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Effectiveness of Process Oriented Guided Inquiry Teaching Strategy on Students' Performance in Chemistry in Secondary Schools in Ondo State, Nigeria

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Abstract
The Study Examined Qualitative Aspect Of "O" Level West African Secondary School Certificate Practical Chemistry Syllabus And Identified Reaction Of Metals With Water As One Of The Concepts That Chemistry Teachers Avoid To Teach Due To Either Unavailability Of Chemical Regents Or Lack Of Teachers' Competence To Handle The Topic. The Study Therefore Examined The Effectiveness Of Process Oriented Guided Inquiry Leaving (POGIL) Strategy On Students' Performance In Chemistry In Secondary Schools In Ondo State, Nigeria. A Pretest, Posttest Control Group Design Was Adopted With POGIL Being the treatment and lecture method as the control group. A total of 60 Senior Secondary School chemistry students (SSS 3) were randomly selected from Akoko South West Local Government Area of Ondo State Nigeria to constitute the study sample. Two intact classes comprising 33 students for POGIL group and 27 students for the lecture method group were taught separately in their respective schools. A 1 item instrument tagged Practical Chemistry Achievement Test (CAAT) with reliability co-efficient of $r=0.78$, $p<0.05$ was used to collect data. The results showed that POGIL was more effective ($\bar{X}=12.63$) than lecture method ($\bar{X}=10.84$), $t=2.97$, $p<0.05$. The study concluded that POGIL strategy is an effective method of teaching practical chemistry concepts in general and the qualitative aspect of practical chemistry in particular.

Keywords: Effectiveness, process oriented guided inquiry, students' performance, qualitative.

1. Introduction

It has been founded that a discovery-based team environment energizes students and provides instructors with instant and constant feedback about what their students understand or misunderstand. This emphasizes that learning is not a solitary task of memorizing information, but an interactive process of refining one's understanding and developing one's skills.

Also, there is increased expectation that science education should encompass practices that embody the ways of doing science and the epistemic practices of the scientific enterprise (Brewer et al, 2011). To this end, there have been various research-based instructional practices that have been widely adopted to improve science process skills (process oriented Guided Inquiry learning (POGIL), with roots in chemistry but now widely used across range of disciplines as a pedagogy that provides opportunities for students to develop and improve specific process skills during science content learning (Moog et al, 2014) POGIL as noted by Douglas & Chiu (2012), was originally developed for curriculum in chemistry but presently has had a wider scope in other fields such as Biology and Engineering.

POGIL as a pedagogy, provides an appropriate avenue by using a Learning Cycle based on three phases of inquiry: Exploration of a model, Invention and Application. This provides opportunities for students to engage in process skills that go above and beyond content and emphasizes the process of integrating knowledge. Moog et al specifically describes seven process skills that can be developed in a POGIL learning environment when using a well-designed POGIL activity: Communication, team working, management, information processing, critical thinking, problem solving, and assessment (specifically self-assessment). That is, POGIL materials are designed to develop transferable skills in the content to be learned, with one or two process skill targets in a well-designed

POGIL activities. To realize these, students in a POGIL classroom take up individual roles with their small group communities. POGIL therefore provides an environment in which students encounter scientific practices and processes as normal part of their classroom activities.

It appears that many students avoid questions that involved qualitative analysis aspect of the West African School Certificate Practical Examination, and where such questions were attempted, candidates performed poorly as reflected in table I

Table I: Trends of Performance in Biology, Chemistry and Physics in the West African Senior School Certificate Examination May/June 2011-2016

Year	Biology			Chemistry				Physics		
	Total entry	Credit passed (A_1-C_6)	% Pass	Total entry	Credit passed (A_1-C_6)	% Pass		Total entry	Credit passed (A_1-C_6)	% Pass
2011	1,505,199	74,432	38.50	565,692	280,280	49.54		563,161	360,096	63.94
2012	1,646,150	587,044	35.66	627,302	270,570	43.13		624,658	429,415	68.74
2013	1,648,363	852,717	51.73	639,296	462,517	72.34		637,023	297,988	46.77
2014	1,365,384	766,971	56.17	636,296	397,649	62.49		635,729	386,270	60.76
2015	1,390,234	989,246	57.42	680,357	412,323	60.60		684,124	410,543	60.01
2016	1,200,367	740,345	61.68	706,873	408,122	57.74		705,125	415,655	58.95

Source: West African Examination Council, Nigeria.

From the table above, it can be seen in chemistry that students performed up to the expected standard only in 2013 with 72.034% followed by yearly decline in the students' performance in the subsequent years. The question one would ask is to what extent would the conventional method of teaching commonly used in Nigeria schools help students in solving problems involving qualitative analysis?

Qualitative analysis is an aspect of chemistry which deals with reactions of metals and non-metals with water, identification of cations and anions in simple salts or in a mixture of two or more salts and so on. These identified concepts involve pure practical work in which POCIL as a classroom and laboratory technique seek to simultaneously teach content and process skills such as the ability to think analytically and work effectively as part of a collaborative team. POGIL classroom consist of students working in small groups on specifically designed guided inquiry materials. These materials supply students with information followed by leading questions designed to guide them toward formulation of their own valid conclusions-essentially a recapitulation of the scientific method. The instructor serves as facilitator, observing and periodically addressing individual needs. POGIL is based on research that;

- teaching by telling does not work for most students
- students who are part of an interactive community, are more likely to be successful and
- knowledge is personal; students enjoy themselves more and develop greater ownership over the material when they are given opportunity to construct their own understanding. It has been founded that a discovery-based team environment energises students and provides instructors with instant and constant feedback about what their students understand and misunderstand. POGIL emphasizes that learning in not a solitary task or memorization of information, but an interactive process of refining understanding and developing one's skills.

2. Theoretical framework

The theoretical framework for this study is constructivist in nature which is guided by the notion that learning is believed to occur through students' actively constructing / generating their own meanings from different experiences to which they are exposed (Bodmer,1986). Also, POGIL is theoretically based on the conception of cognitive theorists.

Jean Piaget (1973) is considered to be the originator of the constructivist approach to education. The constructivist approach states that in order for learning to occur, a student must construct his or her own knowledge by incorporating new knowledge into existing knowledge. It is the role of the educator to provide an educational environment in which a student can construct meaning of new material learned by making meaningful connection to prior knowledge.

3. The concept of POGIL

POGIL is a classroom and classroom technique that seeks to simultaneously teach content and key process skills such as the ability to think analytically and work effectively as part of a collaborative team.

POGIL is a student-centered instructional strategy. In a POGIL classroom or laboratory, students work in small groups on specially designed activities that follow a learning cycle paradigm. There are three key characteristics of the material used in a POGIL learning environment

- They are designed for use with self-managed teams that employ the instructor as a facilitator of learning rather than as a resource of information
- They use discipline/content to facilitate the development of important process skills including higher-level thinking and the ability to learn and apply knowledge in new contexts.
- The goal of the POGIL approach is not only to develop content mastery through student construction of their own understanding, but also to enhance re-learning skills such as information processing, oral and written communication, critical thinking, problem solving and metacognition and assessment.

The key components of POGIL-is active engagement of all students through group leaving. The students work in small groups (of three or four) on a specifically designed activity, with the instructor serving as a facilitator who listens to the discussion and intervenes only when necessary.

4. Statement of the Problem

Current chemistry pedagogy is not producing a desirable results (Omoniyi, 2016). How can chemistry instruction be improved so that students can learn chemistry and produce desirable results in WAESCE.

Inquiry science lessons have been proposed as a best practices for teaching science (Nadelson,2009). Inquiry lessons require that students think and behave like scientists to generate and develop ideas based on the evidence and data they generate.

In a guided inquiry lesson, students work in small cooperative learning groups using print materials that ask questions designed to guide students to “develop their own understanding of the concept” (Combine process skills, 2009).

Guided inquiry offers a new way for teachers to assist students as they develop.

Poor performance of students in chemistry as reported by WAEC Chief Examiners Report (2016) stated that the performance of students in qualitative analysis was poor because of the following reasons:

- Failure to adhere to instruction
- Poor understanding of the questions
- Poor practical exposure and giving theoretical answer to practical questions
- Inappropriate use of terminology especially in qualitative analysis
- Inability to record observation and inference correctly, and
- Wrong fixing of ions

In view of these, sciences teachers need to seek suitable ways of reducing the failure rate in chemistry by using innovative teaching strategies, hence, POGIL is a learning activity that can improve students’ academic performance in practical chemistry if effectively used.

To guide the study, two hypotheses were formulated namely;

- There is no significant difference in the pretest scores of students on the selected chemistry concept-Reaction of metals with water
- There is no significant difference in the academic performance of students exposed to POGIL and lecture method after treatment.

5. Method

The study adopted a pretest, posttest group design. The population for the study consisted of students offering chemistry in Senior Secondary II in the 18 Secondary Schools in Akure South Local Government Area of Ondo State out of which two schools were randomly selected. Two intact science classes were selected from the two schools. A total of 60 Senior Secondary School II Chemistry Students participated in the study. The period of administration was five weeks. The concept chosen is Reaction of Metals with Water which is taught under qualitative aspect of the practical chemistry in the Senior Secondary School Practical Chemistry Curriculum.

6. Instrument and Administration

One instrument tagged Chemistry Practical Achievement Test (CPAT) was used to collect data for the study. CPAT was used as pretest and post test to determine the effect of the treatment on students' performance. This consisted 15 item short structured questions to find out students competence and skills in handling reagents, observation and writing inferential reports on the laboratory experiments carried out by the students. The questions were given to University and Secondary school chemistry teachers for vetting. This was to ensure content validity and suitability.

7. Instructional Package to POGIL

Step I: Students are divided into small groups of four students on a specially designed activity, with the instructor serving as a facilitator who listens to the discussion and intervenes only when necessary

Step II: Students are asked to identify some metals – such as Sodium (Na), Iron II & Iron III (Fe III), Magnesium (Mg), Potassium (K)

Step III: Students are asked to add water (H_20) to these identified metals and observed the reaction

Step IV: Students are to write their observations and the equations for the reactions that took place

e.g (i) $Na_{(2)} + 2H_20$ $_2Na0H + H_2$

(ii) $Mg(s) + H_20$ $MgO_{(s)} + H_{2(g)}$

(iii) $2Ks + 2\ H_20$ $2KOH + H_{2(g)}$

Step V: Teachers collects the practical notes and mark

8. Data Collection and Analysis

At the pre-treatment stage, during the first week of the study, pre-test was administered to the participating students in each school. This was followed by assigning the schools into groups.

Experimental Group I- was the POGIL group, they are given apparatus and reagents on reaction of metals with water, while the teacher serves as facilitator.

The second group is the lecture method group where the students watch the teacher as she explained the concept to the students while students are passive listeners. The two groups were taught separately by the researcher for a period of three weeks after which the post-test was administered.

At the post-treatment stage which was the last week of the experiment, CPAT was administered to both the experimental and control group as post-test. Data collected were analysed using the mean, standard deviation and t-test.

9. Results

Tables 1 and 2 present the results

Table I: Difference between the pre-treatment scores of experimental and control groups

Group	**N**	**X**	**SD**	**Df**	**t**	**p**
POGIL	33	10.64	2.24	58	0.766	0.447
LM	27	10.26	1.35			

Table II: Difference between the post-treatment scores of experimental and control groups

Group	**N**	**X**	**SD**	**Df**	**t**	**p**
POGIL	33	12.63	2.32	58	2.966	0.04
LM	27	10.84	2.26			

From table I, the t-value of 0.766 was not significant at 0.05 level. This showed that there was no significant difference between the mean scores of students exposed to POGIL (X =10.64) and lecture method (X=10.26) before treatment. Also, table 2 shows that the mean score for the students in the POGIL group (X=12.63) was higher than that of the Lecture method (X=10.84). When the mean scores were subjected to t-test, it yielded a value of 2.966 which was significant at 0.05 level.

10. Discussion

The results show that POGIL strategy was an effective method in teaching some chemistry concepts in the qualitative aspect of practical chemistry in the senior secondary school (SSS) chemistry curriculum. Specifically, POGIL is effective in the teaching of the topic- Reaction of metals with water which is an important aspect in the SSS Chemistry curriculum. This was evident in the result of the post -test in POGIL (X=12.63) and lecture method (X=10.84). The low mean scores of both the experimental and control groups before treatment indicated that students had little knowledge about the concept before treatment.

The reason for the better performance of students in POGIL group could be due to students' involvement in the use of real objects/laboratory reagents and which increased their performance on questions requiring higher order thinking such as application and analysis.

11. Conclusion

The use of POGIL strategy had an overall positive effect on students' performance and the classroom environment. Students mean scores improved as a result of higher – order thinking such as application and analysis that were involved in POGIL Class. Also, students' critical thinking improved with the use of POGIL strategy.

POGIL is both a philosophy and a strategy for teaching and learning. It is a philosophy because it encompasses specific ideas about the nature of the learning process and the expected outcomes. It is a strategy because it provides a student-centered methodology and structure that are consistent with the way people learn and achieve these outcomes. The goal of POGIL is to help students simultaneously master discipline content and develop essential learning skills.

POGIL is built on a research base, sharing the key premise that most students learn best when they are actively engaged in analyzing data, models or examples and when they are discussion ideas; when they are working together in self-managed teams to understand concepts and solve problems, when they are reflecting on what they have learned and thinking about how to improve performance, and then they are interacting with an instructor who serves as a guide or facilitator of learning rather than as a source of information.

POGIL materials guide students through an exploration to construct and facilitate the development of higher-level thinking skills and the ability to learn and apply knowledge in new contexts.

12. Recommendation

- Science teachers in general, and chemistry teachers in particular should be encouraged to use POGIL method of construction in laboratory activities so as to make them resourceful instrumentations where laboratory materials are inadequate or unavailable.
- Government should provide well-equipped science laboratory for both teachers and students to make POGIL strategy resourceful.
- Science teachers should be updated and exposed to innovative teaching strategy through seminars, workshops and in service training programme.

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