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MATTER CONCEPT: SUBMICROSCOPIC LEVEL OF DEVELOPMENT IN STUDENTS OF VARIOUS AGE GROUPS

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Based on purposive sampling of 604 secondary students and training institute teachers, this study is conducted to understand the development of the matter concept on the submicroscopic level among students of various age groups (16-17 to 24-25 years). A qualitative study with descriptive design was implemented across the ages. A total of ten open-ended questions from Ujian Kefahaman Konsep Jirim pada Aras Submikroskopik (SUKKJPAS) were used to collect the data. The data then were analysed using descriptive study and content analysis. The results show that the development of the matter concept on the submicroscopic level among the students is moderate from the scientific explanation aspect and poor from the scientific drawing aspect. Majority of the students had a basic knowledge about scientific explanation and scientific drawing;- in fact, in terms of scientific explanation, - the matter concept improves across the age groups. Therefore, this study proposes that teachers emphasize the creation of a drawing when giving an explanation about chemical phenomenon or situation in order that the students will have a greater understanding as well as simultaneously familiarizing the students with scientific drawing. Students on the other hand needs to be urged to adapt this concept in giving explanation about chemical phenomenon or situation.

Keywords: science education, matter, submicroscopic level, scientific explanation, scientific drawing

INTRODUCTION

Matter is identified as one of the fundamental concepts that should be understood by students (Singer and Wu, 2003) and included in the secondary science curriculum in most countries (Martin *et al*., 2004). However, empirical research within science education and learning point out weak understanding of the concept among secondary (Johnson and Papageorgiou, 2010) and tertiary students (Case and Fraser, 1999). Student difficulties in understanding this concept is related to the student's ability in mastering the submicroscopic level. Submicroscopic level means the phenomenon or situation that is understood in the form of particle matter namely atoms, molecules and ions (Williamson and Abraham, 1995). For example, at the submicroscopic level, a corroding nail becomes a chemical process in which the iron atoms of the nail react with the oxygen molecules in the air to eventually produce iron oxide. Although the submicroscopic level is very important in mastering the matter concept, previous studies have shown that the majority of the students fail to grasp this level properly (Ben-Zvi *et al*., 1986; Griffiths and Preston, 1992; Snir *et al*., 2003).

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PURPOSE OF THE STUDY

This study has been undertaken because most of the previous studies concerning the development of matter concept have focused only on the particular age of students, for example, secondary students (Johnson and Papageorgiou, 2010). In addition, research with the specific notion of targeting student drawing at the submicroscopic level is very limited in Malaysia. Therefore, the researcher is using a different strategy by executing a research on students of various age groups which are 16-17 to 24-25 years. This study is carried out to understand the development of the matter concept on the submicroscopic level among students of various age groups from the aspects of explanation and drawing.

METHODOLOGY

The research was carried out with 604 secondary students and training institute teachers (ages 16-17 to 24-25 years) that were chosen by using purposive sampling. In order to collect the survey data, respondents were asked to complete Ujian Kefahaman Konsep Jirim pada Aras Submikroskopik (SUKKJPAS) comprising ten open-ended questions related to the matter concept such as discrete particles, the motion of particles, the arrangement and relative spacing between particles and the movement of the particles. Experts and chemistry teachers' evaluation were used to obtain the content validity of the questions. For the data analysis process, student responses were examined thematically and are classified into two categories; scientific concept and alternative framework. Students' written responses were typed and the figures drawn by them were scanned in order to make it easy to read. The written responses (both pictorial and verbal) were thoroughly analyzed using qualitative analysis namely reading, rereading and coding in order to identify the participants' categories of conceptual understandings of the matter as well as the quantitative analysis such as numeric values for frequency and percentage.

RESULTS AND DISCUSSION

The findings of the study are presented below.

What is the level of understanding of development of the matter concept on the submicroscopic level among students of various age groups?

Results of the Development of Matter Concept on the Submicroscopic Level from Explanation Aspect: Moderate Level

The finding implies that the explanation given by the students in showing the concept of matter could be classified directly into scientific explanation and explanation with alternative framework (Figure 1). Majority of the students' performance for the scientific explanation is moderate with a percentage greater than fifty percent.

The following is an example of the scientific explanation provided by the students for the gas condensation phenomenon:

Lack of heat means lack of energy. Hence, the particles do not move as much as in the gaseous state, so they are arrange close to one another

(20-21 years student)

The following is an example of the explanation with alternative framework given by students for the gas condensation phenomenon:

The gas particles will be reduced and combined when the cooling gas turns to a liquid

(16-17 years student)

Based on Figure 1, majority of the students' performance (ages 18-19 to 24-25 years) is moderate for the scientific explanation a percentage greater than fifty percent. The 16-17 years students mostly give the explanation with the alternative framework (74 percent). That percentage actually is still far behind compared to the older students. This is because the 16-17 year old students represent the secondary school students that employ a very poor understanding in the submicroscopic level compared to the higher education level students (ages 18-19 to 24-25 years). This weakness isn't unexpected as claimed by Chang (1999) and Gopal *et al*. (2004) who unveil that tertiary students also have a superficial understanding regarding this concept.

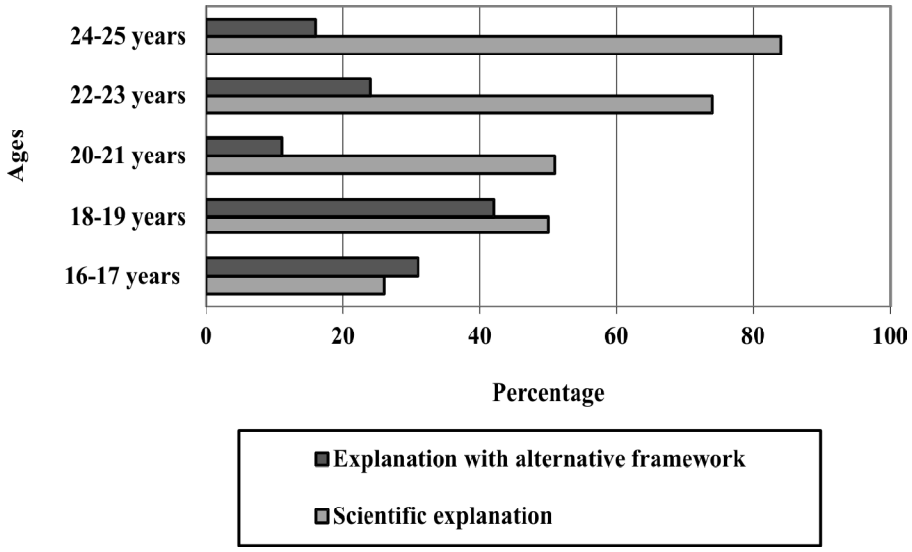

Figure 1: The percentage of scientific explanations and explanations with alternative framework of students of various ages in the concept of matter from the explanation aspect

Results of the Development of the Matter Concept on the Submicroscopic Level from Drawing Aspect: Poor Level

The development of the matter concept by students on the submicroscopic level has also shown that the students' drawing consists of scientific drawing and drawing with alternative framework (Figure 4). Examples of scientific drawing and drawing with alternative framework are as follows:

Figure 2: Scientific drawing by students for the gas condensation phenomenon

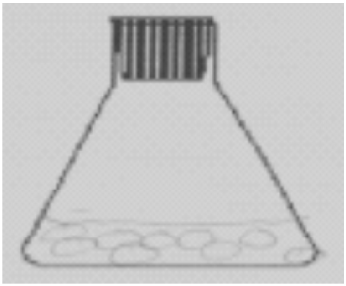

Figure 3: Drawing with alternative framework by students for the gas condensation phenomenon

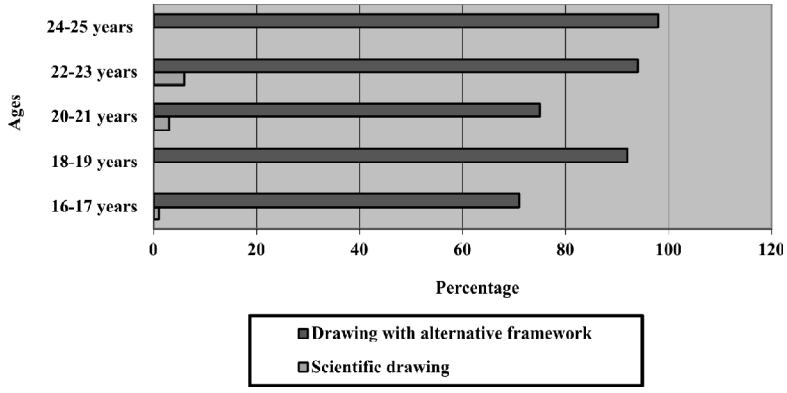

Figure 4: The percentage of scientific drawings and drawings with alternative framework of students of various ages in the concept of matter from the drawing aspect

Figure 4 show that students of various age groups have poor performance for scientific drawings with a percentage less than ten percent. The finding shows that the students failed to produce a scientific drawing on the submicroscopic level. Even though the percentage of the scientific explanation is high, it doesn't assure the ability to produce the scientific drawing on the submicroscopic level. The truth is, the students have the capability to explain the condensation phenomenon appropriately but failed to generate the scientific drawing for the phenomenon. This result is in line with the findings of the study done by Çalýk and Ayas (2005) who stated that the chemistry between the teacher and the student is also a part of the alternative drawing concept on the submicroscopic level. This is because the students received less support and exposure in generating a scientific drawing during the explanation of the chemical phenomenon to help them in having a greater understanding. It can't be argued that the textual explanation that comes with the drawings and figures helps the student to understand, thus explaining the chemical phenomenon better (Nyachwaya and Wood, 2014). Besides that, the drawings generated by the students in the tests play a big role in particularizing the students' thoughts (Mulford and Robinson, 2002; Nyachwaya *et al*., 2011; Onwu and Randal, 2006).

Is there a pattern of scientific concept of matter among students of various ages on the submicroscopic level?

The Student's Scientific Matter Conception on the Submicroscopic Level Develops Consistently with Age

The finding also shows that the percentage of the scientific explanation is enhancing in line with the increasing of the student's age which is 50 to 84 percent for the 18-19 to 24-25 years, but only 26 percent for the 16-17 year group. Therefore, more than fifty percent of the students 18-19 to 24-25 years were able to solve the matter phenomenon problems scientifically while only thirty percent of the 16-17 year old students could do so. This finding proves that the younger students are usually less prepared to solve the problems compared to the older students. The massive difference shows that age and maturity level play a significant role in the chemical learning process. Nevertheless, from the drawing aspect, the finding shows that the increasing age does not influence the student's ability to generate a scientific drawing. More than seventy percent of the students (majority) are only able to sketch a drawing with alternative framework. It shows that there is no certain pattern in constructing the student's concept on the submicroscopic level from the drawing aspect as they grow older. This is in line with Treagust *et al*. (2011) and includes secondary, undergraduate and postgraduate students.

CONCLUSION

It can be concluded from the results that the development of the matter concept on the submicroscopic level among students of various age groups is moderate from

the scientific explanation and poor from the scientific drawing aspect. For the explanation aspect, majority of the students are good in scientific explanation except the 16-17 years students who tend to do the alternative framework. The same situation has also been reported in previous study whereby the secondary students failed to master the matter concept on the submicroscopic level (Boz, 2006). It shows that age and maturity level do influence the chemical learning process. From the drawing aspect, most of the students are only able to generate the drawing with the alternative framework. This difference occurs due to less exposure about this aspect during the explanation. In addition, chemical text book also seems to have less drawing on the submicroscopic level as claimed by Nyachwaya and Wood (2014) where only fifteen percent of the drawings in the chemical text book is on the submicroscopic level. In contrast, 85 percent of the drawings are at the symbolic level. As a result, the students failed to generate scientific drawings on the submicroscopic level even if the drawing was designed to reflect their thoughts, feelings and state of mind (Thomas and Silk, 1990). Their weakness in mastering scientific drawings implies that the teachers should emphasize producing a drawing during the chemical explanation so that it can be easily understood by the students who could at the same time adapt the technique. Some changes by the teacher and students are crucial in order to capture the issues and challenges in mastering the matter concept on the submicroscopic level in particular and the other science concepts in general thus enhancing educational sustainability.

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