CHEMISTRY TEACHERS AND THEIR SENIOR SECONDARY STUDENTS' ANSWERS TO PICTORIAL AND VERBAL QUESTIONS IN EVAPORATION

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ABSTRACT

The purpose of the study was to compare chemistry teachers' answers in a question related to evaporation with that of their senior secondary students. Two hundred and seventy six senior secondary students and their seven teachers participated in the study. The main data collecting instrument was the pictorial and verbal tests in evaporation. According to some teachers (57.14%) when water in a closed container evaporates, no particles would be noticed while about 42.86% of the teachers believe that evaporated water will contain more of water molecules and less than is found in the liquid water. Students' choice of answers to the evaporation question cut across all the options ranging from molecules of oxygen and molecules of hydrogen to water molecules present in evaporated water but less than is found in the liquid water. These and other observations were discussed in the study. Implications for chemical education were considered. *[AJCE, 3(1), January 2013]*

INTRODUCTION

One major objective of teaching Chemistry is to ensure that students learn chemical concepts meaningfully. Teachers find out what students have learnt in chemistry through evaluation. One form of such evaluation is testing. Testing exposes students' learning difficulties in subject matter and indeed in chemistry. Two issues need to be considered in students' achievement in chemistry. Firstly, what students learn and how they view science and indeed chemistry are greatly influenced by how they are taught. Secondly, teachers tend to teach using the same methods and in the same ways they are taught. Although these observations are made for general science teaching, they have implications for chemistry teaching. Following the observations, chemistry students may perform as they are taught.

Educational reform initiatives have identified the need for giving increased attention to teachers' knowledge base and ability in educational testing and assessment. Researchers in chemical education have since changed focus along this direction. For instance, in one research work (1) teachers' estimations of students' performance and actual students' achievement were studied. The study revealed that chemistry teachers tend to overestimate their students' level of achievement on the conceptual understanding test in chemistry. Teachers feel that most of their students have appropriate or partial understanding of chemical concepts and principles. Chemistry teachers' overestimation of their students' performance could also reveal that teachers lack adequate understanding about their students' difficulties in learning chemistry.

Another research (2) has also pointed out that every mistake made by students is quickly judged as a misconception, without further reflection on the actual source of the problem or any analysis of the underlying patterns in the students' reasoning that might in fact be used as a source to promote understanding.

For years, practitioners and researchers have explored how to better assist students in developing a robust conceptual understanding of chemistry. Three levels of chemical representations include macroscopic (observable properties and processes), microscopic (arrangement and motions of particles), and symbolic (chemical and mathematical notations and equations) (3). Many fundamental concepts in chemistry involve microscopic and symbolic representations, which are especially difficult for students to learn. Students' understandings rely primarily on sensory experiences that provide information about tangible, macroscopic phenomena rather than particulate-level explanations.

To support students' understandings, teachers' structured and deep conceptual knowledge base must include the ability to translate among the macroscopic, microscopic, and symbolic representations of chemistry, and specifically, in making meaningful connections between observations of macroscopic phenomena and explanations at the particulate level (4).

In a study (5) designed to compare chemistry teachers' conception with that of the college students, teachers performed better than the students on the Chemistry Concept Inventory. One finding in that study is relevant in the present study. This has to do with the teachers' conception of evaporation. The study noted that 30% of the teachers did not understand the concentration behavior of the saturated solution, stating that as water evaporates, the concentration of salt in solution goes up. Obviously, these teachers give this information to their students. Teachers have often not been exposed to situations that challenge the validity of their constructed idea, and thus they may be unaware of their own misconceptions, much less see a need to provide such meaningful situations to their students.

This study is therefore designed to assess the performance of chemistry students and that of their teachers with the view of finding out what misconceptions teachers held in the concept of

evaporations that would have been held by their students. Specifically, the researcher attempted to provide answers to the following research questions:

(i) What are the teachers' answers to the questions on evaporation?

(ii) What are the students' answers to the questions on evaporation?

(iii) How do the teachers' answers compare with the answers of the students in questions on evaporation?

METHODOLOGY

Sample

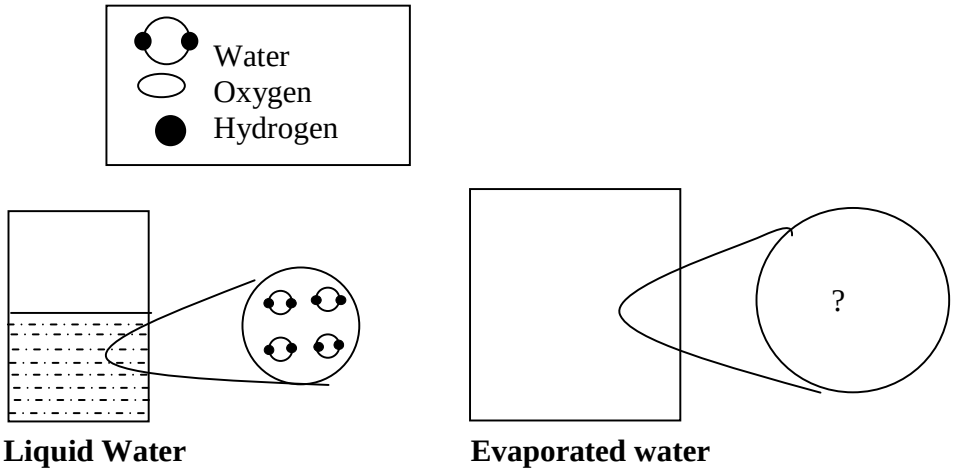
Two hundred and seventy six [276] senior secondary students from a university demonstration school and their seven teachers participated in the study. The students were made up of eighty nine [89] year 1 (SS1), ninety [90] year 2 (SS2), and ninety seven [97] year 3 (SS3) senior secondary students. These students were all offering chemistry as one of the subjects to be taken in Senior Secondary Certificate Examination. The students indicated interest to participate in the study after they were informed about the nature and the purpose of the study. Seven [7] chemistry teachers that taught the students participated in the study. These teachers have been teaching chemistry for the past ten years.

Instrument

Evaporation Test was the main data collecting instrument of the study. This test is made up of two components–the pictorial form and the verbal form. The pictorial form consists of two containers, one containing some liquid water and the other empty showing evaporated water. Students were presented with a magnified view of a very small portion of the liquid water in a closed container without air. Students were required to find out what the magnified view would

show after the liquid water had evaporated. This is similar with the test used in another study (6). Verbal form of the test was a Multiple Choice Objective Test item that required the students to find out the nature of evaporated water in a closed container (see fig. 1 for the evaporation test).

Pictorial Form



Liquid Water **Evaporated water**

The magnified view of a very small portion of liquid water in a closed container without any air would show us the molecules of water. What would the magnified view show after the water evaporated?

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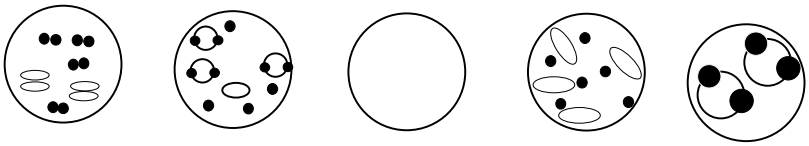

A B C D E

Verbal Form

Which of these would illustrate the nature of evaporated water in a closed container?

A Molecules of oxygen and molecules of hydrogen
B Some water molecules, atoms of oxygen, and atoms of hydrogen
C Nothing, no particles would be noticed
D Atoms of oxygen and atoms of hydrogen
E Water molecules, but less than in liquid water

Fig 1: Evaporation Test: Pictorial and Verbal Forms

Opinions of these forms of test were sought from four practicing chemistry teachers who had taught chemistry for over ten years at the secondary school level. These teachers were not part of those used for the main study. These teachers were to ascertain the suitability of the test for the purpose of the study as regard students' and teachers' choices of answers related to evaporation questions. Notably this test item has been used before in studies (6-8).

Each correct answer for both the pictorial and verbal forms was scored one point respectively. Incorrect answer was scored zero. Option E in both the pictorial and verbal forms of the test item represented the answers.

Administration of the Test

The researcher sought permission from the authority of school and explained to her the nature and the purpose of the study. Teachers, other than those used for the study in the school were called in to assist in the administration of the test. The researcher also explained to the students the nature and the purpose of the study. Students who were interested participated in the study. Students who were not interested were allowed to leave the examination hall. Pictorial form of the test was administered first which took five minutes followed by the verbal form which took another five minutes to complete. Answer scripts of the students were withdrawn after each administration. The researcher personally administered the test to the teachers following the order it was administered on the students. Administration of the test to the students and the teachers took such a short time that the participants were excited that they participated in such a study.

RESULTS AND DISCUSSIONS

Some major findings are revealed in table 1 regarding the answers picked by the chemistry teachers.

Table 1: Teachers' and Students' Answers (%) to Pictorial and Verbal Test Items

Academic Level	Pictorial Test Item (PTI)					Verbal Test Item (VTI)					
	Answer options					Answer options					
	A	B	C	D	E	A	B	C	D	E	X^2
SS1 (n=89)	11.23	15.73	35.95	21.35	15.74	20.23	23.59	23.59	17.98	14.61	14.09*
SS2 (n =90)	16.67	15.55	28.89	22.22	16.67	21.11	18.89	25.56	15.55	18.89	3.28
SS3 (n=97)	25.77	15.46	23.71	20.62	15.10	26.82	16.49	16.49	14.43	25.77	12.04*
Overall (n = 276)	17.89	15.58	29.52	21.40	15.61	22.72	19.66	21.88	15.99	19.75	10.04*
Teachers (n =7)	-	-	57.14	-	42.86	-	-	42.86	-	57.14	0.28

*Significant at P<.05, df = 4

These findings are centered on answer options C and E for the Pictorial Test Item (PTI) and the Verbal Test Item (VTI). These options show the thinking of the teachers that evaporated water consists of (i) an empty space as indicated by more than half of the teachers and (ii) few molecules of water as indicated by less than half of the teachers. This is for the PTI. This is further corroborated by answers given by the teachers in the VTI, thus option C shows "nothing, no particle would be noticed" and option E "Water molecules, but less than in liquid water". Students' answers gave a wide range of what they think about evaporated water, namely:

(i) Over 17% of the total number of students indicated that it consists of hydrogen and oxygen molecules. SS1 had the least number of students who thought this way;

(ii) About 15% of the total number of students thought that evaporated water consists of molecules of water, few hydrogen and oxygen atoms;

(iii) Over 29% of the total number of students reasoned that evaporated water consists of "nothing". The trend here is that more SS1 than SS2 and SS3 had this conception;

(iv) Evaporated water is made up of mainly hydrogen and oxygen atoms. Over 20% of the students chose this answer;

(v) About 15% of the total number of students got the correct answer that evaporated water is made up of few molecules of water (option, E);

(vi) Comparing teachers' answers with that of the students' show that while students answers were on the five options, teachers' answers were only on two (C and E);

(vii) Except for the teachers and SS2, there were significant differences in the frequencies of students' responses to the answer options of the pictorial and the verbal test items.

A recent study (9) found that students' performance on Multiple Choice exam questions depend strongly on the placement of questions and answers, with the answer order probably being the more important factor. One is not sure whether public examination bodies in Nigeria such as West African Examination Council (WAEC) and National Examination Council (NECO) consider this idea in preparing Multiple Choice examinations of various subjects they examine. The concern of the present study was not to probe what the examination bodies do. Before the students proceed to the level of writing these examinations, they have had formal instructions in the classrooms. The students, no doubt, are also familiar with multiple choice examinations. In this case teacher-made tests are placed in the picture.

In this context, it is the teacher-made test in chemistry, and specifically, a topic concerning evaporation. Students are always being assessed by their teachers. Teachers do a lot with students' assessment. For example, such assessments are used for promotion from one lower level to a higher level, classification, for scholarship award and for feedback. Students' poor performance on SSCE chemistry in June 2008 raised a lot of questions concerning how

teachers carried out their duties. Do the chemistry teachers possess the required content knowledge to teach Senior Secondary Students?

Although the present study is more or less a pilot study, it exposed teacher-learner link in chemistry. In the test given to the students in which their teachers were requested to respond to, variations of teacher-teacher answers, teacher-student answers and student-student answers were observed. What quickly draws one's attention is the responses of the teacher and that of the students to the test item. While students' responses cut across the five options given for both the pictorial and verbal test items, teachers' responses were restricted to only two. This seems to suggest, in a way, that teachers show particular interest in teaching some chemistry topics at the expense of others. Possibly students are left on their own to study such topics that are not taught by the teachers. Teachers should try as much as possible to cover all the topics in chemistry syllabus knowing full well that the examination body can pick question from any part of the syllabus. In this light, science educators and indeed chemical educators have advocated team teaching in order to help students fully grapple with all aspects of the chemistry content.

Regarding the test on evaporation, students and teachers showed indications of misconception. It is probable that students' misconception arose from their teachers' misconception. Students responded to the test items according to how they were taught. Further research need to confirm these assertions.

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