Micro Imagination: Imagination with an Alternative Framework in a Chemistry Class

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Abstract. The curriculum for the 21st century must be futuristic, flexible and dynamic in order to produce learners with creative and critical thinking. One of the strategies to inculcate creative and critical thinking among students is to train and familiarize learners with the process of generating imagination in teaching and learning. The process of generating imagination corresponds to the characteristics of the subject itself which consists of abstract concepts and complexities. These concepts require students to use their imagination to illustrate concepts, where learners are usually difficult to achieve. Therefore, this study was carried out to identify alternative frameworks in the students' imaginations of the concept of matter at submicroscopic level. A qualitative study with a descriptive study design is implemented to five secondary school students and ten students of institute of teacher education, aged from 18 to 25 years old. Guided imagery interviews and document analysis are used to collect data from selected students by purposive sampling. The data was analyzed using the grounded theory analysis strategy. The findings show that one of the alternative framework categories found in students' imagination is micro imagination. The image of hydrogen gas is the ultimate framework of the micro imagination of the most generated structure by the students followed by hydrogen electrons, collision of hydrogen molecules and the formation of water molecules. In this regard, scientific imagination needs to be enhanced by students with emphasis on the concept of science with effective imagination so that students can master chemical concepts at the sub-microscopic level competently. From the conclusion, the implication of the study suggests that teachers should expose to the students the aspects of generative imagination during teaching and learning sessions so that the desired skills can be improved effectively.

1 Introduction

Chemistry is a subject based on concepts and most of these concepts are abstract [1]. Therefore, it is difficult to master and learn by students. As a result, the literature shows a range of alternatives and difficulties in learning and under-standing of the chemical concept that exists amongst students [2-4]. The alternative frameworks related to matter are parts of the widely studied and widely reported aspects of the literature [5-8]. In fact, the literature also reveals that students have an alternative framework in the key aspects of matter con-cepts such as composition and structure [9-11], physical properties [11,12] and chemical properties [13].

The alternative framework is the existing knowledge that is in conflict with the scientific concepts that are concepts that are understood and accepted by scientists and are actual concepts. It is accepted by students through their interaction process with the environment and socialization process before or when in the classroom [14]. The alternative framework is also considered a strong concept, very robust and difficult to change and create obstacles to the next learning [15]. The early concepts of students with the world around them and during chemistry lessons may develop into alternative frameworks and these alternative frameworks that arise from the teaching process referred to as school-made misconceptions [16].

2 Literature Review

One of the factors in the existence of an alternative framework among students is that the chemical concept requires the habitual behavior learning of students with micro particle interactions at the submicroscopic level

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[6,17-18]. In chemistry, submicroscopic levels are defined as levels that use the arrangement and movement of particles of atoms, molecules and subatoms to explain phenomena and chemical reactions [19] or levels used to describe the visible changes in the interaction between atoms and molecules [20] which form the matter [21. For students, understanding the phenomena and chemical reactions requires submicroscopic ability to visualize interactions between different types of atoms, molecules and other micro particles [6,12,18,22-23]. The existence of various alternative frames at the submicroscopic level is closely related to those levels that are not capable of being achieved by human sensory organs, levels associated with the world of micro particles (atoms, molecules and ions) and can only be achieved through imagination [24]. Hence, the ability of imagination among students, especially science students need to be nurtured and stimulated consistently, so that these skills can help them to understand better the abstract concepts of abstract science. DePorter (2000) defines imagination as the ability to see, hear and feel in mind. Mazur (2003) states that it is one of the ways to create a 'natural home' for something that is in the mind or one of the mental image creations [25]. The definition of imagination is also associated as one of the most important cognitive capabilities and can therefore be seen as a 'tool' to actively in thinking creatively [26-27]. The highlight of the study demonstrates the many positive impacts the students gain from imagination. One of them is that imagination that helps children to understand their world. This situation occurs when children use their imagination to sort and allocate the world into units that they can explore and eventually assimilate the information into their cognitive schemes. Therefore, children can gain control over their symbolic representation system [28]. Other than being applied to understand the world, imaginations can also be used by educators to understand children's understanding of a field because of its ability as a 'diagnostic tool' in the capability of reflecting the level of development of a child [29].

Teacher as a facilitator in the teaching and learning process of a student plays a role in using appropriate imagination based learning strategies for students. This is because the success of the teacher in utilizing the imagination of the student is directly able to enhance the student's learning. The importance of this learning strategy is supported by previous studies such as Tindall-Ford and Sweller (2006) studies that students of Grade 8 who have knowledge about a material and then imagine the material to be learned with accompanying audio / visual teaching can promote better learning than students who only study the material traditionally [30]. Such learning strategies are also in line with grade 4 and 5 students [31]. Glenberg *et al*. (2004) uses an imaginative based learning strategy in his studies and finds that the strategy is effective in improving the learning of grade 2 students as well [32]. Students demonstrate better reading performance when they are asked to visualize the activities in the book as compared to reading the materials alone. The conclusion of a very young age is evidence that students encouraged to participate in the imagination eventually demonstrate the ability to control emotions, have better empathetic skills and sophisticated cognitive skills [33].

As such, it is important for teachers to identify lessons that emphasize intelligence components such as imagination, analytic, practical and creativity as these teaching strategies are more beneficial to students than traditional teaching that relies largely on analytical intelligence. In addition, using a variety of developmental activities that are appropriate for children's imagination, teachers can also develop children's readiness and social skills, enhance their learning and motivation to learn while having fun and creating interrelationship with the school contexts [33]. Realizing the importance of imagination in the education world from this discussion, it creates a spark to these questions: how is the imagination of students on abstract chemical concepts at the submicroscopic level? Is there an alternative framework in the student's imagination of these chemical concepts? and if the alternative framework exists, what are the features of the alternative framework? Therefore, this study needs to be carried out to learn more about the student's imagination of chemical concepts at the submicroscopic level in general and the alternative framework that exists in the imagination in particular.

3 Research Objective

The objective of this study was to identify the alternative frameworks that the students of various levels of age had in their imaginations on the concept of matter at the submicroscopic level. Identifying alternative frameworks that exist among learners is crucial as the alternative framework affects students' learning when they interpret the teacher's teaching using the alternative framework perspective [34]. Hence, it is important to define the student's alternative framework and to develop appropriate teaching strategies to address these problems. This study is based on the following question: How are the alternative frameworks that exist in the students' imaginations of the concept of matter at the submicroscopic level?

4 Methodology

4.1 Research Design

This study was carried out using a descriptive approach in qualitative study as it is appropriate to collect detailed and in depth information on the alternative frameworks that exist in the students' imagination of the concept of matter at the submicroscopic level among the various levels of age. These methods and approaches are appropriate for being able to be the best strategy to answer the research question in this study. In addition, qualitative studies are also capable of explaining the real situation and producing meaningful insights [35-36].

4.2 Samples

The study involved five science stream of form four students (aged 16-17 years) from secondary school and ten first year until the final semester (age 18-19 to 24-25 years) undergraduate students from a selected teachers' education institute through purposive sampling. This technique is used because of its ability to describe in detail and give an in depth understanding of a phenomenon studied [37]. A total of five secondary schools and ten undergraduate students' education institutes in the southern zone of Malaysia were involved in the study. The main factors of student selection are based on three main criteria: (i) the students who have taken the Test of Matter Concept and Understanding at the Submicroscopic Level (SUKKJPAS), (ii) possess good score in SUKKJPAS which is> 50 percent and (3) the category of age focus of this study. The selection of both categories of these students is due to the concept of matter is one of the concepts in their curriculum.

4.3 Data Collection

Qualitative data collection in semi-structured interviews using guided imagery interviews and document analysis is executed after the students has completed the Test of Matter Concept and Understanding at the Submicroscopic Level (SUKKJPAS). Interview techniques are appropriate and accurate to get in depth information and to know what is expressed and implied in a person's mind [38] where the analysis of the document serves to reinforce and prove a statement and to complement the data obtained from other sources [39]. A total of 15 students were interviewed in guided imagery to identify the alternative framework students had in their imaginations on the concept of matter at the submicroscopic level. Each student was interviewed individually for 60minutes to150 minutes. Interviews involved two main sections, which are guided imagery and follow-up questions. Guided imagery activities began with students watching a two-minute video clip of natrium and water reaction to set the students familiar with the reaction. Inthe video clip, a pebblesized sodium is put into a beaker containing 1000ml of water and the reaction produces fire. After watching the video clip, the teacher read studentswith the guided imagery scenario adapted from Al-Balushi (2003) in a closed eye condition for five minutes [40]. After the activity, follow-up questions were posed to the students. The questions in this study focus on four concepts: the concept of hydrogen gas, hydrogen electrons, hydrogen molecule collision and the formation of water molecule.

4.4 Data Analysis

Data analysis began by recording all interviews and then being copied verbatimally. A copy of the completed transcripts were submitted to the studentsfor review purposes which were; to confirm or add or subtract any part of the interview. The transcript was then analyzed using a grounded theory analysis strategy involving three stages: open coding, axis decoding and selected coding with Nvivo Software version 10.0 and ATLAS.ti version 7.0 to understand and compute the large and unorganized data. The data were analyzed based on the four concepts that were asked to the students during the interview sessions. The data obtained were then endorsed by two experts in the field of chemistry education who have more than 30 years of experience.

5 Findings and Discussions

The findings of the study found that micro imaginations were one of the alternative framework categories that existed in the students' imaginations on the concept of matter at the submicroscopic level with a percentage of 15.30 percent from 31.12 percent imagination with an alternative framework (Figure 1). The micro imagination in this study refers to the imagination generated by the students at the submicroscopic level but it is not based on scientific concept and it contains an alternative framework. The details of the micro imaginations on each of the concepts of matter among the students are presented as in Table 1.

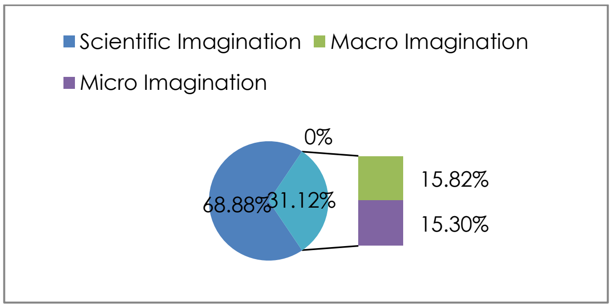

Fig 1. Percentage of scientific imagination, macro imagination and students'micro imagination on the concept of matter

Table 1. Students' micro imaginations on the concept of matter

Micro Imagination	Percentage (%)
Hydrogen gas	7.14
Hydrogen electron	4.08
Hydrogen molecul collision	3.57
Formation of water molecule	0.51
Total	15.30

Table 1 shows the presence of micro imaginations among students on the four concepts of matter studied with the concept of hydrogen gas as the most generated images of students' imagination followed by the concept of hydrogen electrons, collision of hydrogen molecules and water formation.

(1) Micro Imagination of Hydrogen Gas

The study found that among the students' micro imagination of the hydrogen gas concept was to generate the image of hydrogen gas as a circle containing the letter H, the movement of hydrogen gas is going up very slowly and hydrogen gas bondingemerged as if there is a bond in the center of the atom. One example of the students' micro imagination on the form of hydrogen gas is as follows:

Researcher: When I say hydrogen gas is about to form, what do you see?

Student : That's the round hydrogen...

Researcher: [Mmm ...] looks round?

Student: H is round

Researcher: [Mmm ...] Does it look alone round or multiple round to the whole a great extent?

Student : One

P1SK1, 16-17 years old)

In the interview transcript, the students are figuring out the form of hydrogen gas as a circle containing the letter H. This imagination shows the students' confusion on the concept of atoms and molecules for hydrogen gas comprising two hydrogen atoms. Due to the confusion over the term of the particle, students generate micro imaginations that contain an alternative framework. This situation proves the importance of mastering science concepts scientifically in helping students produce scientific imagination. This confusion reveals the existence of long-term integration problems in science education. This means that science students usually learn small pieces of information scattered and cover different concepts by studying different phenomena. Therefore, they are lack of the ability to develop accurate and scientific explanations that incorporate pieces of information that has been learned.

(2) Micro Imagination of Electron Hydrogen

The findings show that the H + black and the charge on letter H are among the micro-imaginations generated by the students on the form of hydrogen electrons. Other than the form, students also generated micro imaginations on the movement of hydrogen electrons, which is to visualize the movement of hydrogen electrons in orbital recip-rocating, static and slow moving circles. Here is an example of a student's micro imagination:

Researcher: So electron hydrogen you imagine H + ... it has no color because it is writing ... so the writing is black?

Student : Ha'a black color

(GP1M1, 24-25 years old)

From the above reponses, it clearly exhibits a student's micro-imagination on an electron shape which implies an electron shape as black H +. This demonstrates the existence of alternative framework in students' imagination. This imagination also proves that the student's confusion about the term electron with the charge that exists in hydrogen atoms. In addition, the H + symbol indicate that a student's imagination is influenced by reading from textbooks. This is due to text illustration is one of the factors that influences the student's imagination when the image of the student's imagination is dominant with text illustration, resulting that only text elements can be activated from past experiences [40].

(3) Micro Imagination of Hydrogen Molecule Collision

Micro imagination to the concept of collision of hydrogen molecules occurs when the student generates collision image in a state of water molecules joined to each other and the hydrogen molecules merge with oxygen molecules. The student describes the following collision situations:

Researcher : Ok when I say, you see the water molecules formed swirling swiftly and collide with the molecules around them, so what do you see?

Students : Water molecules try to join each other ... enforcing their energy to fight with the fire to extinguish the fire

Researcher: [Mmm ...] it moves fast?

Student : [Mmm ...] very fast

(GP4M1, 18-19 years old)

The analysis of the answers indicates the failure of students to comprehend the current situation of water molecule collisions with other molecules around them. Student imag-ine the collision by producing imaginations of water molecules trying to join each other. The reason given to this perspective is to extinguish the fire formed from the sodium and water reactions. Although students were generating images of micro imaginations at first, however, the reason given to extinguish the fire for the dissemination process re-vealed the imagination of students at the submicroscopic level was a combination of macroscopic and submicroscopic levels. This is because students are not able to differ-entiate and separate their physical world with submicroscopic level. This finding is co-herent with the study of Al Balushi (2003) that one of the students imagined some of the water molecules moving in the liquid water. The presence of both these water molecules and water fluids in the student imagination marks the difficulty of students accepting and understanding the concept of macroscopic and submicroscopic levels. This phenomenon is called Raisin Cake Model. This situation occurs when the student accepts the presence of particles in matter but still confused with the concept of matter consisting of discrete particles.

(4) Micro Imagination of the Formation of Water Molecules

The formation of water molecules is the concept that the least image of a micro-imagination is generated by a student. Students only generate images of hydrogen atoms into oxygen orbit when asked to imagine the formation of water molecules. This is evi-dent from the conversation:

Researcher: Ok when I say, now that both hydrogen atoms are combined with oxygen atoms, what do you see?

Student: Looks like a hydrogen atom trying to get in orbit

Researcher: [Mmm ...] the hydrogen atom enters orbit?

Student: Yes ... oxygen orbit

(GP2M3, 22-23 years old)

In this interview transcript, students figure out the concept of molecular combination for the formation of water molecules by generating imagination of hydrogen atoms entering the oxygen orbit. This imagination shows students have an alternative framework for the concept of sharing and electron transfer to form the bond between the particles for the formation of water molecules. On the other hand, no micro imagination is produced by students for the concept of water molecule state. From a positive aspect, no micro imagination image produced by the student on this concept indicates that the student is able to imagine the concept well. However, from a negative aspect, it indicates that the students are less or rarely use the submicroscopic level during their teaching and learning chemistry.

6 Conclusion

In conclusion, the findings revealed that the majority of students produced more micro-imaginations for hydrogen gas images of 7.14 percent compared with other images such as hydrogen electrons (4.08 percent), hydrogen moleculescollision (3.57 percent) and formation water molecules (0.51 percent). The scenario implies the concept of matter at submicroscopic level with the existence of an alternative framework among students not surprisingly due to lack of pedagogy in giving a fair emphasis to submicroscopic levels rather than macroscopic and symbolic levels when designing and planning texts and teaching materials. As a result, such educational systems produce incompetent students to think and use submicroscopic levels for natural phenomena and chemical phenomena. Gabel *et al*. (1987) [41] and Al-Balushi (2003) [40] also revealed the disruption of the situation among students. Compounding to the aforesaid matter, studies by Kokkotas and Vlachos (1998) also show that chemistry teachers have the same alternative frameworks on submicroscopic levels of matter [42]. If teachers are lack of the ability to explain and investigate chemicals phenomenon at the submicroscopic level, then the probability of their students to experience the same condition is high. This situation also encourages students to create imaginative imagery that has an alternative framework despite the fact that students are encouraged to imagine learning abstract science concepts. Thus, existing knowledge plays an important role in the process of generating a student's imagination.

7 Implications

The findings of this study on the imagination of students with alternative frameworks suggest that teachers need to relate the imagination of students to the relevant science concepts so that even though they are imaginative according to their own interests and tendencies, they still maintain a scientific perspective in the course of their imagination. By applying these strategies, students are expected to acquire imaginations that are not only interesting and creative, but also accurate and scientific as the subject of chemistry has great importance in accuracy and scientific concepts. In addition, teachers' exposure to the aspects of imagination generation during teaching and learning sessions among students should also be enhanced. It is important for students to understand a chemical phenomenon more profoundly when the imagination is generated by students according to their own ability and interest without interfering scientific concepts. This situation allows students to imagine in the absence of boundaries yet retaining the concepts of science and chemistry as a foundation and goundwork. For example, when students are figuring out the movement of gas particles, students need to know the basic concept of the gas particle movement, which has the form of Brownian motion. Thus, the imagination generated by the students is based on the basic concepts so that the imagination produced by the students is accurate and scientific.

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