type of classroom emphasizes social and communication skills because the students are expected to collaborate with one another and exchange ideas (Bruner, 1996). This is in line with the SWH teaching approach.

Some studies like those of Şen and Sezen-Vekli (2016) and Arnold (2011), have shown that scientific process skills can be developed by using inquiry and science writing heuristics (discovery learning). It can also be developed through investigative approach of teaching and learning science that gives them opportunities to practice these skills. Exposing male and female biology students to scientific skills through SWH teaching approach in practical lessons could help equip them with the capacity of thinking critically, generate ideas about how the world around them works, and how living things function in their environment.

They can then apply the knowledge and skills learnt in the classroom to their everyday lives unlike when they learn through conventional methods which make it hard to acquire skills.

Conventional teaching method is a teacher-centred method whereby the teacher is seen as an authority imparting knowledge to the students. It could involve a mix of different methods, but it is mainly the lecture or expository methods that are commonly used. Although, conventional method of teaching has been shown in a number of studies to be less effective compared to other innovative methods, teachers still adopt them for teaching and learning. This is because conventional method is suitable for teaching large groups of students and for covering large content area. Conventional method has however, not proven effective for male as well as female students.

Gender is one of such factors also mentioned in various research studies to have considerable influence on students' academic achievement especially in science subjects (Ezeano, 2013). It is the range of physical, biological, mental and behavioural characteristics pertaining to and differentiating between the female and male population (Gunel, 2006). The importance of examining performance in relation to gender is based primarily on the socio-cultural differences between girls and boys. Some vocations and professions are today seen as female jobs while others are also seen as male jobs. In the society tasks that are regarded as complex and difficult are allocated to males whereas females are expected to handle the relatively easy and less demanding tasks. As a result of this way of thinking, the larger society has tended to see females as a weaker sex. Consequently, an average Nigerian girl goes to school with these fixed stereotypes (Femi & Adewale, 2012). There is need to examine therefore, the influence of gender on the acquisition of science process skills.

II. Purpose Of The Study

The purpose of the study was to investigate the effect of teaching with science writing heuristics on biology students' acquisition of science process skills.Specifically, the study sought to find out the:

1. Effect of science writing heuristics on biology students' acquisition of science process skills.
2. Effect due to gender on biology students' acquisition of science process skills.
3. Interaction effect of instructional methods and gender on biology students' acquisition of science process skills

III. Research Questions

1. What are the mean science process skills acquisition scores of students in the observing, experimenting, inferring, classifying and communicating, taught biology using science writing heuristics (SWH) teaching approach and those taught using the conventional method?

2. What are the mean science process skills acquisition scores of male and female students in the observing, experimenting, inferring, classifying and communicating, taught biology using science writing heuristics (SWH) teaching approach and those taught using the conventional method?
3. What are the mean science process skills acquisition scores of students taught biology using science writing heuristics (SWH) instructional approach and those taught using the conventional method?
4. What is difference between the mean science process skills acquisition scores of male and female students?

IV. Hypotheses

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

1. There is no significant difference in mean science process skills acquisition scores of students in the observing, experimenting, inferring, classifying and communicating, taught biology using science writing heuristics (SWH) teaching approach and those taught using the conventional method.
2. There is no significant difference in mean science process skills acquisition scores of male and female students in the observing, experimenting, inferring, classifying and communicating, taught biology using science writing heuristics (SWH) teaching approach and those taught using the conventional method.
3. There is no significant difference in mean science process skills acquisition scores of students taught biology using science writing heuristics (SWH) instructional approach and those taught using the conventional method.
4. There is no significant difference between mean science process skills acquisition scores of male and female students.
4. There is no significant interaction effect of instructional methods and gender on biology students' acquisition of science process skills

V. Method

Research Design

The design of this study is quasi-experimental, specifically the non-equivalent control group design. According to Nworgu (2015), quasi- experiment is an experiment where random assignment of subjects to experimental and control groups is not possible. The design was therefore adopted for the study because variables were manipulated within intact or pre-existing groups. The design is summarized below.

$$0_1 \quad X \quad 0_2$$
- - - - - - - - - - - - - - -
$$0_1 \quad \sim X \quad 0_2$$

Figure 1: Design of the Study

Where,
E = Experimental Group on Science
C = Conventional teaching method
0_1 = Pre-test
0_2 = Post-test
X = Treatment – SWH

Area of the Study

The study was carried out in Oshimili North Local Government Area of Delta State. Oshimili North is one of the twenty-five Local Government Areas that make up Delta State, South-south geo-political region of Nigeria. The Local Government was created in 1997 and until its creation, was part of the old Oshimili Local Government Area. The Local Government is headquartered at Akwukwu-Igbo and comprises of prominent towns such as Ukala, Ibusa, Illah and Okpanam. The people of this region speak Igbo, which the Igbo indigenes refer to as the Enuani language dialect of Igbo language. The people of Oshimili North are mostly farmers with steady and ready markets for their produce. There are nine government co-educational and two non co-educational secondary schools in Oshimili North Local Government Area. This area is considered appropriate for the study because the inhabitants of this area are mostly farmers and business people, with very few civil servants. The researcher believes that the study in this area could help equip teachers and students of biology with teaching and learning tools that could help improve achievement and acquisition of science process skills in biology.

Population of the Study

The population of the study comprised of 1,946 senior secondary school year two (SS 2) biology students of the eleven secondary schools in Oshimili North Local Government Area (Source: Ministry of Education, Asaba).

Sample and Sampling Techniques

The sample for the study is 207 senior secondary year two (S.S 2) students. Multi-stage sampling procedure was used. First, schools were stratified according to the towns in the Local Government Area. The schools were further stratified according to public and co-educational schools under each town. From the co-educational schools, purposive sampling was used to select four schools from the towns. The choice of the four selected school was because they are situated miles apart and will help to take care of class interaction of subject; an extraneous variable that involves students in the different experimental groups interacting and confounding the outcome of the study. In each of the schools, the intact classes were listed on a piece of paper and picked at random (Balloting without replacement). In the first and second schools, class arms A and B were selected as the experimental group 1, class B and A in the second and third school as experimental group II. Experimental group 1 has 52 students in the first school and 49 in the second school. while the control group had 58 students in the first and 41 students in the second school.

Instrument for Data Collection

The instrument for the study was Science Process Skills Acquisition Test (SPSAT) developed by the researcher. SPSAT consisted of four practical biology questions with a template developed by the researcher in the content areas taught which was used to evaluate the students' acquisition of the science process skills of observing, classifying, inferring, experimenting and communicating. The questions in SPSAT probes the students ability to carry out simple laboratory experiments and using science writing heuristics through writing on the templates to give an indication of their level of acquisition of science process skills. A table of specification was used to determine the areas and skills measured. Lesson plans were also developed by the researcher in the content areas taught.

Validity of the Instrument

The initial draft of the SPSAT, the objectives of the study, research questions, hypotheses and lesson plans were given two lectures from the Departments of Science Education and Educational foundation, Nnamdi Azikiwe University, Awka and one experienced Biology teacher. Validators' were requested to validate the SPAT in-terms of the following;

- Suitability of the items for the students
- Clarity of the language
- Content coverage and any other considerations

There corrections and suggestions were effected in the final copy of the instrument.

Scoring the Items

The Science Process Skills Achievement Test and Template (SPSAT) has four practical questions, each question carries ten marks which yielded a total score of 40 marks. The scores were to be converted to 100 percent by multiplying the students' score in the test with 100 and dividing with 40.

Reliability of the Instrument

The reliability of SPSAT instrument was established using Kudder-Richardon 20 (Kr-20) formula. The rationale behind the Kr-20 method is that it is appropriate for objective test items that are dichotomously scored. Kr-20 was chosen because the difficulty level in 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 in Illah and the obtained scores were tested for reliability using the formula. The coefficient of internal consistency obtained for SPSAT is 0.83.

Experimental Procedure

In 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 briefed as research assistants. The briefing program before the treatment process commenced, involved the biology teachers from the selected schools for both the experimental school and control group schools. They were briefed on how to use the science writing heuristics teaching approach, and the developed lesson plans. The briefing of the research assistant for the study lasted for one week.

In the schools used in the study, the experimental groups were taught using science writing heuristic instructional method, while the control groups was taught the same topics using the conventional method for four weeks.Before the experiment commenced the SPSAT was administered to the students as pre-tests to obtain the students' prior knowledge on the content areas to be taught. They were given no feedback on their achievement in the pretest in order to reduce test knowledge in the posttest. The teachers carried out the treatement in the experimental group as follows:

Week 1: 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 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 are requested to solve problems in the templates 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. The students were after the report requested to exchange their templates with other students so as to compare ideas and learn from each other. Thereafter, the teacher gave explanations on the stages on 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.
Week 2: Inthe second weak, the topic germination of seeds was treated. The students before the lesson were asked to plant different kinds of seeds with good soil and manure. Students were also told to monitor the growth of the seed and write down their day to day observations. To commence the lesson the teacher questioned the students on concepts relating to germination of seed. The students then using the templates attempted SWH on the topic. The teacher to facilitate interaction among students, called for explanation from students from their templates about ideas relating to germination of seeds. The students then carry out experiments with the provided apparatus and report further on their templates. Students exchanged their templates and have the teacher evaluate the reports. The teacher then offered summary on important points based on students' weaknesses.
Week 3: the concept of flower as an organ of reproduction in flowering plant was treated in week 3. The students were provided with dissecting kits, flower from different plants such as hibiscus flower, pride of barbados, ixora flower and chart showing a transverse section of an hibiscus flower. The teacher explained the contents relating to flower. The students on their part observed the specimen and identified all the part of the flowers, identified the type of ovary in the specimen, type of flower given to them as specimen, and observed the ovules of the specimen on their own and reported their observation where necessary. The students towards the end of the lesson exchanged their templates, and had the teacher evaluate their exercise. The teacher gave summary on the areas of weaknesses in the lesson.
Week 4: Adaptation in Xerophytes was treated in week four. For the experiment, students were provided with live specimen of prickly pear (opontia specie), aloe vera, Christmas cactus, and dissecting kit. The students observed the specimen on their work station and use the result of their finding to answer questions on their SWH template. As the teacher offered explanation for the lesson, students paid attention and further observed the specimen placed before them, while they try to compare the report of their findings with the teacher's explanation. After explanations from the teachers, student dissected the specimen to observe the succulent stems, waxy cuticles and compared their observations with the teachers' explanation writing down their observation to further build their report on the experiment. They exchanged their report with their classmates to observe the difference in their report.
The control group was taught the same concept using traditional laboratory experiment. The students were taught with the teacher modeling the experiment for the students after which the students are 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.

Control of Extraneous Variables

1. Experimental bias: the treatment was administered by the regular biology teachers in the respective schools to avoid experimental bias. They were trained as research assistants in the use of the instructional method before teaching the students. The researcher also made sure that each group receives the treatment due to them and are taught the same subject matter contents so that each group remained comparable to the other.
2. Teacher variable:The researcher prepared the materials and ensured the lesson contents are the same. The teachers to administer them were adequately trained in the use of the lesson packages and asked to do a mock teaching to ensure that they have mastered the strategy to be used.
3. Class interaction:The schools used in the study are all situated some distances away from each other in three different towns to avoid subject interaction.
4. Initial group difference:Analysis of covariance (ANCOVA) was used to remove the initial group differences among the students used in the study.

Method of Data Analysis

All the research questions were analyzed using descriptive statistics (Mean and Standard deviation). The hypotheses were tested for significance using analysis of covariance (ANCOVA). ANCOVA was used because it helped to take care of the initial difference among groups. The decision rule is as follows:Reject null hypothesis when P-value is less than (<) 0.05, otherwise do not reject the null hypothesis.

VI. Results

Research Question 1: What are the mean science process skills acquisition scores of students in the observing, experimenting, inferring, classifying and communicating, taught biology using science writing heuristics (SWH) teaching approach and those taught using the conventional method?

Table 1: Mean and Standard Deviation of Science Process skills (SPS) Scores of Students taught Biology using Science Writing Heuristics (SWH) and Conventional Method

SPS	Method	N	Mean Pre-test	Mean posttest	Mean gain score	SD Pretest	SD Posttest
Observing	SWH	101	4.48	10.31	5.83	1.87	3.65
	Conventional	106	4.88	8.26	3.38	1.91	1.37
Experimenting	SWH	101	2.77	6.64	3.87	1.35	1.90
	Conventional	106	2.90	4.76	1.86	1.54	0.94
Inferring	SWH	101	5.23	11.64	6.41	1.37	3.05
	Conventional	106	5.06	9.88	4.82	1.51	2.60
Classifying	SWH	101	1.24	3.91	2.67	0.79	0.87
	Conventional	106	1.29	2.37	1.08	0.78	1.02
Communicating	SWH	101	7.31	14.22	6.91	3.16	2.86
	Conventional	106	6.43	10.42	3.99	2.63	2.76

In table 1 the mean gain science process skills scores of the students exposed to SWH are observing 5.83, experimenting 3.87, Inferring 6.41, classifying 2.67, and communicating 6.91. Those exposed to conventional method had mean gain science process skills scores of observing 3.38, experimenting 1.86, Inferring 4.82, classifying 1.08, and communicating 3.99. In both groups the variation of scores increased in observing, experimenting, inferring and classifying. In communicating, spread of score decreased in the group exposed to SWH but increased in the group exposed to conventional method.

Research Question 2: What are the mean science process skills (SPS) acquisition scores of male and female students in the observing, experimenting, inferring, classifying and communicating, taught biology using science writing heuristics (SWH) teaching approach?

Table 2: Mean and Standard Deviation of Science Process skills (SPS) Scores of Male and Female Students taught Biology using Science Writing Heuristics (SWH)

SPS	Gender	N	Mean Pre-test	Mean posttest	Mean gain score	SD Pretest	SD Posttest
Observing	Male	51	4.27	10.41	6.14	1.97	3.63
	Female	50	4.68	10.20	5.52	1.77	3.70
Experimenting	Male	51	2.67	6.61	3.94	1.34	1.88
	Female	50	2.88	6.68	3.80	1.37	1.93
Inferring	Male	51	5.25	11.69	6.44	1.40	2.99
	Female	50	5.20	11.60	6.40	1.36	3.14
Classifying	Male	51	1.43	3.86	2.43	0.61	0.87
	Female	50	1.04	3.96	2.92	0.90	0.88
Communicating	Male	51	6.94	14.08	7.14	2.77	2.93
	Female	50	7.68	14.36	6.68	3.50	2.81

In table 2 the mean gain science process skills scores of the male students exposed to SWH are observing 6.14, experimenting 3.94, Inferring 6.44, classifying 2.43, and communicating 7.14. The Females had mean gain science process skills scores of observing 5.52, experimenting 3.80, Inferring 6.40, classifying 2.92, and communicating 6.68. In both groups the variation of scores increased in all the skills except in classifying and communication in which the female score variation decreased.

Research Question 3: What are the mean science process skills (SPS) acquisition scores of students taught biology using science writing heuristics (SWH) instructional approach and those taught using the conventional method?

Table 3: Pretest and Posttest Mean of SPS Scores of Students taught Biology using SWH and those taught using Conventional Method

Source of Variation	N	Pretest Mean	Posttest Mean	Gained Mean	Pretest SD	Posttest SD
SWH	101	21.02	58.39	37.37	4.10	9.39
Conventional	106	20.56	35.69	15.13	4.01	4.53

Table 3 shows that the students exposed to SWH had overall gain in mean science process skill score of 37.37 while those exposed to conventional method had overall gain in mean score of 15.13. SWH increased the spread of SPS scores much more than the use of conventional method did.

Research Question 4: What is difference between the mean science process skills acquisition scores of male and female students?

Table 4: Mean of SPS Scores of Male and Female Students in Biology

Group	Gender	N	Pretest mean	Posttest mean	Gained Mean	Pretest SD	Posttest SD
SWH	Male	51	20.57	57.24	36.67	3.26	9.13
	Female	50	21.48	59.56	38.08	4.79	9.60
Conventional	Male	56	20.51	35.96	15.45	4.08	4.92
	Female	50	20.60	35.44	14.84	3.99	4.17

Table 4 shows that the male students exposed to SWH had gain in mean science process skill score of 36.67 while the female students had gain mean score of 38.08. The male students exposed to conventional method had gain in mean science process skill score of 15.45 while the female students had gain mean score of 14.84. SWH increased the spread of SPS scores among both the male and female students.

Hypothesis 1: There is no significant difference in mean science process skills acquisition scores of students in the observing, experimenting, inferring, classifying and communicating, taught biology using science writing heuristics (SWH) teaching approach and those taught using the conventional method.

Hypothesis 2: There is no significant difference in mean science process skills acquisition scores of male and female students in the observing, experimenting, inferring, classifying and communicating, taught biology using science writing heuristics (SWH) teaching approach and those taught using the conventional method.

Hypothesis 3: There is no significant difference in mean science process skills acquisition scores of students taught biology using science writing heuristics (SWH) instructional approach and those taught using the conventional method.

Table 6: ANCOVA on difference in the mean SPS Acquisition of Students in Biology taught using SWH and those taught using Conventional Method

Source of variation	SS	df	MS	F	Sig.	Decision
Corrected Model	26925.275[a]	4	6731.319	128.008	.000	
Intercept	16927.627	1	16927.627	321.909	.000	
Pretest	2.256	1	2.256	.043	.836	
Gender	88.080	1	88.080	1.675	.197	NS
Method	26726.283	1	26726.283	508.248	.000	S
Gender * Method	31.733	1	31.733	.603	.438	NS
Error	10622.203	202	52.585			
Total	490871.000	207				
Corrected Total	37547.478	206				

Table 6 shows that there was a significant main effect of the treatment on the mean scores in science process skills of the students, F (1, 206) = 508.248, P (0.000) <0.05. Thus, the null hypothesis was rejected. Therefore, there is significant difference in the mean achievement scores of students taught using SWH and those taught using conventional method.

Hypothesis 4: There is no significant difference between mean science process skills acquisition scores of male and female students.

Table 6 also shows that there was no significant main effect of gender on the mean SPS acquisition scores of the male and female students, F (1, 206) = 1.675, P = .197 >0.05. Thus, null hypothesis was not rejected. Therefore, there is no significant difference between the mean SPS acquisition scores of male and female students.

Hypothesis 5: There is no significant interaction effect of instructional methods and gender on biology students' acquisition of science process skills.

Table 6 further reveals that there was no significant interaction effect of instructional method and gender on SPS acquisition scores of students, F (1, 206) = .603, P= 0.438 >0.05. Therefore, the null hypothesis was not rejected. There is thus, no significant interaction effect of instructional methods and gender on biology students' acquisition of science process skills.

VII. Discussion, Conclusion And Recommendations

The results of the study also revealed that SWH significantly improved students' acquisition of science process skills of observing, experimenting, inferring, classifying and communicating, when compared to those taught using SWH. The students taught using SWH had higher mean gain scores in science process skills of observing, experimenting, inferring, classifying and communicating than those taught using the conventional method. There was also a significant difference in the overall mean scores of students in the science process skills of those taught biology using science writing heuristics (SWH) teaching approach and those taught using the conventional method. The overall mean gain score in science process skill acquisition revealed that students in SWH had a mean gain score of 25.70 and those in the conventional group had an overall mean gain score of 15.13.

The significant difference in the acquired skills of both group expressed by the significant difference in their mean science process skills acquisition scores is explained by the fact that the SWH templates are a learning tool rather than just a reporting tool (McDermott, 2010). When utilizing the SWH template, students generated and clarified their understanding of scientific concepts for themselves, rather than simply communicating with a teacher for evaluation. They also develop science process skills in the course of the experiments and writing heuristics. Şen and Sezen-Vekli (2016) and Arnold (2011) have showed that science process skills can be developed by using inquiry, science writing heuristics (discovery learning) or investigative approach of teaching and learning science that gives them opportunities to practice these skills. This idea is also supported by Burner's (1966) theory that instruction should address four major aspects in learning: predisposition of the learner towards learning, the ways in which a body of knowledge can be structured so that it can be most readily grasped by the learner, the most effective sequences in which to present the learning material, and the nature and placing of rewards and punishments. The use of SWH incorporates these instructional skills in the learning process of students. The use of SWH templates by the students result in simplifying, generating new propositions, and increasing the manipulation of information, thus, improving on their science process skills.

SWH helped the students to solve problem by using scientific attitude, demonstrate the experiment, illustrate the results of the experiment, acquire knowledge about new science concepts, think independently, collect and analyze data for information and therefore acquired the science process skills of observing, experimenting, inferring, classifying and communicating. The conventional teaching method (traditional laboratory method) on the other hand do not reinforce science process skills or teach the students how to work together for a common goal, without additional guiding questions.

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. On the other hand, SWH arranges for students to interact frequently and in smaller, more intimate groups. Having knowledge of the social and cognitive behaviours of the adolescent, the teacher utilizes 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 skill. Evidence from Dirks and Cunningham (2006) showed that freshmen who participated in a course in which they were explicitly taught science process skills out-performed students who did not participate in the program in subsequent introductory biology courses

SWH is not just a tool used for writing the laboratory reports but rather an argument-based inquiry because it successfully integrates inquiry activities, collaborative group work, meaning making via argumentation and writing-to-learn strategies. The use of SWH therefore leads to acquisition of science process skills.

It was concluded therefore, that SWH positively enhance the students' acquisition of science process skills of observing, experimenting, inferring, classifying and communicating. The implication of the findings of this study is that biology teachers' adoption of SWH would indeed help students to acquire and improve science process skills through the set of activities involved in using the SWH templates. Students' achievement would also be improved whereas biology teachers consider the adoption of SWH approach to teaching biology. In the light of findings and conclusion drawn from the study, it is recommended that:

1. Provision should be made by government for students' templates just as there are work/exercise books in different subject areas. The templates should be made ready and designed according the content areas for each term so that students can utilize them for every experiment.
2. Enough time should be allotted to biology practical lesson by education administrators so that teachers can effectively use SWH to teach students important biology concepts that can enable the students transfer their knowledge to real life experiences.

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