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An Investigation into the Influence of Frequency of Practicals on the Students' Levels of Conception in Volumetric and Qualitative Analysis

By

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Abstract

The quality of science instruction is estimated by the extent to which students' conception of the phenomenon being taught is changed from non-scientific idea to scientific idea and this is the central focus of any science instruction. During chemistry practical, students can attain three levels of conception which are, macroscopic, submicroscopic and symbolic. This study constructed a two tier multiple choice questions to assess the influence of frequency of practical on the levels of conception of students in volumetric and qualitative analysis. The population consisted of all S.S.S.3 students in Ibadan south-west local and Ibadan north government areas of Oyo state, Nigeria. The sample was made of 500 male and female from both public and private schools selected from the two local governments areas. Three hypotheses were tested and two research questions raised were answered. It was found out that frequency of practical significantly influenced students' conception at the macroscopic and submicroscopic levels of conception. The result of the study showed that frequent practicals is the only means of assuring quality in science education.

Background to the study

Conceptual change is the central goal of science education. Several researchers to design novel teaching strategies that could facilitate the change in learners. Failure to attain this change results into poor performance in public examination. Chemistry education seeks to provide a course which is complete for students not proceeding to higher education while it is at the same time a reasonably adequate foundation for post-secondary chemistry course. Unfortunately students' performance in this subject is very poor as reported by Njokwu (2007). This discouraging trend has been traced to students' poor performance in chemistry practicals (WAEC 2000). The first aspect of the examination is volumetric analysis which requires students' ability to compute variables. The second aspect is the test for salts and identification of various ions called qualitative analysis. The last aspect requires students' cognitive understanding of the basic principle underlying the first two aspects. Njoku (2007) stated that students have difficulty with this last aspect. Volumetric analysis is the least difficult because it has more to do with algorithm and less of conceptual understanding. Millar (1989) opined that at the level of concepts, it is necessary to engage students in experiment, so that students can understand the theoretical ideas involved. Practical work helps students construct a meaningful concept from the laboratory experience which is useful either for further scientific study or everyday life (Toplis and Allen 2011). On the other hand several researchers argue that students participation in practical does not translate into mastery of concepts and theory (Hofstein and Lunetta 1982; Klopper 1990; Shepperson and Pizzini 1993; Watson 2000).

Onwu and Randall (2006) believes that the major reason for students' inability to solve problems in chemistry is that in most cases the chemical concepts on which the problems are based do not make sense to the students. Students often come to science lesson with varieties of non-scientific ideas of the concept to be learnt. Nott and Smith (1995) stated that experiencing science by oneself through practical in order to understand gives a deeper level of understanding rather than superficial understanding that is acquired from being lectured.

During chemistry practical, it is possible for students to attain three levels of conception as they interact with the reagents in the Laboratory. Taylor (1978) stated that

science teaching at any level should aim at developing awareness of underlying principles and interest in seeing connections between events. The first level is the macroscopic level of conception. According to Onwu and Randall (2006) this level describes the bulk properties of matter that is tangible and visible this includes colour changes, effervescence of gases, formation of precipitate and residue. Brosnan and Reynolds (2010) refer to this phenomenon as non-micro level, students are always excited with changes at this level. The second level of conception is submicroscopic level of conception. Students who attain this level of conception are able to provide explanation at the particulate level in which matter is described as being composed of atom, molecules and ions. The most important level of conception which all students must attain is the symbolic level of conception. Students at this level clearly make use of chemical symbols, formulae and equation as well as molecular structure. At this level also students are able to draw diagrams of atoms as well as models and use computer animation to symbolize matter. At this level students are able to differentiate between molecules and atoms. However, there is no established guideline among science educators and curriculum planners on the frequency of practicals in chemistry but there is a continuous outcry among sections of science community, industry and teachers on the quantity and quality of practical students are exposed to in chemistry. This is because when it comes to service delivery the practical skills of graduate scientist cannot meet the work place demand. Borich and Tombari (2004) stated that when we initially learn about something, our understanding is underdeveloped and not very sophisticated, as we have more experience with it, our understanding deepens. This study aims to ascertain whether the frequency of practical influence students' level of conceptions at the three levels of conceptions using a two tier multiple choice question.

Research Questions

1. How many students are at the different levels of conceptions?
2. Does frequency of practical influence the number of students at the various levels of conceptions?

Hypotheses

1. There is no significant influence of frequency of practical on students' conception at the macroscopic level in volumetric and qualitative analysis.
2. There is no significant influence of frequency of practical on students' conception at the submicroscopic level volumetric and qualitative analysis.
3. There is no significant influence of frequency of practical on students' conception at the symbolic level of conception in volumetric and qualitative analysis.

Methodology

Research design

The study adopted a descriptive survey design of the ex-post facto type.

Sample and sampling technique

The sample consisted of 500 students, which were purposively selected from five public schools and five private schools in the Ibadan south west and Ibadan North West local government in Ibadan metropolis. The criteria for selection are:

(a) The schools have no constraint to conduct chemistry practical.
(b) Students were selected without gender bias.
(c) The schools have chemistry teachers.
(d) The schools have registered the students for senior school certificate examination S.S.S III students were selected because they were ready to take SSCE chemistry practical examination which involves volumetric and qualitative analysis. This was very certain because they had covered volumetric and qualitative aspects of SSCE chemistry syllabus.

Instrument

The instrument contains 20 items. Each item is a two tier multiple choice volumetric and qualitative analysis conception test (**VQACT**).**VQACT** was two tiers because it intended to ascertain the levels of conceptions of students. It also contains questions on background information on gender, type of school, frequency of practical. The first tier of the items consists of content questions that have to do with macroscopic level of conception while the second tier is related to the submicroscopic and symbolic levels. The second tier revealed the underlying reasons for the option selected in the first tier. All the questions covered the qualitative and inorganic analysis. The distracters were obtained from common misconception of inorganic reactions found in the literature. Ordinary multiple choice question requires recall of facts and cannot be used to diagnose student thinking (Klassen 2006). First tier of a two tier multiple choice is usually a content question with three or four choices. The second tiers also have three or four choices but they are reasons for the choice of the first tier. Only one of the choices in the second tier is the scientifically acceptable reason while the rest are misconception and alternative misconceptions.

For example the first tier of item no 14 in the instrument Indicators **X** (pH3.4-4.4),**Y** (6.0-7.6) and **Z** (8.2-10.0),which of them is suitable for the titration of NaOH against CH_3COOH (a) **X** (b) **Y** (c) **Z** (d)**X** and **Z** Second tier.

The reason for my answer is

1. The salt formed is acidic
2. The salt formed is basic
3. There are more OH^- at the end point than H^+
4. There are more H^+ at the end point than OH^-

The correct answer to the first tier is option C and the correct option to the second tier is option 1.

Validation of Instrument

The volumetric and qualitative analysis conception test content validity was determined by giving the questions to four experienced chemistry teachers from different secondary school. The reliability of the instrument was determined when it was administered to twenty SSS 3 students who are not part of the study. The reliability index of 0.81 was obtained using Kuder-Richardson formulae 20.

Procedure

The instrument was administered to students in their schools. Students exposed to practical at least once a week or once in two weeks were classified as those exposed to frequent practicals while those who are not having that much were classified as infrequent. Those who are not exposed to practical at all are also classified as infrequent.

Scoring of the Instrument

The students' response to the two tiers multiple choice questions were scored 2 marks. One mark is assigned for correct response to first tier and one mark for the second tier where student state reasons for their choice in the first tier. No mark is awarded if the response to the first tiers was wrong and the response to the second tier was correct.

Table 1:

First tier	Second tier	Levels of Conception
Correct responses in 10 items and above	Incorrect response in 10 items and above	Macroscopic
Correct responses in 10 items and above	Correct response in 10 items	Submicroscopic
Correct responses in 15 items and above	Correct response in 15 items and above	Symbolic

It is important to note that the categorization of the levels of conceptions used in this study does not assume that students at the macroscopic level of conception absolutely lack the ability to represent matter at the submicroscopic or symbolic level rather they have low proficiency to do so. This is responsible for some students that supplied correct responses in both tiers, four of five items that were still classified as at the macroscopic levels.

Data analysis

The data for this study were analysed using both descriptive statistics of simple frequency count, mean and inferential statistics of independent t-test.

Result

Table 2: Descriptive statistic for students levels of conception and frequency of practicals

Conception level	Frequency of practical	Mean	Std. Deviation	N
Macroscopic level	Frequent,practical	18.53	4.372	110
	Not frequent practical	10.97	4.645	115
	Total	14.66	5.885	225
Submicroscopic level	Frequent practical	26.74	1.777	90
	Not frequent practical	24.86	2.117	95
	Total	25.78	2.169	185
Symbolic level	Frequent practical	31.62	1.627	50
	Not frequent practical	32.20	2.633	40
	Total	31.88	2.140	90
Total	Frequent practical	24.10	6.133	250
	Not frequent practical	19.64	9.119	250
	Total	21.87	8.078	500

Research question 1

How many students are at the different levels of conceptions?

Table 2 shows that there are 225 students at the macroscopic level of conception, at the submicroscopic level there are 185 students and 90 students at the symbolic level. This shows that majority of the students are unable to meaningfully understand the causes of the observable changes that takes place at the macroscopic level.

Research question 2

Does frequency of practical influence students' levels of conception?

Table 2 shows that out of the 225 students at the macroscopic level 115 were not exposed to frequent practical. The table also shows that of the 185 students at the submicroscopic level, 95 were not exposed to frequent practicals. On the contrary at the symbolic level, there were 50 students out of the 90 who were exposed to frequent practical.

Table 3: Independent t-test for frequency of Practical at the macroscopic level of Conception

Practical	N	Mean	Standard Deviation	Degree of Freedom	t	Sig
Frequent	110	18.53	4.372	223	12.164	.000
Not Frequent	115	10.97	4.645	222.808		

Hypotheses 1: There is no significant influence of frequency of practical on students' conception at the macroscopic level in volumetric and qualitative analysis.

From table 3, students exposed to frequent practicals obtained a mean score of 18.53 which is higher than that of their counterparts who were not exposed to frequent practicals 10.97. The difference is also significant, $p<0.05$. Hence, frequency of practical influence students' conception at the macroscopic level, therefore hypothesis 1 is rejected.

Table 4: Independent t-test for frequency of Practical at the submicroscopic level of conception

Practical	N	Mean	Standard Deviation	Degree of Freedom	t	Sig
Frequent	90	26.74	1.777	183	2.520	.013
Not Frequent	95	24.86	2.117			

Hypothesis 2: There is no significant influence of frequency of practical on students' conception at the submicroscopic level in volumetric and qualitative analysis. Table 4 shows that students exposed to frequent practicals had a mean score of 26.74 at the symbolic level whereas those who were not exposed to frequent had a mean 24.86. The difference is also significant $p<0.05$. Hence, frequency of practical influence students conception at the submicroscopic level therefore hypothesis 2 is rejected.

Table 5: Independent t-test for frequency of practical at the symbolic level of Conception

Practical	N	Mean	Standard Deviation	Degree of Freedom	t	Sig
Frequent	50	31.62	1.62744	88	.157	.875
Not Frequent	40	32.20	2.63			

Hypothesis 3: There is no significant influence of frequency of practical on students' conception at the symbolic level in volumetric and qualitative analysis.

From table 5, students who were exposed to frequent practicals obtained a mean score of 31.62 which is lower than that of their counterparts who were not exposed to frequent practicals 32.20. The difference is not significant, $p>0.05$. Hence, frequency of practical do not influence students' conception at the symbolic level, therefore hypothesis 3 was rejected.

Discussion

The results show that frequency of chemistry practical significantly influenced students' conception at the macroscopic level. This finding is not in line with the submission of Hofstein and Lunetta (1982) who concluded that laboratory work does little to improve understanding science. This may be attributed to the fact that students who are exposed to practical had a constant interaction with the observable realm of chemical reactions in volumetric and qualitative analysis. This observable realm describes bulk of tangible and visible phenomenon such as colour changes, effervescence of gases, formation of precipitates and solubility of residue and precipitates which easily capture students' attention. At the submicroscopic level the frequency of practical significantly influence students' conception. This finding corroborates that of Okebukola (2006) that student's participation in laboratory activities has the greatest independent contribution to the variance of student's performance in chemistry. Perhaps this could be explained by the way the students exposed to volumetric and qualitative analysis have opportunity to present their findings where they represent matter as atoms, molecules and ions and they are able to compare their findings with that of their peers and scientific communities. The frequency of practical did not influence students' ability to represent matter at the symbolic level because that level of representation is ontological and independent of hands on activities. The findings at the symbolic level is a total deviation from that of Hofstein, Cohen and Laraowitz (1996)

that Hebrew students who are not engaged laboratory work do not have the same conception and perception of Chemistry.

Based on these findings, frequent chemistry practicals cannot be substituted in volumetric and qualitative analysis. Therefore opportunity provided to secondary school students to carry out volumetric and qualitative analysis should not be considered as a chance to show dramatic chemical changes or to impress students with magic of chemistry rather it should be approached as an opportunity to teach scientific concepts and learn properties of chemical.

Recommendation

The Nigerian Chemistry curriculum had recommended that wherever the curriculum will be used, chemistry should be taught as an experimental science and in the absence of necessary apparatus and reagent, the teacher should improvise. The Science teacher (chemistry teachers inclusive) should be reminded through seminar and workshop the demands of the curriculum they are trying to implement. This will discourage any form of deviation from the agreed goal of science teaching including chemistry. On weekly basis, the diary of work should be regarded as incomplete if the portion meant for recording practical activities is not filled appropriately. Since teachers will teach students the way they were taught during their training, it is crucial to increase the frequency of practical during the in-service science teacher training at all levels.

Government should make financial commitment towards the building of laboratory and provision of all the necessary apparatus for practical. Just like we have interschool quiz competition which deals with theoretical part of science, the inclusion of practical in such competition where students will conduct real practical such as titration, salt analysis, mechanics and light to mention a few. Experts in various fields will grade them based on the principles of scientific process and product. The two-tier multiple choice question should be introduced as a means of evaluating students' practical knowledge. This will discourage rote learning and students will be able to relate observation to appropriate inference.

Conclusion

Students who are not familiar with physical changes at macroscopic level of conception will not be able to relate observation in chemistry practical to the appropriate inference accurately and precisely which is very important at the submicroscopic and symbolic levels. Since students cannot attain other level of conception without practical, frequent practical is the only way to ensure quality in science education at the secondary school. And it is impossible for students to attain other levels of conception without the first level. Therefore, frequent practical in chemistry is the appropriate mechanism to assure quality in chemistry education at the secondary school level.

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