Prestige Journal of Education, Vol. 5, No. 2, December 2022 ISSN: 2645-324X (Print)
A publication of the Association for the Promotion of Innovation in Education (APIE) ISSN: 2645-3223 (Online)

Effect of Assessment Technique on Students' Acquisition of Science Process Skills in Senior Secondary School Practical Chemistry

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Abstract
This study investigated the effect of on-the-spot assessment technique on students' acquisition of science process skills in senior secondary school practical chemistry compared with the traditional paper and pencil assessment technique. The study adopted a true experimental pre-test post-test design. Purposive sampling technique was used in selecting a sample size of one hundred (100) senior secondary two (SSII) chemistry students used for the study. Two instruments, an adopted "Practical Test on Quantitative Analysis" (PTQA) and researchers-developed "Process Skills Assessment Checklist" (PSAC) were used for data collection. The instruments were validated and pre-tested for internal consistency using inter-observer reliability. Reliability coefficient of .75 was obtained. The data obtained from the study were analyzed using mean, standards deviation and analysis of covariance. The findings indicated that on-the-spot assessment technique has positive effect on students' acquisition of science process skills in senior secondary schools practical chemistry and that gender has no significant effect on the acquisition of science process skills during chemistry practicals. Based on the findings, it was recommended among others that examination bodies and science teachers should use on-the-spot assessment technique for the assessment of practical works in science.
Keyword: on-the-spot, assessment, process, skills, chemistry

Introduction
Science can be conceived as a process of inquiry and investigation. It is also a way of thinking and acting, not just a body of knowledge to be acquired by memorizing facts and principles. The scientific method demands practical examination questions that would subject students to investigational activities such as observing, measuring, classifying, communicating, predicting, inferring, questioning, among others. Critical to understanding scientific concepts is the use of scientific inquiry to develop explanations of natural phenomena. Therefore, acquisition of science process skills is a prerequisite for carrying out laboratory activities.

Science process skills are broad transferable abilities which scientists utilize when studying or investigating natural phenomena. They are the thinking skills that are used to

get information (Saat, 2004). According to Nwosu and Okeke (1995), science process skills are 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. These skills will inspire reflective thinking and innovativeness towards problem solving processes (Ozgelen, 2012). Science process skills are often classified into basic and integrated science process skills. According to the American Association for the Advancement of Science (AAAS, 2001), the basic science process skills are observing, measuring, classifying, communicating, predicting, inferring, using numbers, space/time relationships and questioning while the integrated science process skills includes controlling variables, formulating models, interpreting data, defining operationally, designing experiment and formulating hypothesis. The basic (lower order) process skills provide a pre-requisite knowledge for learning the integrated (higher order) process skills. Science process skills form the basis of the ability to carry out specific chemistry practical activities during practical examinations.

Integration of science process skills in teaching methods has been noted to improve students' performance in chemistry (Myers, 2004). They awaken and stir students' reasoning abilities towards problem solving, improving their perception and understanding of concept during learning experiences (Chan, 2002). Conflation of science process skills in teaching methods assists students to retrieve prior knowledge and anchor new incoming information in their cognitive frameworks.

Assessment technique is a strong determinant in teaching-learning process. According to Ojokuku (2008), assessment remains the most important and appropriate technique that can be used to determine whether learning has taken place or not. Omoifo and Oluruntegbe (1999) submitted that modes of assessment adopted by teachers influence the ways in which learning takes place. Ugwu (2009) opines that mode of assessment adopted by teachers influences teachers' teaching style, students' learning style and attitude towards practical work.

Science process skills acquisition can be assessed using paper and pencil assessment technique, e-testing and on-the-spot assessment technique. Pencil and paper assessment technique is an assessment technique in which learners read questions and respond in writing. This technique cannot test practical skills; it typically assesses knowledge only and students may often memorize the concepts with rote learning. Moreover, this technique assesses only the product neglecting the processes involved in achieving the results. e-testing is a method of administering tests in which the responses are electronically recorded and assessed. It makes use of computer or an equivalent electronic device. As examination bodies move toward e-testing, they are discovering that it is important to consider not only the positive benefits, but also the potential unintended consequences. These include for example, the possibility that additional training will be needed for students with disabilities to interact successfully with computers. The cost of setting up an electronic assessment system is quite expensive.

ISSN: 2645-324X (Print)
ISSN: 2645-3223 (Online)

Consequently, appropriate assessment strategy has to be employed in assessing students' performance in practical work in science if the objectives of the lesson are to be achieved; hence, the choice of on-the-spot assessment technique as the focal interest of this study. On-the-spot assessment technique is an assessment technique where one watches the completion of a task and assesses the process (how the work is done), and the product (what has been done) (Reece & Walker, 2006). It is also known as Direct Observational Assessment Technique. This technique involves scoring of both the processes and products of a task. It involves watching the completion of the task, assessing both how the task is done and what has been done as well.

On-the-spot assessment technique makes use of observation schedule that is designed for identifying and scoring the processes that the students are expected to undergo, the skills they are expected to exhibit and acquire as the activities go on and finally the answers (products) obtained. Here, students are awarded marks at different stages of the practical activities as they carry out the processes involved and exhibit the appropriate skills in carrying out the activities and in manipulating the equipment/apparatuses and also at the getting of correct product(s). Students are made to understand that their marks are spread out into processes involved and products obtained as well, and not just on the products obtained as it is with the traditional paper and pencil assessment technique. This assessment technique thus encourages the student to carry out the activities and learn the process involved as they get marks for processes involved and not only on the products. This results in the acquisition of science process skills by the students. It is against this background that this study sought to find out the effect of on-the-spot assessment technique on students acquisition of science process skills in senior secondary school practical chemistry.

Germann (2002), Olubiyo (2010) and Ugwu (2013) observed that direct observation improved the interest and achievement of students. Reece and Walker (2006) also submitted that direct observation had become more widely accepted for assessment of practical work. Giddings and Fraser (cited in Ugwu, 2013) in their study observed that assessment of practical work influences the teachers' teaching style, students' learning style and attitude towards practical work. According to Omoifo and Oluruntegbe (1999), assessment of science process skills are better done using paper and pencil assessment technique and on-the spot assessment rather than paper and pencil assessment technique only. Durun and Ozdemir (2010) observed that the introduction of direct observational assessment techniques to teaching and learning of science enabled learners to learn with insight and understanding. Rabunda and Frazer (2004) conducted a study in South Africa on the perception of teachers on the application of direct observational assessment technique in assessing practical chemistry in secondary schools. The findings indicated that direct observational assessment technique could improve students' acquisition of science process skills.

Statement of problem

It is often argued that practical work is central to teaching and learning science, and that good quality practical work helps develop students' understanding of scientific processes

and concepts (Anderson & West, 1994). The acquisition of science process skills is pre-requisite for carrying out laboratory activities. Those promoting enquiry-based approach to science education argue that if students were to learn about how science works, then they need to acquire science process skills.

The problem of this study is to determine the relative effectiveness of on-the-spot assessment technique on students' acquisition of science process skills. How effective is on-the-spot assessment technique in enhancing students' acquisition of science process skills? This study, therefore sought for plausible answers to this question.

Research questions

To guide the study, the following research questions were asked:

1. What is the difference between the mean achievement scores of students in science process skills acquisition during practical chemistry when assessed using on-the-spot assessment technique and paper and pencil assessment technique?
2. How does gender differentiate students' acquisition of science process skills during practical chemistry when assessed using on-the-spot assessment technique and paper and pencil assessment techniques?

Hypotheses

Ho1: There is no statistically significant difference in science process skills acquired by students during practical chemistry when assessed using on-the-spot assessment technique and paper and pencil assessment technique.

Ho2: There is no statistically significant difference in the science process skills acquisition of male and female students during practical chemistry when assessed using on-the-spot assessment technique and paper and pencil assessment technique.

Methodology

A true experimental pre-test post-test design was used for the study. This composed of two randomly assigned groups (experimental and control). The population of the study consisted of all the 4,812 senior secondary II chemistry students in all the 10 public secondary schools in Abak Local Government Area of Akwa Ibom State in 2020/2021 school year. The sample consisted of one hundred (100) chemistry students from two selected schools in the study area. Purposive sampling technique was used in selecting the two schools in the area, the students were randomly assigned to the groups. Both schools had fifty (50) chemistry students. The instrument "Practical Test on Quantitative Analysis" (PTQA) which was adopted from the 2019 West African Senior Schools Certificate Practical Chemistry Examination was used for data collection while "Process Skills Assessment Checklist" (PSAC) developed by the researchers was used for on-the-spot assessment of science process skills acquired by the students. The instruments were validated by experts in science education, measurement and evaluation and a chemistry teacher. The reliability of the PSAC was determined using inter-observer reliability and the reliability coefficient of .75 was obtained.

ISSN: 2645-324X (Print)
ISSN: 2645-3223 (Online)

Teachers used in the study were inducted on the use of science process approach. Teachers in the experimental group were trained on the use of on-the-spot assessment technique. Before the treatment, the students in the experimental group were pre-tested using on-the-spot assessment technique while the students in the control group were pre-tested using paper and pencil assessment technique. After the pre-test, the chemistry teachers started the experiment by teaching the students Quantitative Analysis in Chemistry using science process approach. The students in the experimental group were evaluated at regular intervals using on-the-spot assessment technique while the students in the control group were evaluated using the traditional paper and pencil assessment technique. The experiment lasted for four (4) weeks and each week, some exercises were given to the students to do after the lesson. Each group was assessed and feedback given to the students each time based on the assessment technique used. At the end of the experiment post-test were administered to the students and data collected.

The data generated from the study were analyzed using mean, standard deviation and analysis of covariance (ANCOVA).

Presentation of results

The result of the analysis is presented below in line with research questions and hypothesis.

Research question one: What is the difference between the mean achievement scores of students in science process skill acquisition during practical chemistry when assessed using on-the-spot assessment technique and paper and pencil assessment technique?

Table 1: Mean scores of science process skills acquired by students when assessed using on-the-spot assessment technique and paper and pencil assessment technique

Groups	N	Pre-test scores		Post –test scores		Mean Achievement Gain
		$\bar{x}$	SD	$\bar{x}$	SD	
On-the-spot Assessment (Experimental)	50	18.30	3.62	52.95	8.81	34.65
Paper and pencil Assessment (Control)	50	18.10	2.29	30.80	4.50	12.70

The result presented in table 1 shows that the mean pre-test and post-test scores with the standard deviation scores for the experimental group are 18.30, 52.95, 3.62 and 8.81 respectively. However, the pre-test and post-test mean scores for the control group are 18.10, 30.80, 2.29 and 4.50 respectively. Table 1 also shows that the mean achievement gain of the experimental group is 34.65 against the mean achievement gain of 12.70 of the control group indicating the superiority of the experimental group over the control group in students' acquisition of science process skills in practical chemistry.

Ho1: There is no statistically significant difference in science process skills acquired by students during chemistry practical when assessed using on-the-spot assessment technique and paper and pencil assessment technique.

Table 2: Summary of Analysis of Covariance result for experimental and control group in science process skills acquisition

Source	**Type II sum of square**	**Df**	**Means Square**	**F.cal**	**F.crit**	**Decision at p<.05**
Corrected model	7452.915	2	3726.458	159.878		
Intercept	169.939	1	169.939	.7.291		
Pre-test (Covariate)	7317.157	1	7317.157	313.933		
Treatment	308.722	1	308.722	13.245	4.24	s
Error	862.389	87	23.308			
Total	133299.000	100				
Corrected Total	11315.304	99				

The result presented in table 2 shows that the critical F and df 1 and 99 is 4.24 at .05 level of significance. Since the computed F(13.245) is greater than the critical F-value, the null hypothesis is rejected. There is, therefore, a significant difference in the science process skills acquired by students during practical chemistry when assessed using on-the-spot assessment technique and paper and pencil assessment technique. On-the-spot assessment technique has a significant positive effect on students' acquisition of science process skills.

Research question two: How does gender differentiate students' acquisition of science process skills during practical chemistry when assessed using on-the-spot assessment technique and paper and pencil assessment technique**.**

Table 3: Means cores and standard deviation of students on pre-test and post-test classified by treatment group and gender

Groups	**Gender**	**N**	**Pre-test**		**Post-test**	
			$\bar{x}$	**SD**	$\bar{x}$	**SD**
On-the-spot Assessment (Experimental)	M	26	18.78	2.53	52.89	9.59
	F	24	17.90	2.73	53.00	8.59
Paper and pencil Assessment (Control)	M	23	18.16	2.16	30.75	4.19
	F	27	18.00	2.62	30.83	5.23

The result presented in table 3 shows the post-test scores of male and female participants in the experimental group as 52.89 and 53.00 respectively while the post-test scores for male and female subjects in the control group are 30.75 and 30.83 respectively. A

ISSN: 2645-324X (Print)
ISSN: 2645-3223 (Online)

comparison of these results shows that on-the-spot assessment technique had the best enhancing effect on the performances of both male and female students with the performance of the female students being slightly higher than that of the male students. Those assessed by paper and pencil assessment technique had the least performance with the scores of the females being slightly higher than that of the males.

Ho2: There is no statistically significant difference in the science process skills acquisition of male and female students during practical chemistry when assessed using on-the-spot assessment technique and paper and pencil assessment technique.

Table 4: Summary of ANCOVA of students' post-test scores classified by treatment groups and gender with pre-test as covariate

Source	**Type II sum of square**	**Df**	**Means Square**	**F.cal**	**F.crit**	**Decision at p<.05**
Corrected model	154.521	2	77.261	.432		
Intercept	678.617	1	678.617	3.798		
Pre-test (Covariate)	42.853	1	42.853	.240		
Treatment	125.514	1	125.514	.702	4.24	ns
Error	6611.854	89	178.699			
Total	76907.000	100				
Corrected Total	6766.375	99				

The result presented in table 4 shows that the critical F at df l and 99 is 4.24 at .05 level of significance. Since the computed F (.702) is less than the critical F value, the null hypothesis is accepted. There is no significant difference in the science process skills acquisition of male and female students during practical chemistry when assessed using on-the-spot assessment technique and paper and pencil assessment technique. Gender therefore has no significant effect on the acquisition of science process skills.

Discussion of the findings

The findings from hypothesis one indicate that students assessed using on-the-spot assessment techniques differ significantly from students assessed using the traditional paper and pencil assessment technique. Students assessed using on-the-spot assessment technique acquired more skills than students exposed to the traditional paper and pencil assessment technique. This finding is in agreement with Ugwu (2013), who submitted that direct observational assessment technique improved the interest and achievement of the students assessed by direct observational assessment technique but not conventional paper and pencil assessment technique. It also agrees with the submission of Reece and Walker (2006) who submitted that direct observation had become more widely accepted for

assessment of practical work. It further agrees with Giddings and Fraser (cited in Ugwu, 2013), that mode of assessment of practical work influences the teachers' teaching style, students' learning style and attitude towards practical work. The higher acquisition of science process skills with on-the-spot assessment could be attributed to its ability to assess both the processes and products thereby compelling the students to acquire and master the skills involved in the activities.

The findings from hypothesis two revealed that there is no statistically significant difference in the science process skills acquisitions of male and female students during practical chemistry when assessed using on-the spot assessment technique and paper and pencil assessment technique. This observation corroborates with the findings of Germann (2002) and Olubiyo (2010), that gender has no significant effect on the acquisition of science process skills by students.

Conclusion

From the findings of the study, it was concluded that on-the-spot assessment technique has positive effect on students' acquisition of science process skills in senior secondary school practical chemistry and that gender has no significant effect on the acquisition of science process skills during practical chemistry.

Recommendations

1. Examination bodies and science teachers should use on-the-spot assessment technique for the assessment of practical work in science.
2. Chemistry and other science subjects teachers should develop and validate assessment checklist that can assess and score science process skills in practical works.
3. Scientific and technological skills can only be acquired through practical work. Hence, science practicals should be assessed with techniques like on-the-spot assessment that can assess both the processes and products.

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