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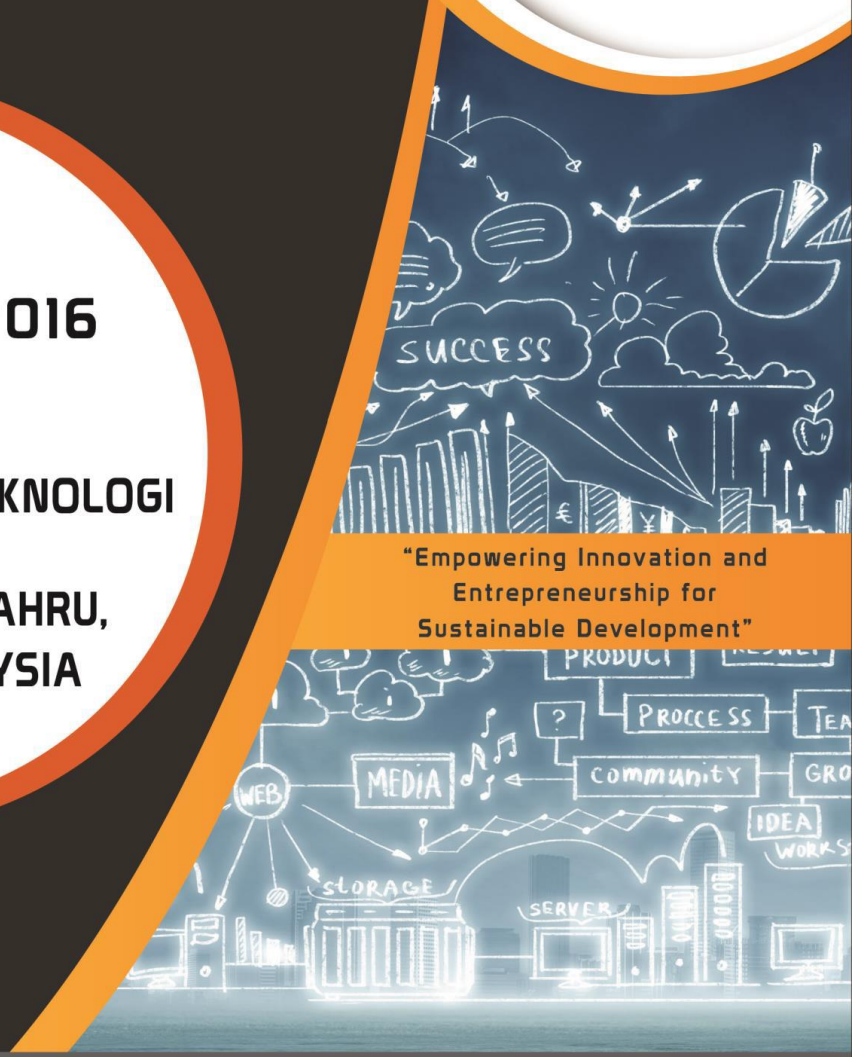

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A STUDY ON MALAYSIAN SCIENCE STUDENTS CONCEPTION OF ACIDS AND BASES

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ABSTRACT

Knowledge of chemistry involves abstract concepts and it should be explained in three representative levels, namely, macroscopic representative level, sub-microscopic representative level and symbolic representative level [7]. The first concrete and actual level is the macroscopic level which contains visible and tangible concepts or processes; the second level is about the actual phenomenon which explains the sub-microscopic level depicting entities which are too small to be seen under an optical microscope and, the bonding within and between them and the third level is symbolic, which involves figures, signs, symbols, letters, equations, mathematical representations and formulae. The success of students in mastering the concepts of Chemistry is closely related to their ability to create relationships among the three levels of representation. The different levels of representation are integral to understanding chemical phenomena, a fact that makes learning in chemistry challenging. To understand chemistry in a meaningful way, students need to be exposed to the three levels of representation in chemistry. Relying on this basis, the purpose of this study is to investigate the student's conception of acids and bases according to these representation level among form four science stream students. The test was administrated by the researchers involving a total of 146 respondents from three different schools. The instrument used in this study is Chemistry Achievement Test (CAT). This achievement test consisted of 4 different items, based on the multiple representations by Johnstone [7] covering the topic of Acids and Bases, developed according to the Malaysian context. The measurement of CAT is based on three representation level, which is macroscopic, sub-microscopic and symbolic level. The finding revealed that the student's achievement in the test is at the low level with the mean score of 31.28. The minimum score is 0.00 while the maximum score is 83.33 with standard deviation of 18.11. All of this finding will be discussed further in this paper including the difficulties faced by students in each representation level that have been evaluated.

Key words: Multiple representation, Science education, Acid and base, Chemistry.

INTRODUCTION

Chemical knowledge is represented at three levels, namely, macroscopic, sub-microscopic and symbolic levels [9]. The first concrete and actual level is the macroscopic level which contains visible and tangible concepts or processes; the second level is about the actual phenomenon which explains the sub-microscopic level depicting entities which are too small to be seen under an optical microscope and, the bonding within and between them [2] [6] and the third level is symbolic, which involves figures, signs, symbols, letters, equations, mathematical representations and formulae [10] [11] [6] [4]. All of these three representational levels are interrelated with each other in the *Chemistry Triangle* [7]. The success of students in mastering the concepts of Chemistry is closely related to their ability to create relationships among the three levels of representation. All of these three levels should overlap significantly during the learning process, so that, within the long-term, the students' memories develop appropriate mental models that reflect adequate levels of chemical literacy [3] [4]. From observations of the macroscopic changes, students have to explain these changes at the particulate level, which in turn is represented by symbols and formulas. As a result of having to deal with these three levels of representation simultaneously and the acquisition of knowledge by students without a clear understanding, confusion arose among the students who generally experienced difficulty in explaining chemical concept [5]. Any chemistry teaching that cannot relate these three chemistry representation properly will have great possibility to create misconceptions in students and make them cannot fully understand the concept [14]. In Chemistry there are some topics that students find more difficult to understand, one of those topics is acids and bases [14] [16] [17]. The topic of acids and bases is dense with concept and requires an integrated understanding of many areas of introductory chemistry [15].Therefore the purpose of this study is to investigate the student's conception of acids and bases according to these representation level among form four science stream students.

STUDENTS CONCEPTION OF ACID AND BASES

In identifying students' conception of acids and bases, Chemistry Achievement Test (CAT) by [21] was used as the instrument. The test comprised 4 different items, based on the multiple representations by Johnstone [7] covering the topic of Acids and Bases, developed according to the Malaysian context. It is based on three levels of representation, namely, macroscopic, sub-microscopic and symbolic levels as shown in Table 1.

Table 1. Distribution of CAT item based on subtopic and representation level

Subtopic	Chemical properties of acid	Strength of an acid	Concentration of an acid	Neutralization
Item	1	2	3	4
Macroscopic	1a	2a	3a	4a
Sub-microscopic	1b	2b	3b	4b
Symbolic	1c	2c	3c	4c

The students were allotted a total of 40 minutes to solve the questions, and their responses were categorized according to a rubric, modified from those of Erickson [12] and Noor Dayana

[13]. Table 2 shows the scoring rubric to determine the level of students' mastery of concepts, while Table 3 shows the Rating Scale of Chemistry Achievement Level used to determine the level of students' mastery of concepts in Chemistry.

Table 2. Scoring Rubric for Chemistry Achievement Test

Representation Level	Scoring Criteria	Score Awarded
Macroscopic	Answer or statement given is not aligned with the scientific concept/Does not answer	0
	Answer or statement given is aligned with the scientific concept	1
Sub-microscopic	Answer or statement given is not aligned with the scientfic concept/Does not answer	0
	Partial of answer or statement given is aligned with the scientific concept	1
	Answer or statement given is aligned with the scientific concept	2
Symbolic	Answer or statement given is not aligned with the scientific concept/Does not answer	0
	Partial of answer or statement given is aligned with the scientific concept	1
	Answer or statement given is aligned with the scientific concept	2

Each of the students' answers was qualitatively analyzed and checked for its consistency with scientific concepts, after which, the answers were categorized according to the levels shown in Table 3.

Table 3. Rating Scale of Chemistry Achievement Level

No of Marks	Percentage of Marks	Level
14-20	$70 \leq x \leq 100$	High
7-13	$35 \leq x \leq 65$	Moderate
0-6	$0 \leq x \leq 30$	Low

The students' achievement levels were categorized based on three levels, namely, low, moderate and high. Overall, the students' mastery of concepts in Chemistry was found to be at a low level, with a mean of 31.28%. The descriptive analysis of the students' mastery of concepts in Chemistry is shown in Table 4.

Table 4. Descriptive statistic of test scores of students (N=146)

N	Min	Max	Mean	Standard Deviation
146	0.00	83.33	31.28	18.11

Based on Table 4, the scores obtained fall in the range of 0 – 83, with a mean score of 33.53. While the frequencies of the test score is shown in Figure 1.

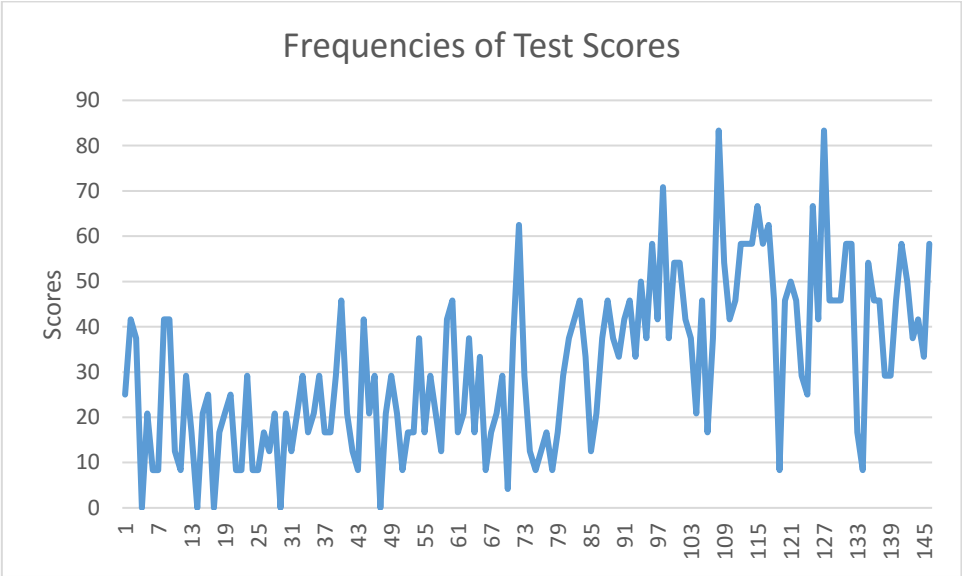

Figure 1. Frequencies of test scores of students (N=146)

Although the overall results showed a low mastery level, the descriptive analysis made, based on the level of representation in Table 5, also showed a low-level performance, at the macroscopic and symbolic levels, with mean values of 56.68% and 30.05%, respectively. and sub-microscopic performance was also at the low level, with a mean value of 7.11%.

Table 5. Descriptive statistic of test scores based on representative level

Representation Level	N	Minimum	Maximum	Mean	Standard Deviation
Macroscopic	146	0.00	100.00	56.68	29.70
Sub-microscopic	146	0.00	62.50	7.11	13.12
Symbolic	146	0.00	100.00	30.05	24.55

The results indicated that, the students' mastery at all representation is low with the sub-microscopic level was the most problematic for them.

DIFFICULTIES FACED BY STUDENTS IN EACH REPRESENTATION LEVEL

Based on the qualitative analysis carried out, a number of major difficulties and mistakes often experienced by the students at all the representation levels were identified. For questions on macroscopic representation, most students could state their observations correctly, although there were those who failed to make observations. For example, in the third CAT question, students were required to determine the pH value of two solutions with the same volume but different concentrations. It was found that, they could not relate the concentration value with the number of moles of the hydrogen ions per unit volume, resulting in incorrect solution being selected. In addition, the students also had difficulties determining the colour change of phenolphthalein on reaching the end point. This was because, they found the term "end point" awkward, while some of them just could not tell the colour change of the phenolphthalein indicator correctly. Most of the students memorized the end point concept, but failed to apply it well when answering questions. These difficulties showed that students had not fully understood about acids and bases [15] and they do not know what is actually they have to observed. For questions which required them to observe reactions of ethanoic acid with magnesium, most of them provided the correct answer, namely, release of gaseous bubbles. Very few of them had the answer of magnesium plate becoming thinner.

For the section in sub-microscopic representation, almost all the students failed to answer correctly. This indicated that, the students had not mastered the knowledge on reactions between particles, that is invisible to the naked eye. They failed to describe the particles in the proper forms as either atoms, molecules or ions. Although indicators were provided on each of the questions, they still failed to get the correct answers. As an example, for questions which required the students to describe particles for ethanoic acid solution, most of them drew them as molecules. There were no hydrogen ion and ethanoate ion shown in their sketch. In addition, they also failed to describe the ionization process that occurred to ethanoic acid. They failed to state the role of water in the ionization process, schematically. In fact, there were also students who drew the ethanoic acid particles in the same state, before and after the ionization process, as if the process did not actually take place. Although some of them were able to state the definition of ionization correctly, orally, they failed to describe the ionization process. This clearly showed that, these students learnt the subject by memorizing without a clear understanding of the meaning of a fact or a concept.

Another difficulty faced by the students was to visualize particles of two solutions of the same volumes but different concentrations. When asked orally, they answered correctly, choosing the solution that was more concentrated, but when asked to draw differences in particles of both solutions, they failed to do so. The sketch drawn could not distinguish the number of water molecules supposedly present in both solutions. This difficulty shows that most of students just focused in memorizing the formulas and theories given in learning process without comprehending them [14] [20]. For questions which required the students to draw a picture of the particles in the conical flask during the titration process, almost all of them failed do it. Among the major mistakes in this section were, the student still drew a picture of acid molecules in the conical flask, whereas, by then, all the molecules of hydrochloric acid dripped

through the burette had already reacted with potassium hydroxide the flask to form potassium chloride and water. Some of the students had the same number of potassium hydroxide and hydrochloric acid in their drawings. This indicated that, they could not relate between the number of particles which had reacted and that which had not.

In this study, most of the students answered well for the symbolic representation level, except a small number of them who failed to write balanced ionization equations and chemical equations. For example, in questions which required them to state the ionization equation for ethanoic acid, most of the students could not write it correctly, mainly due to incorrect ionic formula, specifically, that of ethanoate ion. In addition, for questions with chemical equations, there were students who wrote wrong chemical formulae for potassium hydroxide. As a result, the overall chemical equations written were wrong. Another identified problem was that, the students failed to understand the meaning of chemical formulae. The third question required students to state the chemical formula for hydrochloric acid. The right answer to be given was HCl. However, some of the students wrote the chemical formula in the forms of hydrogen ions and chloride ions. Sirhan [19] also have recognized this as one of main problems in learning chemistry. He explained that the use of representational symbolisms in chemistry could create misunderstandings and confusions and suggested that students should be given more opportunity to verbalise and discuss ideas when chemistry concepts were being taught. Based on this discussion, there was a variety of difficulties faced by the students in all the three representation levels. Thus, initiatives should be intensified to help students overcome these difficulties, in order for them to understand the concepts of Chemistry better.

CONCLUSION

As a conclusion, the students achievement on topic of acid and base is at low level with mean of 31.28. This shows that the student are having a problem to create relationships among the three levels of representation. This finding was supported by the previous research that revealed that students are often unable to see the linkages between the three levels of representation although they may know Chemistry at all the three levels. They also find these representations difficult to grasp and use. Thus, it is important to help students see the connections between the three levels of representation so that they will be able to generate comprehensible explanations [10] and generate relational understanding [8]. Although, the most difficult challenges faced by Chemistry teachers in teaching the subject is conveying students with the three chemical representations when explaining the concepts of Chemistry [1] opportunities and exposure should be provided to the students to the three levels of representations, in order for them to master the concepts of Chemistry better.

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