Effect of Guided Inquiry with Analogy Instructional Strategy on Students Acquisition of Science Process Skills

Loretta Ngozi Nworgu[*], Victoria Vivian Otum
Dept of Science Education, University of Nigeria, Nsukka – Enugu State, Nigeria
* E-mail of the corresponding author: lnnworgu@gmail.com

Abstract
This study investigated the effects of guided inquiry with analogy instructional strategy on students' acquisition of science process skills in biology. The study which adopted a non-equivalent control group quasi experimental design was conducted in four secondary schools in the area. Out of these schools, two schools were exposed to the use of guided inquiry with analogy instructional approach (experimental) while the remaining two used the conventional instructional approach (control). The participants comprised 160 junior secondary class three (JS III) students.   The 'Test of Science Process Skills Acquisition' (TOSPSA) which was developed by the researchers was used as an instrument for data collection. TOSPSA was subjected to both face and content validation while it's reliability was established using Kudder-Richardson formula 20 (K-R 20). Mean and standard and the analysis of covariance (ANCOVA) were used to test the hypotheses at 5% level of significance. The result of the study revealed that whereas teaching method was statistically significant ($p<0.05$) in enhancing students' acquisition of science process skills in favour of the guided inquiry with analogy Based on these findings, it was recommended that science teachers should adopt the guided inquiry with analogy teaching method in science classrooms since it would encourage both male and female students to perform well and reduce the gap between the two groups.
Keywords: guided inquiry, inquiry, science process skills, scientific inquiry, instructional approach

1. Introduction

Science may be regarded as a dynamic and objective process of seeking knowledge which involves scientist in the process of   searching, investigating and seeking verification of natural things occurring in our environment. It can also be seen in terms of methods and processes as well as the products comprising facts, concepts, principles and laws that make up the body of science. From these views, students learning science are placed in a problem solving situation. This problem situation enriched with appropriate materials will enable them process information with a view to solving problems using the scientific method.

Some researchers have even argued that the processes which make up this method otherwise referred to as 'science process skills' are more important than the teaching of the products of science (Nzewi 2000; Nwosu, 2001). Science process skills are the abilities, potentials and technical know-how which can be developed through experience and used in carrying out mental operations and physical actions (Brotherton and Preace1995; Nwosu 2004; Funk 2006). According to Padilla (2009) they are transferable abilities appropriate to many science disciplines and reflective of the behaviour of scientists.

Science process skills can be classified as either basic or integrated (Collette and Chiappetta 2004). Basic science process skills form the backbone of the more advanced problem solving skills and capacities. These include observing, communicating, measuring, inferring, classifying and predicting. It appears that basic skills provide the intellectual ground work in problem solving.

Integrated science process skill combine two or more basic process skills and are therefore more advanced than basic process skills. They are the immediate skills that are used in problem solving. These include such skills as: identifying variables, formulating hypotheses, describing relationship between variables, designing, investigations, experimenting, acquiring data, organizing data in tables and graphs, analyzing investigations and their data, formulating models, defining variables operationally, understanding cause and effect relationships (Funk, 2006). Brotherton and Precce (1995) noted that scientists can only use integrated skills effectively once they have mastered the basic skills.

Science process skills are inseparable from the practice of science and play a key role in both formal and informal learning of science contents (Keil, Haney and Zoffel, 2009). They have the enduring quality that will contribute to students abilities to answer questions and solve problems even when the information base of science and technology changes. Hence, possession of these skills is basic to scientific inquiry and the development of intellectual skills needed to learn science concepts. In recognition of this, the National Policy on Education (NERDC, 2004) incorporated 'the acquisition of appropriate skills, both mental and physical as equipment for the individual to live in and contribute to the development of his society' as one of the national

education goals. However, it has been noted that "students at all levels show poorly developed skills of problem analysis, planning and carrying out of controlled experiments" (Hackling and Garnett, 1991:89). Their lack of skills is part of a more general and widespread problem. Biology learning and the development of science process skills are integrated activities.

On the basis of these, it would seem appropriate to require students to acquire competence in basic science process skills. Most of the topics taught in biology emphasize activity-centred learning. Therefore students should be involved in considerable hands on activities during biology lessons in order to develop the appropriate process skills. But unfortunately, studies show that the teaching of science in Nigeria secondary schools falls short of certain expectations (Aghadinuno1995; Mandor 2002; Ezeliora 2008). For instance, it has been observed that the present methods used in teaching science in secondary schools do not augur well for the acquisition of science process skills by students (Ibe 2004, Madu 2004). The nature of science as a dynamic and objective activity has great implication for the teaching and learning of science. It emphasizes science as a mode of inquiry through which knowledge is generated and expanded.

Inquiry is an approach to learning whereby students find and use a variety of sources of information and ideas to increase their understanding of a problem, topic or issue (Cheryl Bell 2003). Inquiry does not stand alone, it engages interests and challenges students to connect their world with the curriculum. According to the National Research Council (NRC 2000) inquiry teaching and learning can occur at several levels or types. These levels or types include:

- More teacher-directed: With guiding questions provided and step-by-step procedures given, students are involved with the materials in an effort to re-discover some identified phenomenon (a confirmation activity).
- Less teacher-directed: with guiding questions, suggested materials and students directed investigation (guided inquiry).
- Student-centred: allowing students to generate questions based on observations and materials are provided as needed. The teacher serves as facilitator of the activity (Open-inquiry).

The role of the teacher and the learners in generating investigation questions, planning and conducting an investigation as well as the development of scientific ideas determines the level of inquiry.

Guided inquiry which this study is employed has been defined as a set of activities characterized by a problem solving approach in which the students are most of the time placed in a problem situation and are surrounded by a lot of appropriate and suitable materials with which to explore their environment and solve problems (Nwosu and Nzewi, 1998). According to Carol and Kuhlthau, (2007) guided inquiry creates an environment that motivate students to learn by providing opportunities for them to construct their own meaning and develop deep understanding. Through guided inquiry students gain ability to use tools and resources for learning as they are learning the content of the curriculum. In guided inquiry, the activities concentrate on what students are thinking, feeling and doing as the students are learning through out the inquiry process. The end product becomes a natural way of sharing their learning with the rest of the students in their learning community.

Ruhi (2003) described analogy as comparison of something unfamiliar with something familiar in order to explain a shared principle, like a bridge that spans the gap between what a teacher wants a student to learn and what the student already knows. Glynn (1991) cited in Nworgu (2009) noted that analogy can be regarded as comparison between something that is familiar to students (base) and an unfamiliar things in science in which teachers want the students to acquire. Analogy builds on the framework of the learner's existing knowledge so that learners are not starting from the scratch. In teaching with analogies, the goal is to transfer ideas from a familiar concept (the analogue) to an unfamiliar one (the target). Analogy may play a significant role in problem solving, decision making, creativity, explanation and communication. According to Nworgu (2009), the use of analogy has been found to be very effective in teaching students in that it aids motivation and visualization of difficult concepts.

Many researches have been carried out on the use of guided inquiry on students' achievement in science and biology inclusive (Opara, 2011; Kurumeh, Jimin, Mohammed 2012). However, none of these studies tried to examine the combined effect of guided inquiry with another instructional strategy such as analogy.

1.1 Purpose of the Study

The main purpose of this study was to investigate the relative effect of guided inquiry with analogy instructional approach on male and female students' acquisition of science process skills using the conventional instructional approach as a baseline.

1.2 Hypotheses

It was therefore hypothesized as follows:

Ho_1:   There is no significant ($p<0.05$) difference in the mean score of students on science process skills when

exposed to guided inquiry with analogy instructional approach and the conventional instructional approach.

Ho$_2$:   There is no significant (p<0.05) difference in the mean process skill scores of male and female students.

Ho$_3$:   There is no significant interaction (p<0.05) effect between teaching method and gender on students' acquisition of science process skills.

2. Materials and Methods

2.1 Design

This study adopted the non equivalent control group quasi-experimental design. This is because intact classes (i.e pre-existing groups) were used, because the experiment was conducted in school setting where randomization was not possible.

2.2 Sample

The sample comprised 160 junior secondary class three (JS III) students from four co-educational secondary schools in Abia state, Nigeria. The schools were purposively selected based on the availability of:

- At least two classes of J.S III
- A functional science laboratory
- Science teachers in J.S III. who specialized in any of the three science subjects (physics, chemistry, biology and integrated science) and have not less than five years teaching experience.

2.3 Instrumentation

A Science Process Skills Acquisition Test (SPSAT) develop by the researchers was used for data collection. In its final form, SPSAT consists of 40 short-answer questions items. The items were drawn from the following units in the junior secondary school science curriculum.

• Simple food test

• Separation of mixtures.

• Electric circuit.

2.4 Experimental Procedure

Out of the four (4) schools that were used for the study, two schools were randomly assigned to experimental and control groups respectively. The science teachers from the experimental classes of each school were trained in science teaching and learning using guided inquiry complimented with analogy. These teachers were trained for a period of four days by the researchers who explained to them the use of inquiry in teaching, how teachers can infuse analogy in an inquiry based lesson and what the students are required to do. The classes that served as the experimental group were taught by those teachers that was trained while the control group was taught using conventional method by their regular teachers.

The instructional objectives, instruction materials, content as well as method of evaluation were basically same for both experimental and control groups. To ensure adherence to these two approaches detailed lesson plans were developed following each approach for the use of the teachers handling the groups.

Pretest was administered to both the control and experimental groups before the instructional intervention. After the pretest the trained teachers who were also their regular science teachers taught the students in the experimental group in their respective schools using the guided inquiry with analogy lesson plans. Students in the control groups were taught concurrently by their own regular teachers using the conventional lesson plans. The experiment was carried out during normal school periods and it lasted for four weeks. At the end of the experiment, the science teachers administered the posttest on the students in both groups.

2.5 Method of Data Analysis

Data collected from the pretest and posttest were analyzed quantitatively using the mean, standard deviation and 2-way analysis of co-variance (ANCOVA).

3. Results

The result in Table 1 shows that in the pretest, the mean achievement score of students under experimental condition was 51.53 with standard deviation of 8.42 while those students under the control condition had a mean score of 48.58 and standard deviation of 5.57. This result showed that the two groups were almost homogenous prior to the experimental intervention. After the experimental intervention, students exposed to the inquiry approach with analogy (experimental condition) had a mean achievement score of 76.30 with a standard deviation of 9.60 whereas those under the control condition had a mean achievement score 58.67 with a standard deviation of 8.56. This indicates a higher mean gain achievement score by the students exposed to the experimental condition. This

Table 1. Mean and Standard Deviation of Pre-test and Post-test Scores of Students by Method and Gender

			Pre-test		Post-test	
Group	**Sex**	**N**	**Mean**	**SD**	**Mean**	**SD**
Experimental	M	15	52.90	8.90	76.80	7.80
	F	25	50.70	8.50	76.00	9.70
	Total	40	51.53	8.42	76.30	9.60
Control	M	20	51.90	7.80	58.70	8.40
	F	24	45.81	7.30	58.64	7.40
	Total	44	48.58	5.57	58.67	8.56

result suggests that the experimental group performed better than the control group. In effect, the use of guided inquiry complimented with analogy proved superior to conventional instructional approach in enhancing student's acquisition of science process skills.

The male students under experimental condition had a mean gain score of 23.90 while their female counterparts had a mean gain score of 25.30. On the other hand, male students in the control group had a mean gain score of 6.8 whereas their female counterparts had a mean gain score of 12. 83. These figures show that the gender gap in process skills as measured by the mean gain scores, reduced substantially from 6.03 in the conventional instructional approach to 1.40 in the inquiry with analogy instructional approach.

Table 2. ANCOVA (Analysis of covariance) on Student Acquisition of Science Process Skills

Source	**Type III sum of squares**	**DF**	**Mean square**	**F**	**Sig**
Corrected model	9043.261	4	2260.815	555.773	.000
Intercept	3365.060	1	3365.060	83.013	.000
Pre test	826.120	1	826.120	20.380	.000
Teaching Method	7967.435	1	7967.435	196.550	.000
Gender	86.566	1	66.566	1.642	.204
Teaching Method X Gender	18.403	1	18.403	.454	.503
Error	3040.227	80	40.536		
Total	347359.000	84			
Corrected total	12083.488	83			

Table 2 which presents the summary of the ANCOVA shows that the treatment (i.e. teaching method) was significant at 0.05 level of significance (F = 196.55, P < 0.05). However, gender (F = 1.642, P = 0.204) and teaching method x gender interaction (F = 0.454, P = 0.503) were not significant at 0.05 level of significance.

4. Discussion

The results of this study showed that guided inquiry with analogy had a significant effect on students' acquisition of science process skills. The guided inquiry with analogy empowered the teachers to change their instructional approach by incorporating strategies that enabled learners with different characteristics to benefit from the instruction. For instance, the guided inquiry with analogy provided the students with learning experiences enriched with in-depth examples from their environment. Students' therefore had opportunities to engage in concrete activities that facilitated their development of science process skills. For instance, this approach offered the students a variety of learning experiences, opportunity to ask questions, formulate tentative solutions, make observations and draw inferences from their observations. As suggested by Elliot (2000), students tend to be more successful in tasks when they turn to their cultural environment for clues. Through analogy, the learning experiences were related to the students' cultural environment and this engendered their interest and motivation to engage in the relevant tasks that culminated in the development of science process skills.

Another significant feature of the guided inquiry with analogy which may have contributed to its relative efficacy is its activity-oriented nature. Activity oriented learning aids understanding and retention of information as noted by Ajewäle (1990). It ensures that learners irrespective of their gender participate actively in lessons through laboratory experiments, cooperative learning, asking and answering questions. Both gender groups had ample opportunities to explore, explain and elaborate their views, hence the deep understanding of the subject by the students.

The result of the study also indicated that the inquiry with analogy instructional approach produced a substantial

reduction in gender gap in the acquisition of science process skills of the students. From the study, it could be deduced that male students also participated actively because they developed greater enthusiasm and enjoyed the science lessons much more than the female students. Similar findings of instructional models that helped in bridging the gap that exists in science achievement between male and female students have been reported by Illoputaife (2001) and Nworgu (2002).

5. Conclusion
The use of guided inquiry with analogy did not only significantly enhance students' acquisition of science process skills when compared to the conventional instructional approach, it led to a significant or substantial reduction in the gap in acquisition of science process skills between males and females.

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Loretta N. Nworgu is a member of the Association for Promoting Quality Education in Nigeria (APQEN) and Nigerian Association of Education Researchers and Evaluators [NAERE]. Born in Owerre-ebiri autonomous community in Orlu LGA of Imo State on Auhust 10, 1963, she holds Ph.D and M.Ed. in science (biology) Education from University of Nigeria, Nsukka obtained in 2004 and 19 92 respectively as well as a Bachelor of Science (B.Sc.) degree [First Class Honours] in Physics Education from same university obtained in 1986. Currently, this author is a senior lecturer in biology education at the university of Nigeria

Victoria Vivian Otum is a postgraduate student in the Department of Science Education at the University of Nigeria, Nsukka, Nigeria.