Journal of Engineering and Applied Sciences 14 (Special Issue 2): 5322-5332, 2019
ISSN: 1816-949X

Effects of Microscale Experiments on Senior Secondary School Student's Achievement and Science Process Skills Acquisition in Practical Chemistry

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Abstract: This study investigated the effects of microscale experiments on senior secondary school student's achievement and science process skills acquisition in practical chemistry. The study was conducted in Igbo-Eze North Local Government Area of Enugu State. The sample was made up of 102 students consisting of 39 male students and 63 female students. Quasi-experimental research design was adopted for the study. The scores obtained from the pre-test and post-test were analyzed using the mean and standard deviation to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypothesis at 0.05 level of significance. The findings of the study showed that, students who were exposed to microscale experiment achieved significantly, higher than their counterparts who were taught using standard experiment. Also, Students who were exposed to microscale experiment had significant higher mean science process skills acquisition score than their counterparts who were exposed to standard experiment. It was further, revealed that there is no significant difference in the mean achievement scores and mean science process skills acquisition score of male and female students in practical chemistry. However, it was further revealed that there is no significant interaction effect of experiment methods and gender on student's achievement and science process skills acquisition in practical chemistry. Based on the findings, the researchers recommended among others that: practical activities in Chemistry should not be neglected even in the phase of inadequate laboratory. However, microscale experiment which has been identified to facilitate practical activities in miniaturized form should be utilized. Teachers should also be trained on the use of microscale experiment on teaching practical chemistry.

Key words: Microscale experiment, standard experiment, science process skills, achievement, gender, practical, chemistry

INTRODUCTION

Pressure to excel in the fast growing world increases as nations seek solutions to meet up with the global growth. In today's global economy, a workforce trained in science, technology, engineering and mathematics is recognized as a primary driver of growth which is needed by many countries (MyLab, 2015). Advancement in science and technology has led to a better understanding of one's environment. This makes science inevitable for national development of any nation. Science is defined as a body of knowledge acquired through experimentation and investigation of events in nature. It is a systematic inquiry into the universe (Nworgu, 2009). Through such inquiry, knowledge, attitude and skills about the nature and natural phenomena which help in solving real life problems are acquired. According to Jantur as cited in Njoku and Ezinwa (2014) Chemistry is presumed to be the fulcrum on which all science and technology disciplines and careers are hinged for national development. Chemistry is a branch of science which deals with the studies of the structure, composition, properties and reactions of matter in different forms.

The important aspects of Chemistry can be seen in modern medicine, manufacturing industries, food processing, etc. (Anonymous, 2016). Chemistry is one of the subjects in school that is of utmost importance for the development of an economically and technologically sound country. The curriculum content of Chemistry for senior secondary schools in Nigeria is expected to enable students, acquire basic theoretical and practical knowledge and skills with the spirit of inquiry (FME., 2011). The selection of the contents was based on globalization, information/ communication technology and entrepreneurship. Chemistry being inquiry based is

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resource based. Hence, to achieve desired outcome in Chemistry, practical activity is essential. Inquiry implies that students are in control of an important part of their own learning where they can manipulate ideas to increase understanding (BE., 2016). It involves students handling science, manipulating it, working it into new shapes and formats, integrating it into every corner of their world.

Despite these laudable objectives of Chemistry at secondary school level in Nigeria, the students achievement in both internal and external examinations has been a thing of concern of major stake holders in education particularly Chemistry educators. Adeoye and Abimbola lamented that the yearly dwindling of Nigeria senior school students achievement in external examinations such as the West African Senior School Certificate Examinations (WASSCE) has been an issue of concern to all and sundry. According to Aniodoh and Egbo (2013) the unimpressive academic achievement in Chemistry at the secondary school level in Nigeria, if not nipped in the bud will have adverse consequences on the students and the society at large. WAEC. (2016) shows that student's achievement in Chemistry is poor. The WAEC Chief Examiner stated some weakness that affected the student's achievement most of which are caused by inadequate experimental experiences. They include non adherence to instructions, especially with regard to stepwise tests, cancelation/alteration of titre values to agree with that of their teacher, arithmetical errors in volume of acid used, poor mathematical skills, poor knowledge of SI units of mass concentration and molar concentration, test on solids instead of solutions, lack of knowledge of laboratory set up and names of laboratory apparatus, poor knowledge of solubility of gases in water, assigning wrong charges on ions, inability to make simple inference from observation recorded, recording of volumes of burette to one place of decimal instead of two places of decimal. Exposure to experimental work was posed as remedy to the problem (WAEC., 2016).

However, studies have reviewed that most schools are faced with poor laboratory conditions or absence of laboratory, chemical hazards, risk and environmental pollution (Tesfamariam *et al.*, 2014; Onasanya and Omosewo, 2011; Njoku and Ezinwa, 2014; Edomwonyi-Otu and Avaa, 2011) of which Chemistry students in Igbo-Eze North LGA are not left. These make the chemistry teachers resort to teaching Chemistry more theoretically than using practical activities. Chemistry has always had its practical side because it is an experimental science. Whatever was learnt about substances and their behavior during the past centuries came from observation, practical experience and deliberate scientific investigation. Achimugu (2012) stated that, Chemistry as a branch of science can be taught and learned most effectively, if Chemistry teaching involves hands-on and minds-on activities or if it is activity-centered or student-centered, rather than conventional method or chalk and talk method which is teacher-centered, theoretical, boring, disconnected and artificial. Through the act of inquiry/practical activities, scientific process skills alongside knowledge and attitude are acquired. The science process skills are those learned potentials, capabilities or intellectual skills which a child develops as a result of his/her involvement in scientific investigations (Nworgu, 2009). The process skills are the underlying skills and premises that direct the experiments. These skills pave way for arriving at scientific knowledge. These skills affect the personal, social and global life of an individual. These skills allow everyone to conduct objective investigation and to reach conclusions based on the results. Science process skills are separated into basic science process skills and integrated science process skills (Chiappetta and Koballa as cited by Zeidan and Jayosi (2015) and Ozgelen (2012). Basic science process skills consist of observing, inferring, measuring, communicating, classifying and predicting while integrated science process skills include controlling variables, defining operationally, formulating hypothesis, interpreting data, experimenting, formulating models and presenting information. This study focused on the basic science process skills which include, observing, communicating, classifying, measuring, inferring and predicting. The basic science process skills will be considered because, from the (WAEC., 2016), poor exhibition of these skills highly contributed to the student's poor achievement in Chemistry. All the 6 basic skills are important individually as well as when they are integrated together. Aside, the six basic skills, experimenting skills will also be considered because Abruscato as cited by Ozgelen (2012), stated that experimenting involves all basic and integrated processes. Acquiring scientific process skills is necessary to cope with the ever evolving needs of modern workplace especially in problem solving. According to Tifi *et al.* (2006) there is serious educational gap in bringing these skills into the classroom. The researchers believed that hands-on-investigative activities should be a significant component of science teaching to enhance acquisition of science process skills. In other word practical work/experimental activities are seen as significant components of science teaching that enhance acquisition of science process skills. Practical work refers to any type of science teaching and learning activity in which students, working either individually or in groups, interacts with materials to observe and understand the natural world (Tesfamariam *et al*., 2014). Practical work involves relating to what is real rather than to what is possible or imagined through direct experience and experiments. Standard experiment in Chemistry is carried out on a large scale in the laboratory. It requires the use of standard equipment like pipette of 20/25 cm^3 for base, burette of 50 cm^3 for acid, beakers and conical flasks of various volume, test tubes, droppers, etc. This demands that each student will use at least 100 cm^3 of acid and 50 cm^3 of the base. In standard experiment, it turns out that the chemicals will be used in a large quantity while the apparatus are large scale and expensive (Onasanya and Omosewo, 2011; Igaro *et al*., 2011; Pesimo, 2014; Tesfamariam *et al*., 2014). In such a situation, inadequacy of the resources will hinder the standard experiment or resort to grouping of the students. Grouping the students on the other hand might hinder opportunity of active participation by all students as there might be some students that will dominate the activities. Non-active participation of the students will in turn prevent the acquisition of process skills and may also lead to poor achievement. Since, experimental research involves a high consumption of expendables use of equipment and apparatus which in most cases are costly, alternative method that may enhance student's practical activities at affordable price should be considered. The use of micro scale experiment in teaching and learning of Chemistry will go a long way to achieving effective teaching and learning of Chemistry, especially in schools that lack adequate funding of the laboratory equipment, apparatus and expendables without affecting the experimental procedures and results.

Microscale experiments also referred to as small scale experiments is the process of carrying out experiment by reducing the size, mass and volume of experimental quantities (Carol Farmer and Wilson as cited in Igaro *et al*., 2011). This is done by the use of micro kits without affecting the experimental procedures and results when compared with the macro counterpart and without jeopardizing the overall learning achievement. Many of the experiments associated with general Chemistry can be carried out in simpler equipment like injection bottles, dropper bottles, syringes, well plates, plastic pipettes which are cheaper than the traditional glass ware in a laboratory. Research and Development in Mathematics, Science and Technology Education (RADMASTE) Center, University of Witwatersrand, South Africa, introduced the use of micro kits with the aim of addressing the problem of science practical work in schools of disadvantaged communities in 1990's. MyLab small scale science kits were also designed in South Africa in 2001 by CorriedToit and his colleague (Tesfamariam *et al*., 2014). MyLab small scale science kits are purpose built small scale apparatus to aid teachers and learners to enjoy science subjects through the hands-on use of the kits and by carrying out the experiments themselves (MyLab, 2015). One that performs experiment using the kits can perform experiment in a large scale laboratory confidently. Properties of the small scale Chemistry kit include, all the experiments are done with small amounts of chemicals (not more than 10-20 cm^3 of acid and 8-10 cm^3 of base), cutting costs, pollution and the danger of explosions, the kits can be used in an ordinary classrooms, very little storage space is needed and the kit is a cost-effective alternative to a full scale science laboratory. This enables the expansion of the laboratory experiences of students in large classes and introduces laboratory work into institution too poorly equipped for standard type work. Teaching Chemistry at microscale level is an innovative teaching strategy that does not just save time and effort but solve problems and issues on the high cost of chemicals and apparatus (Pesimo, 2014). Micro Scale Experiment (MSE) avails the opportunity of active participation by all students which hinders gender issue that may rise in a situation where male/female students will struggle to dominate in the activity within the group.

Gender is a psychological term and a cultural construct developed by society to differentiate between the roles, behaviour, mental and emotional attributes of males and females (Eugene and Ezeh, 2016). According to Njoku as cited by Nzewi boys always dominate science learning activities in co-educational schools, especially when the instructional materials are insufficient and the students are meant to carryout activities in groups. Such situation can affect the achievement of students in Chemistry. Aniodoh and Egbo reported that female students achieve higher than male students while Ezeudu and Theresa (2013) are of the view that male students achieve higher than their female counterparts. Achor and Ukwuru (2014) stated that achievement in Chemistry is related to gender issue. Nzewi affirmed that the brains of the male and female students can take in the subject matter of science. In the light of these controversies, the present study decided to investigate the effects of microscale experiments on male and female student's achievement and science process skills acquisition on male and female students.

Theoretically, microscale experiments is based on John Dewey and Jean Piaget constructivist theories. These theories stressed active participation of students in the teaching and learning processes which enhances student's achievement and skills acquisition. The theories are of the view that learning occurs by doing, through direct experience and interaction with the learning object and environment. They are relevant to the present study, since, it emphasizes learner-centered instructional approach which provides the students more chances of performing experiments and encourage student's interaction with the environment. Hence, it is hoped that microscale experiments will also improve the student's achievement and science skills acquisition in practical chemistry.

Purpose of the study: The major purpose of this study was to investigate the effects of microscale experiments on student's achievement and science process skills acquisition in practical chemistry. Specifically, this study sought to determine the:

- Effect of microscale experiment and standard experiment on student's achievement in practical chemistry
- Effect of gender on student's achievement in practical chemistry
- Effect of microscale experiment and standard experiment on student's science process skills acquisition in practical chemistry
- Effect of gender on student's science process skills acquisition in practical chemistry
- Interaction effect of experimental methods and gender on student's achievement in practical chemistry
- Interaction effect of experimental methods and gender on student's science process skills acquisition in practical chemistry

Scope of the study: This study was conducted in Igbo-Eze North local Government Area of Enugu State. The study focused on using microscale experiment in carrying out Chemistry experiments. The study was based on quantitative and qualitative analysis. The quantitative analysis was simple acid-base titrations. The senior secondary students III was used for the study since the content to be used is in their scheme of work for the period the experiment took place. The achievement and process skills acquired during the experiment were also considered.

Research questions: The following research questions guided the study:

- What is the effect of microscale experiment and standard experiment on student's achievement in practical chemistry?
- What is the effect of microscale experiment on the mean achievement scores of male and female students in practical chemistry?
- What is the effect of microscale experiment and standard experiment on student's science process skills acquisition in practical chemistry?
- What is the effect of microscale experiment on acquisition of science process skills in practical chemistry among male and female students?
- What is the interaction effect of experimental methods and gender on student's achievement in practical chemistry?
- What is the interaction effect of experimental methods and gender on student's science process skills acquisition in practical chemistry?

Hypothesis: The study was guided by the following null hypothesis and was tested at 0.05 level of significance.

- H_{O1}: there is no significant difference between the mean achievement scores of students exposed to microscale experiment and those exposed to standard experiment
- H_{O2}: there is no significant difference in the mean achievement scores of male and female students in practical chemistry
- H_{O3}: there is no significant difference between science process skills acquisition mean scores of students taught chemistry using microscale experiment and those using standard experiment
- H_{O4}: there is no significant difference in the science process skills acquisition mean scores of male and female students in practical chemistry
- H_{O5}: there is no significant interaction effect of microscale experiment and gender on student's achievement in practical chemistry
- H_{O6}: there is no significant interaction effect of microscale experiment and gender on student's science process skills acquisition in practical chemistry

MATERIALS AND METHODS

Design of the study: The quasi experimental research design was used for this study. Specifically, the pretest, post test non-equivalent control group design was adopted for the study. This design was considered appropriate for this study because intact classes (non-randomized groups) will be used for the study. The design is illustrated as showed below:

Group 1 O_1 X O_2

Group 2 O_1 ~X O_2

Where:

O_1	=	Pretest
O_2	=	Post test
Group 1	=	Experimental group
Group 2	=	Control group
X	=	Treatment with microscale experiment
~X	=	Treatment with standard experiment
----	=	Non equivalent of the two groups

Area of the study: The study was carried out in Igbo-Eze North Local Government Area of Enugu State. There are 21 secondary schools in the area. The choice of this area of study is based on the fact that students had recorded poor achievement in chemistry practical due to poor exposure to chemistry practical which might lead to non-acquisition of science process skills of students in the area. Also, research has shown that inadequate laboratories have hindered practical chemistry activities in the area (Nnadi *et al*., 2014).

Population of the study: The population of the study comprised all the senior secondary class III chemistry students of the 20 public senior secondary schools in Igbo-Eze North Local Government Area, Enugu State. This comprised of 1,126 SSIII chemistry students.

Sample and sampling technique: The sample size comprised 102 SSIII chemistry students (39 male and 63 female) drawn from two intact classes in two co-educational schools. The choice of 2 intact classes was to ensure proper management of students. Purposive sampling technique was used to select two intact classes and two co-educational schools. The schools were selected because gender is a variable of the study and the researchers want to find out the interaction effect of experimental methods and gender. The sampled schools were randomly assigned to experimental and control group. The experimental group comprised 40 students (16 males and 24 females) while the control group comprised 62 students (23 males and 39 females).

Instrument for data collection: The two instruments were used for data collection in this study. They were Chemistry Practical Achievement Test (CPAT) and Science Process Skills Rating Scale (SPSRS). The chemistry practical achievement test was adopted from West African Senior School Examination past questions for 2014/2015 Session. Number 1 and 2 of the practical questions covering quantitative and qualitative analysis were used. The instrument was used to collect data pertaining to the student's achievement in chemistry practical. The science process skills rating scale was developed by the researchers. The rating scale consisted of two sections, section A and B. Section A seeks personal data of the students. Section B consisted of a 22 item rating scale designed to assess the extent of acquisition of science process skills among senior secondary school III chemistry students. The SPSRS was a four point rating scale ranging from 1-4. Where poor, fair, good and excellent.

Reliability of the instrument: Trial testing was carried out using 21 SSIII chemistry students in secondary school that was not in the area of study. The Chemistry Practical Achievement Test (CPAT) was administered to the students to determine the appropriate timing for the tests, the reaction of the students towards the tests, the suitability of the test items in terms of clarity of the questions and to identify any problem which may affect the administration of the instruments during the study. The Science Process Skill Rating Scale (SPSRS) was used to rate the extent of acquisition of science process skill by the students. The rating was done while the students were engaged in the practical. Data collected from trial testing were used to determine the reliability of the instrument. The reliability coefficient of the CPAT was determined using Kendall's Coefficient of Concordance, W. A reliability index of 0.855 was obtained. The reliability of science process skills rating scale was estimated using Cronbach's alpha method, a reliability index of 0.641 was obtained. The reliability indices gotten from the instruments indicated that the instruments were reliable.

Experimental procedure: The regular chemistry teachers of the school were used to assist in the study. The study involved both experimental and control groups in the sampled schools. The chemistry teacher in the experimental group was trained using the micro kits to carry out chemistry practical. The experimental group was exposed to microscale experiment in Chemistry using the micro-kits while the control groups were exposed to standard experiment. The teachers were provided with lesson plan adequate for all the lessons for the groups, both experimental and control groups.

The exercise lasted for 6 weeks. All the students in the groups were pretested using the research instruments in the first week. The result of the pretest was collected by the researchers. While the students were engaged in answering the chemistry practical achievement test under the supervision of the regular teachers, the researchers rated their acquisition of science process skills on the spot using the science process skills rating scale. The next 4 weeks involved the teaching and learning of practical chemistry by the regular chemistry teachers in each of the sampled schools at the normal lesson periods. The instruments were administered again to the students in both experimental and control groups on the 6th week. The scores of the two groups on pre-test and post-test were computed by the researchers for data analysis.

Method of data analysis: The data obtained from the pretest and posttest was analyzed using mean and standard deviation to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypothesis at 0.05 level of significance.

RESULTS AND DISCUSSION

Research question 1: What is the effect of microscale experiment and standard experiment on student's achievement in practical chemistry?

Data in Table 1 showed that students taught practical chemistry using microscale experiment had posttest mean score of 57.60 with a standard deviation of 12.00 and mean gain score of 23.25 while their counterparts taught practical chemistry using standard experiment had posttest mean score of 43.45 with a standard deviation 9.02 and mean gain score of 11.58. The result indicates that students who were exposed to microscale experiment achieved higher than their counterparts who were taught using standard experiment:

- H_1: there is no significant difference between the mean achievement scores of students exposed to microscale experiment and those exposed to standard experiment

Table 2 showed that, the effect of microscale experiment and standard experiment were significant on mean achievement scores of students in practical chemistry. This is because the probability value of 0.000 is <0.05 level of significance, the null hypothesis was rejected indicating that the difference in the mean achievement scores of students taught practical chemistry using microscale experiment and standard experiment was significant.

Research question 2: What is the effect of microscale experiment on the mean achievement scores of male and female students in practical chemistry?

Table 3 revealed that male students taught practical chemistry had post test mean score of 50.46 with a standard deviation of 12.79 and a mean gain score of 18.61 while their female counterparts had post test mean score of 48.10 with a standard deviation of 12.11 and a mean gain score of 17.12. This indicates that male student's taught Chemistry achieved higher than their female counterparts at posttest:

- H_2: there is no significant difference in the mean achievement scores of male and female students in practical chemistry

Table 3 showed that, the effect of gender on posttest mean scores of students in practical chemistry was not significant. Since, the probability value of 0.442 >0.05 level of significance, the null hypothesis was accepted indicating that the posttest mean scores of gender were not significant.

Table 1: Mean and standard deviation of achievement scores of students taught practical chemistry using microscale experiment and those taught using standard experiment

		Pre-test		Post-test		
Groups	n	Mean	SD	Mean	SD	Mean gain
Microscale experiment	40	34.35	11.19	57.60	12.00	23.25
Standard experiment	62	31.87	10.35	43.45	9.02	11.58

Table 2: Analysis of covariance of the effect of microscale and standard experiments on student's achievement in practical chemistry

Sources	Type III sum of squares	df	Mean square	F-values	Sig.
Corrected model	5427.018[a]	4	1356.754	13.128	0.000
Intercept	17493.120	1	17493.120	169.260	0.000
Pre-test	325.925	1	325.925	3.154	0.079
Group	4670.645	1	4670.645	45.192	0.000
Gender	61.530	1	61.530	0.595	0.442
Group*gender	167.936	1	167.936	1.625	0.205
Error	10024.982	97	103.350		
Total	260354.000	102			
Corrected total	15452.000	101			

[a] $R^2 = 0.317$ (Adjusted $R^2 = 0.299$)

Table 3: Mean and standard deviation of achievement scores of male and female students in practical chemistry

		Pre-test		Post-test		
Groups	n	Mean	SD	Mean	SD	Mean gain
Male	39	31.85	10.58	50.46	12.79	18.61
Female	63	30.98	10.43	48.10	12.11	17.12

Table 4: Mean and standard deviation of science process skills acquisition taught practical chemistry using microscale experiment and those taught using standard experiment

		Pre-test		Post-test		
Groups	n	Mean	SD	Mean	SD	Mean gain
Microscale experiment	40	60.78	10.16	79.88	13.96	19.10
Standard experiment	62	59.87	6.93	72.52	6.16	12.65

Table 5: Analysis of covariance of the effect of microscale and standard experiments on student's science process skills acquisition

Sources	Type III sum of squares	df	Mean square	F-values	Sig.
Corrected model	2001.492[a]	4	500.373	5.259	0.001
Intercept	15792.828	1	15792.828	165.988	0.000
Pre-interest	510.445	1	510.445	5.365	0.023
Group	1308.969	1	1308.969	13.758	0.000
Gender	207.294	1	207.294	2.179	0.143
Group*gender	8.691	1	8.691	0.091	0.763
Error	9229.028	97	95.145		
Total	591147.000	102			
Corrected total	11230.520	101			

[a].R^2 = 0.384 (Adjusted R^2 = 0.368)

Research question 3: What is the effect of microscale experiment and standard experiment on student's science process skills acquisition in practical chemistry?

Table 4 showed that, the students who were taught practical chemistry using microscale experiment had post-test mean science process skills acquisition score of 79.88 with standard deviation of 13.96 and a mean gain score of 19.10 while those who were taught using standard experiment had posttest mean science process skills acquisition score of 72.52 with standard deviation of 6.16 and a mean gain scores of 12.65. The results indicate that the students who were exposed to microscale experiment had higher mean science process skills acquisition score than their counterparts who were exposed to standard experiment.

- H_3: there is no significant difference between science process skills acquisition mean scores of students taught chemistry using microscale experiment and those using standard experiment

Table 5 showed that the differences of microscale experiment and standard experiment were significant on science process skills acquisition mean scores of students in practical chemistry. This is because the probability value of 0.000 is <0.05 level of significance, the null hypothesis was rejected indicating that the difference in science process skills acquisition mean scores of students taught chemistry using microscale experiment and standard experiment was significant in favour of those taught using microscale experiment.

Research question 4: What is the effect of microscale experiment on acquisition of science process skills in practical chemistry among male and female students?

Table 6: Mean and standard deviation of male and female students in science process skills acquisition in practical chemistry

		Pre-test		Post-test		
Groups	n	Mean	SD	Mean	SD	Mean gain
Male	39	59.36	8.47	76.00	10.00	16.64
Female	63	60.76	8.23	74.27	10.86	13.51

Table 6 revealed that male students had post-test mean science process skills acquisition score of 76.00 with a standard deviation of 10.00 and a mean gain of 16.64 while their female counterparts had post-test mean science process skills acquisition score of 74.27 with a standard deviation of 10.86 and a mean gain scores of 13.51. This indicates that male students had higher mean science process skills acquisition score than their female counterparts.

- H_4: there is no significant difference in the science process skills acquisition mean scores of male and female students in practical chemistry

Table 5 showed that, the effect of gender on the science process skills acquisition mean scores of students in practical chemistry was not significant. Since, the probability value of 0.143>0.05 level of significance, the null hypothesis was not rejected indicating that there was no significant effects of gender on the science process skills acquisition mean scores of students in practical chemistry.

Research question 5: What is the interaction effect of microscale and standard experiments methods and gender on student's achievement in practical chemistry?

Table 7 showed that male students who were exposed to microscale experiment had post-test

Table 7: Mean and standard deviation of achievement scores of students for the interaction effect of experimental methods and gender on their achievement in practical chemistry

Groups/Gender	n	Mean	SD	Mean	SD
Microscale experiment					
Male	16	36.31	10.98	60.56	11.69
Female	24	33.04	11.36	55.62	12.04
Standard experiment					
Male	23	35.52	10.54	43.43	7.98
Female	39	29.72	9.74	43.46	9.69

achievement mean score of 60.56 with a standard deviation of 11.69 while the female students who were also exposed to microscale experiment had a posttest mean achievement score of 55.62 with a standard deviation of 12.04. Similarly, male students who were exposed to standard experiment had post-test achievement mean score of 43.43 with a standard deviation of 7.98 while the female students who were also exposed to standard experiment had a posttest mean achievement score of 43.46 with a standard deviation of 9.69. This by implication showed that both male and female students who were exposed to microscale experiment had higher posttest mean achievement scores than the male and female students who were exposed to standard experiment. Hence, there is no interaction between method and gender on student's achievement in practical chemistry.

- H_5: there is no significant interaction effect of microscale experiment and gender on student's achievement in practical chemistry

Data in Table 2 showed that, the interaction between methods and gender on student's mean achievement scores was not significant. This is because the probability value 0.205 obtained was >0.05 set as bench mark, the null hypothesis which stated that there is no significant interaction effect of methods and gender on student's achievement in practical chemistry was not rejected. Hence, the interaction effect of methods and gender on student's achievement in Chemistry is not significant.

Research question 6: What is the interaction effect of experimental methods and gender on student's science process skills acquisition in practical chemistry?

Table 8 showed that, male students who were exposed to microscale experiment had posttest mean science process skills acquisition score of 81.63 with a standard deviation of 13.42 while the female students who were also exposed to microscale experiment had posttest mean science process skills acquisition score of 77.38 with a standard deviation of 14.39. Similarly, male students who were exposed to standard experiment had posttest mean science process skills acquisition score of 73.48 with a standard deviation of 5.81 while the female students who were also exposed to standard experiment had posttest mean science process skills acquisition score of 71.13 with a standard deviation of 6.35. This by implication showed that both male and female students who were exposed to microscale experiment had higher posttest mean science process skills acquisition scores than the male and female students who were exposed to standard experiment. Hence, there is no interaction between method and gender on student's achievement in practical chemistry.

Table 8: Mean and standard deviation of achievement scores of students for the interaction effect of experimental methods and gender on their science process skills acquisition in practical chemistry

		Pre-test		Post-test	
Group/Gender	n	Mean	SD	Mean	SD
Microscale experiment					
Male	16	61.06	10.37	81.63	13.42
Female	24	50.58	10.23	77.38	14.39
Standard experiment					
Male	23	58.17	6.85	73.48	5.81
Female	39	60.87	6.87	71.13	6.35

- H_6: there is no significant interaction effect of microscale experiment and gender on student's science process skills acquisition in practical chemistry

Data in Table 5 showed that, the interaction between methods and gender on student's science process skills acquisition mean scores was not significant. This is because the probability value 0.763 obtained was <0.05 set as bench mark, the null hypothesis which stated that there is no significant interaction effect of methods and gender on student's science process skills acquisition in practical chemistry was not rejected. Hence, the interaction effect of methods and gender on student's achievement in chemistry is not significant.

The results of data analyzed in Table 1 showed that, the students who were exposed to microscale experiment achieved higher than their counterparts who were taught using standard experiment. Further, analysis in Table 2 revealed that there is a significant difference between the mean achievement scores of students exposed to microscale experiment and those exposed to standard experiment in favour of those exposed to microscale experiment. The finding agrees with the research of Pesimo (2014) who revealed that microscale experiment was effective in developing the learning outcomes of students in Chemistry. The result confirmed the findings of Tesfamariam *et al.* (2014) who affirmed that small scale Chemistry approach increased students understanding of

Chemistry concepts which accounted for the high achievement in Chemistry. The findings also strengthen the use of microscale experiment as a cost-reducing strategy in chemistry teaching which is in line with the research of Mogbo (2002).

Likewise, the findings of the study concurred with the research of Ezeano (2010) who posited that the use of small-scale experiment has a facilitative effect on the student's achievement in Chemistry. It also affirmed John Dewey and Jean Piaget constructivist theories. Dewey's theory believed that learning occurs by doing rather than by passively receiving. Dewey believed that each child is active, inquisitive and ought to learn through experience, experimentation and practical works whereas Piaget is of the opinion that learning is an active process were learners construct their knowledge through direct experience. Therefore, ensuring that students participate actively in practical chemistry lessons is essential as it promotes student's achievement. Hence, the use of microscale experiment is of great importance, since, it ensures participation and direct experience of student's in the learning process and leads to higher achievement. However, the findings of the study contradict the result of Igaro *et al.* (2011) who revealed that no significant difference existed between the learning outcomes obtained on the use of macro and micro modes, even though the chemistry students taught chemistry by the micro model had a slight edge over the macro model counterparts. On the other hand, the findings of the study supports the use of hands-on approach in teaching and learning of Chemistry which leads to high chemistry achievement in line with the research of Fatokun *et al.* (2016), Nathaniel *et al.* (2016), Achor and Ukwuru (2014) and Nbina (2012) who revealed that hands-on approach enhance students achievement in Chemistry. Therefore, ensuring that each student participate in chemistry practical activities is necessary as it enhances student's achievement. Hence, inadequate or ill-equipped laboratory or scarcity of chemicals should not hinder practical activities, since, microscale experiments in chemistry not only opportune the students direct practical chemistry experiences but also leads to higher achievement, its use is of great advantage.

The findings in Table 2 and 3 indicated that no significant difference existed in the mean achievement scores of male and female students in practical chemistry, even though the male students had a slight edge over their female counterparts. The finding is in tune with the study of Eugene and Ezeh (2016) that discovered that there is no significant difference in the mean achievement of male and female students in Chemistry. The researchers concluded that gender was shown not to be a significant factor in student's achievement. Contrary to the findings of the study, Aniodoh and Egbo (2013) showed that female students performed better than their male counterparts when taught using inquiry role instructional model. On the other hand, Ezeudu and Theresa (2013) found out that male students achieve significantly better than the female students in Chemistry which contradicts the findings of the present study.

However, the findings of this study show that gender is not a significant factor in student's achievement in practical chemistry. The findings in Table 4 showed that the students who were exposed to microscale experiment had higher mean science process skills acquisition score than their counterparts who were exposed to standard experiment. The result in Table 5 also, revealed that the science process skills acquisition mean scores of students taught Chemistry using microscale experiment is significantly higher than students taught using standard experiment.

The findings agrees with the finding of Ajoke and Joe (2012) who reported that students acquire scientific process skills when taught using student-teacher demonstration approach than when taught using teacher demonstration approach. Also, Jack (2013) revealed that laboratory adequacy and utilization influences student's acquisition of science process skills.

Hence, practical opportunities which microscale experiments grant students have been shown to have positive effect on student's science process skills acquisition. Data analyzed in Table 6 revealed that male students had higher mean science process skills acquisition score than their female counterparts. However, Table 5 revealed that no significant difference existed in the science process skills acquisition mean scores of male and female students in practical chemistry.

The finding agrees with the result of Jack (2013) who stated that gender do not influence student's acquisition of science process skills. The present study, therefore, affirmed that gender do not influence student's acquisition of science process skills.

Table 7 shows that both male and female students who were exposed to microscale experiment had higher posttest mean achievement scores than the male and female students who were exposed to standard experiment. Further analysis (Table 2) revealed that there is no significant interaction effect of experimental method and gender on student's achievement in practical chemistry. This is in agreement with the findings of Ezeano (2010) who reported that the 2-way interactive effect of ability and methods of teaching (small scale experiment and demonstration method) do not significantly affect student's achievement in Chemistry.

Table 8 shows that both male and female students who were exposed to microscale experiment had higher posttest mean science process skills acquisition scores than the male and female students who were exposed to standard experiment. Table 5 further, revealed that there is no significant interaction effect of experiment methods and gender on student's science process skills acquisition in practical chemistry.

CONCLUSION

Based on the findings and discussion of this study, the following conclusions were made. Microscale experiments in Chemistry enhance student's achievement and science process skills acquisition. It also has the advantage of reducing cost, damage and waste as small amount of chemical was used in each phase of the experiments. It also avails all student's direct practical experiences and can be used in the absence of or inadequate supply of laboratory apparatus and chemicals. There is no significant difference in the mean achievement scores and science process skills acquisition mean score of male and female students in practical chemistry. There is no significant interaction effect of experiment methods and gender on student's achievement and science process skills acquisition in practical chemistry.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made: practical activities in Chemistry should not be neglected even in the phase of inadequate laboratory apparatus and chemicals. However, microscale experiment which has been identified to facilitate practical activities in miniaturized form should be utilized. Teachers should also be trained on the use of microscale experiment on teaching practical chemistry. Teachers should avoid gender biased strategy in the learning process. Students, both male and female should be given equal opportunity and required access to practical activities. Government and school administrators should create/invest in the production of micro kits for chemistry and other science related subjects.

ACKNOWLEDGEMENT

The researchers are grateful to participants for their commitment to the study.

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