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The Existence of Alternative Framework in Students' Scientific Imagination on the Concept of Matter at Submicroscopic Level: Macro Imagination

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Abstract

This study is conducted with the purpose of identifying the alternative framework contained in students' imagination on the concept of matter at submicroscopic level. Through the design of purposive sampling techniques, a total of 15 students are interviewed to obtain the data. Data from analysis document is utilized to strengthen the interview. The qualitative data is analyzed using the grounded theory analysis strategy. The finding shows there is an existence of alternative framework in the students' scientific imagination: macro imagination. The image of hydrogen gas is the highest macro alternative framework imagination generated by the students while the second is the water molecules formation and followed by hydrogen molecules collision. On the other hand, no imagination is produced on the hydrogen electron. Hence, the emphasis on scientific concept upon imagination must be enhanced so that they are able to master the chemistry concepts at submicroscopic level. The summary of the implications of the study suggests that the teachers need to associate the students' imagination with the related science concepts so that even they are imagining according to their own capabilities and interest propensity, they are still maintaining the scientific perspective in the course of their imagination.

Keywords: Imagination with alternative framework, Qualitative, Chemistry education, Submicroscopic level, Guided imagery, Macro imagination

1. Introduction

Meyer (2013) defines imagination as ability and a process in forming a mental model or image of something that cannot be detected with common sense, ability to solve problem in a non linear way, ability to create a new image from the past experience either in pictorial or verbal way. On the other hand, concerning children's perspective, Garcia (2013) defines imagination as one of the main forms used by the children to express the information received. Most of previous studies on imagination show several of positive impacts obtained by the students from imagination.

Sarach (2002) notes that one of the impacts are the students are able to ask and explore the alternative mental representation of reality while Mellou (1996) found that students' involvement in imagination are able to enhance the enjoyment of learning process in the classroom. This is because the students are motivated to learn as it comes from their own interest and at the same time fulfills their emotion, intellectual and artistic needs. Therefore, when imagination experiences are used effectively by the teachers, it could encourage the students' learning by letting them to direct their own learning (Singer and Singer, 2005) according to their interest and propensity.

From the cognitive development perspective, imagination is able to help the students to understand their world. This situation happens when the students use their imagination to break the world to the unit that they can explore and manipulate and eventually assimilates the information to their cognitive scheme. Hence, the students can get control on to their symbolic representation system (Bouldin, 2006). Besides being used to understand the world, imagination can be utilized by the teachers to understand the students' comprehension of a particular field due to its capability as a 'diagnostic tool' that reflects the students' development level (Russ, 2003).

Teachers as a facilitator in the process of teaching and learning play a big role of utilizing an appropriate imagination-based teaching strategy as the success of this strategy could improve the students' learning process. The importance of the learning strategies are supported by the previous studies, for instance, Tindall-Ford and Sweller (2006) who claims that the Grade 8 students who has the knowledge of a material and then imagining it for the purpose of learning, accompanied by the audio or visual are able to encourage a better learning compared to the students who are revising the material traditionally. These learning strategies also are suitable for the Grade 4 and 5 students (Leahy and Sweller, 2005).

The existence of various alternative frameworks at submicroscopic level is closely linked to the characteristics of that level which cannot be achieved by human senses; concerns the world of atoms and their derivatives; ion and molecules which accessible only by imagination (Bucat and Mocerino, 2009). Thus, submicroscopic level can be concluded as the most difficult level (Nelson, 2002), since it cannot be seen directly by human senses even though their principles and components are accepted as true and real. This level is described by the particles such as electrons, atoms and molecules, and commonly referred as the particle theory of matter. Its dependence on the particle theory of matter makes this level become the most difficult level to be understood by the students properly. Highlight of the previous studies notes that there are several factors contributes to the students' inability in understanding and mastering the submicroscopic level in chemistry learning process.

One of the factors is most of the chemistry classes are focusing on the symbolic level while ignoring the macroscopic and submicroscopic level (Johnstone, 1991). As a result, the student assumes chemistry as science symbols towards the elements and formulas for the chemistry equations solely, which means that they are failed to understand the particles characteristics and unable to illustrates the chemistry phenomenon dynamically. Consequently, students in various age groups has a variety of alternative frameworks related to this level in their chemistry learning process (Mulford and Robinson, 2002; Nakhleh *et al*., 2005; Yizierski and Birk, 2006; Ayas *et al*., 2010; Rahayu and Kita, 2010). This situation shows that submicroscopic level is the marginalized level compared to macroscopic and symbolic level (Wright, 2003).

Alternative framework is an existing knowledge which contradicts with the scientific concepts which is a real concept and accepted by the scientists. It is accepted by the students through the process of their interaction with the environment and the process of socialization before or while in the classroom (Johari, 2010). Alternative framework is also considered as a strong concept, highly resistant and hard to change as well as creating an obstacle in learning process (Canpolat, 2006; Pabuçcu and Geban, 2006). The initial concept had by the students about the world around them could evolve into alternative framework and this kind of concept which is results from the teaching process is referred as school-made misconception (Barke *et al*., 2009).

The finding of the previous studies notes that students at various ages own several of alternative frameworks on the concepts of matter at submicroscopic level (Krnel *et al*., 2003; Boo and Watson, 2001). As such, this study should be conducted to explore the imagination of students of all ages to the concepts of matter at submicroscopic level. From this exploration, it is hoped that the alternative framework owned by the students during the imagination process could be identified and understood more deeply so that the teaching and learning strategies can be improved.

2. Purpose of the Study and Research Question

This study is conducted to identify an alternative framework that exists in the students' imagination on the concept of matter at submicroscopic level. This is very crucial as the alternative framework is actually gives a massive impact to the students' learning process when they interpret their teachers' instruction in the light of these alternative frameworks (Tastan *et al*., 2008). Therefore, it is important to determine students' alternative frameworks and develop suitable teaching strategies in order to remedy them. The following research question was investigated in this study: How is the students' alternative framework in the imagination of the concept of matter at submicroscopic level?

3. Methodology

3.1Research Design

To gather in-depth and detailed information, a qualitative research with descriptive approach is used in this study. This approach is used as it can be the best strategy to answer the research questions. In addition, qualitative research is able to analyze the natural phenomenon with all the inherent complexity (Fraenkel and Wallen, 2006). In fact, qualitative research applies the inductive analysis and involves the specific data (Hittleman and Simon, 2002).

3.2 Sample

The study involves five science stream students from secondary school and ten students majoring in science from teacher training institute which are selected by purposive sampling. This technique is used because of its ability to provide a proper understanding of the phenomenon as well as the detailed illustration of it (Merriam, 2002). A total of five secondary schools and four teacher education institutes in southern zone of Malaysia are participated in this study. The main factor of the sample selection is based on three criteria:

(1) The student has taken the test of Matter Concept Understanding Test Set at the Submicroscopic Level

(2) The student obtained a good score in the test of Matter Concept Understanding Test Set at the Submicroscopic Level which is >50 percent

(3) The student represent the eligible age

Matter Concept Understanding Test Set at the Submicroscopic Level is research instrument which comprising open-ended questions intended to assess the students' comprehension on the scientific aspects of the concept of matter at submicroscopic level.

4. Data Collection

Data were collected right after the students done answering the Matter Concept Understanding Test Set at the Submicroscopic Level through the semi-structured interview which are the guided imagery interview and document analysis. This interview is an instrument that is carried out in the form of open-ended questions with the purpose of assessing the students' understanding on the scientific aspects of the concept of matter at submicroscopic level. The interview selection as a method to collect the data is very appropriate in obtaining in-depth and detailed information as well as to discover the explicit and implicit in an individual's mind (Patton, 2002) while document analysis plays a role as the third source of data in the qualitative research (Merriam, 1998).

5. Data Anaysis

All interviews are recorded and transcribed verbatim. After each of guided imagery interview is done, the recording is heard and the transcription of it is produced to make sure the interview can be written perfectly. One of the transcription's copies is handed to the participants for the purpose of review and validation. The transcription is then analyzed using grounded theory analysis strategy which involves three stages, namely open coding, axial coding and selected coding. NVivo Program version 10.0 and ATLAS.ti version 7.0 is used as assistance in understanding the large and unorganized data.

6. Results and Discussion

The finding indicates that 68.88 percent of the students' imagination is the scientific imagination while 31.12 per cent is the imagination with alternative framework (refer Figure 1).

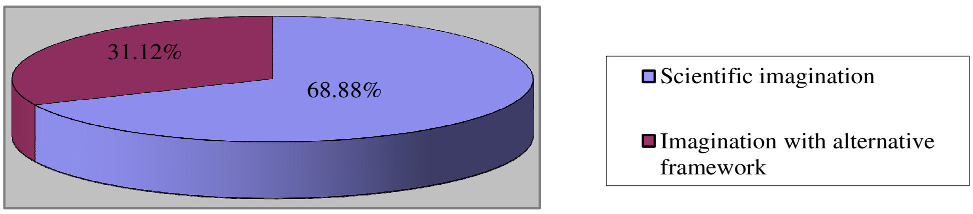


Figure 1 Percentage of Scientific Imagination and Imagination with Alternative Framework

One of the alternative framework categories that exist in the students' imagination on the concept of matter at submicroscopic level is the macro imagination (15.81 percent). This situation shows that the students are difficult to generate the imagination scientifically. This is supported by Johnson and Papageorgiou (2010) who found that majority of five years old students (nine to ten years old) views the particles as matter but they have a macroscopic character. It means that macroscopic level is not only influence the students' imagination, but also the understanding of the students regarding the particle theory of matter. Macro imagination in this study refers to the imagination generated by the students at macroscopic level and contains alternative framework characteristics. Details of the macro imagination are shown in Table 1.

6.1 Hydrogen Gas with A Shape of Cloud of Smokes

The study finds that a total of 5.61 percent of macro imagination of hydrogen gas are generated with the cloud of smokes dominated the imagination followed by the gas, bubbles as well as no form. Some examples of the students' imagination are as follows.

Table 1 Students' macro imagination

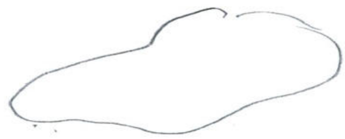
Students' imagination			**16-17 y/old**		**18-19 y/old**		**22-23 y/old**		**24-25 y/old**		**Total**	
			N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Hydrogen Gas	Hydrogen gas form	Gas	1	1.69	0	0.00	0	0.00	0	0.00	1	0.51
		Bubbles	0	0.00	2	6.90	1	2.86	1	1.37	4	2.04
		Cloud of smoke	1	1.69	1	3.45	0	0.00	3	4.11	5	2.55
		No form	0	0.00	0	0.00	0	0.00	1	1.37	1	0.51
	Hydrogen gas movement	Ballon moving up from slow to fast	1	1.69	0	0.00	0	0.00	0	0.00	1	0.51
	Hydrogen gas bond	Form of rope	0	0.00	1	3.45	0	0.00	1	1.37	2	1.02
	Total		3	5.08	4	13.80	1	2.86	6	8.22	14	7.14
Hydrogen electron	Hydrogen electron form	-	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	Hydrogen electron movement	-	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	Total		0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Hydrogen molecules collision	Condition of collision	White condition	0	0.00	0	0.00	0	0.00	1	1.37	1	0.51
		Floating slowly	0	0.00	0	0.00	0	0.00	1	1.37	1	0.51
		Release more smokes and heats	0	0.00	0	0.00	1	2.86	0	0.00	1	0.51
	After collision	Split into 4 circles	0	0.00	0	0.00	1	2.86	1	1.37	1	0.51
		Release stars	1	1.69	0	0.00	0	0.00	0	0.00	1	0.51
	Total		1	1.69	0	0.00	2	5.71	3	4.11	6	3.06
Water molecule formation	Molecule combination	Fountain	0	0.00	0	0.00	0	0.00	1	1.37	1	0.51
		Water looks	1	1.69	0	0.00	0	0.00	1	1.37	2	1.02
		Water droplets	0	0.00	0	0.00	0	0.00	1	1.37	1	0.51
		Create bonds on combination	1	1.69	0	0.00	0	0.00	0	0.00	1	0.51
		Create chains on combination	0	0.00	1	3.45	0	0.00	0	0.00	1	0.51
		Create ropes on combination	1	1.69	0	0.00	0	0.00	1	1.37	2	1.02
		Create vertical ropes on combination	0	0.00	0	0.00	1	2.86	0	0.00	1	0.51
		Create distance on combination	0	0.00	0	0.00	0	0.00	1	1.37	1	0.51
	Molecule condition	Stagnant	1	1.69	0	0.00	0	0.00	0	0.00	1	0.51
	Total		4	6.78	1	3.45	1	2.86	5	6.85	11	5.61
Total			8	13.52	5	17.25	4	11.43	14	19.18	31	15.81

Researcher: When I say the hydrogen gas is start to form, what do you imagine?

Student: I see a cloud of smokes.

(GP1M3, 18-19 years old)

From the answer given, the image of the smokes are produced from the influence of the macroscopic level observation during the sodium and water reaction which a cloud of white smokes are released once the sodium is dropped into a beaker of water. The influence of macroscopic level observation is not surprising as Harrison and Treagust (1996) claims that the students' atom mental model is commonly influenced by their experience of the physical world (macroscopic level). Some students believe that the solid atoms are harder than liquid and gas atoms. Meanwhile, some students also consider the gas atoms are larger than solid atoms for the same matter. This situation gives the impression that the images in the imagination world do own the characteristics of macroscopic level observation and past experiences. Example of imagination generated by the students is as the following drawing:



(GP1M3, 18-19 years old)

Figure 2 Students' Drawing for the Hydrogen Gas Imagination

The drawing shows a clear macro imagination of a student on hydrogen gas (a cloud of smokes). The influence of macroscopic level observation is apparent as the level can be seen by the human senses (Gilbert and Treagust, 2009).

6.2 Hydrogen Gas Moves Like A Balloon

In contrast, for the hydrogen gas movement, 0.51 percent of the macro imagination generated by the students is the imagination of a balloon moving upwards from slow to fast. The imagination can be seen in the following example:

Researcher: What do you imagine when I say the hydrogen gas is moving upwards?

Student: It's like a balloon is moving upwards.

Researcher: You mean it's floating? Is it in a slow or fast motion?

Student: Slow, but become faster.

(P2SK1, 16-17 years old)

As being explained in the conversation, the movement imagined as the balloon moves up from the slow to fast motion. This image of macro imagination is generated by the students with the influence of their daily experiences. This situation proves that the students are trying to link their own daily experience with their imagination whilst ignoring the science concepts that should be the basis of the image. This failure can be associated to Taxonomy White (1988) which claims that in order to integrate three different experiences in building the hydrogen molecules and in-depth characteristics of that image (like movement) on the same time requires a high level observation during the process. If fail, the alternative framework imagination will be produced. In addition, to create a detailed image, for instance, the color aspect, shape and movement also requires a leap of imagination capabilities of the students (Al-Balushi, 2003). This is because the imagination capability is one of the factors that is able to influence the students' imagination.

6.3 Hydrogen Gas Bond Imagined As A 'Rope'

The same situation also happens to the imagination of hydrogen gas bond when 1.02 percent of the students have produced the macro imagination which there is an existence of something that resembles a rope between the hydrogen atoms. It can be seen from the conversation below:

Researcher: What do you imagine when I say the hydrogen gas is bound?

Student: It's a bond. There is a bond between the hydrogen.

Researcher: A bond? What do you mean?

Student: It's like a rope.

(GP6M1, 24-25 years old)

It can be seen that the students are imagining the bond as a rope in the middle of the hydrogen atoms. Even though the image is categorized as macro imagination, it is clearly shows that based on the usage of the word 'bond', the student is already has the basic knowledge regarding the particles bond but fails to use that knowledge to imagine the phenomenon. The imagination of that rope is not surprising as line is a common illustration to describe the bond between the atoms. Al-Balushi (2003) also notes a similar situation where two students imagines two lines that connects two oxygen atoms to represent the presence of both atoms' bond.

6.4 No Macro Imagination For Hydrogen Electron

The finding reveals that the students do not have the macro imagination against the formation and movement of hydrogen electron. From the guided imagery interview result, it can be seen that a new link has been activated by the students has produced a format that changes based on the past experiences. This unstable situation shows an unorganized network concept in the students' thinking scheme which the characteristics that characterize the mental network of the students (Rozma and Russell, 1997). This situation reveals that they still lack of the experience and knowledge regarding the electron as this concept is very abstract in the chemical learning process.

6.5 Hydrogen Molecules Collision Situation Imagined As 'White'

From the findings, it can be seen that 1.53 percent of the collision imagination is a macro imagination where the students are imagining the white situation, the hydrogen molecules floats slowly and the collision's reaction releases more smoke and heats. The following is the example of the students' macro imagination:

Researcher: What do you see when I say the water molecules are spinning rapidly and collide with the other molecules around?

Student: I see white.

(GP1M1, 24-25 years old)

This conversation explains that the students just imagining the existence of white situation for this phenomenon. This occurs because the imagination is affected by the macroscopic level observation which a cloud of smokes generated once the sodium is dropped into a beaker of water. It shows that the experience and observation of macroscopic level plays a role during the imagination process even it is unnoticed by the students, due to the inability of the students to imagine the object in a state of micro entities (atoms, molecules and ions).

In contrast, the students are imagining the phenomenon which is obtained from their physical world, since macroscopic level is the most difficult level to be mastered by the students compared to submicroscopic and symbolic level (Haidar and Abraham, 1991; Onwu and Randall, 2006). The same situation is experienced by ten students in the study of Al-Balushi (2003) who imagines the movement of water molecules as a 'whirlwind'. This 'whirlwind' imagination shows that the alternative framework of macro imagination is emanating from the word 'water' itself that is closely related to the daily lives. This situation happens when the students fails to seclude the life experience (macroscopic level) with the submicroscopic level.

6.6 Hydrogen Molecules After Collision Releases 'Stars'

After collision concept also recorded the same percentage with collision situation (1.53 percent). One of the imaginations from the students is the stars. The following is the example of the imagination:

Researcher: Hydrogen molecule is moving towards oxygen molecule and hit it hard, what do you sees?

Student: Maybe there are some stars.

Researcher: Meaning after hydrogen molecule hit the oxygen molecule, the stars will come out, or the stars are the one who hit the oxygen molecule?

Student: No. The stars went out after the collision. And they are orange.

(P3SK1, 16-17 years old)

This conversation explains that the students' imagining some stars in orange color after the collision happened. Images generated by the student shows that they are ignoring the scientific concept of collision between molecules. The image of the stars represents the failure of the students to master the scientific concept and failure to recall their basic knowledge. This is not surprising as Pairio (1980) points out that recall is better for a real word, such as cat and house which is easier to imagine compared to abstract words, such as hydrogen and oxygen molecules.

6.7 Water Molecule Formation Imagined As 'Water'

The result reveals that the students have the macro imagination on the concept of water molecules combination when 5.61 percent of them are produced. Some of the macro imaginations are water drops, water combination bond and water combination chain. The following is the example of student's answer:

Researcher: When I say two hydrogen atoms are now combines with the oxygen atom, what do you sees?

Student: I see water.

Researcher: Colourless water?

Student: Mmm.

(P4SK1, 16-17 years old)

The student is spontaneously imagining the water when two hydrogen atoms are now combines with the oxygen atom. This imagination is generated from the basic knowledge owned by the students which is water (H_2O) is consisting of two hydrogen atoms and one oxygen atom. In addition, this existing macro imagination is stems from the word 'two hydrogen atoms are now combines with the oxygen atom' which is used during the guided imagery interview. Hence, the students are unknowingly linked the words with their macroscopic level observation (water). The alternative framework gives an impression of the students' failure to give their full attention and participation during the interview is conducted.

This is in line with the lowest level in Taxonomy White (1988); where there is no attention is given during teaching and learning process. In this situation, the students themselves are not giving their full attention or they are distracted from focusing. Therefore, the word units cannot be processed in their mind. Conversely, if the student is at the highest level of attention, all acts of connecting and evaluating are occurs in their mind. Hence, by combining the students' thought with the learning objectives, the mental images that are not relevant will not be generated.

6.8 Water Molecules Imagined As 'Stagnant'

On the other hand, for the concept of situation during the water molecules formation, there are only 0.51 percent of the macro imagination are generated by the students by imagining the molecules as 'stagnant' as being shown below:

Researcher: When I say the oxygen molecule bond is breaking, what do you sees?

Student: They stagnate.

Researcher: Sorry?

Student: Yes, they stagnate.

(P1SK1, 16-17 years old)

Based on the conversation, the students are imagining the breaking of water molecules bond as 'stagnant'. This imagination is produced because of the characteristics of macroscopic liquid which is stagnant. This proves that the students' macroscopic level observation gives a massive influence and impact to their imagination, but they are not using it by ignoring the science concepts that must be put into the imagination elements. In fact, they are also affected by the word 'water' itself that is used in the guided imagery interview, makes the image of water is spontaneously produced. Therefore, the type of words that are heard during the guided imagery interview is directly influences the students' imagination if they are not giving attention during the activity. This situation indicates that the teachers and students are tending to isolate the students' daily lives with chemistry learning. It encourages the students to build two knowledge systems that are unrelated with the chemistry, which one system is used to solve the chemical reactions in school and the other one is used in their daily lives (Osborn and Freyberg, 1985). Surprisingly, when the chemical concepts are related to the daily lives during the teaching and learning process, the retention of the concepts in the students' mind is better (Demircioğlu *et al*., 2005). The separation of these two systems also is supported by Oloruntegbe *et al*. (2010) who claims that the students are not able to relate the chemical concepts learned at the school with the activities at home.

7. Conclusion

This study is conducted to identify the alternative framework contained in the imagination of the students on the concept of matter at submicroscopic level. The result shows that one of the alternative frameworks that exist in the students' imagination is macro imagination. In this study, students' macro imagination is seen from four concepts, namely hydrogen gas, hydrogen electron, hydrogen molecules collision and water molecules formation. For the imagination of hydrogen gas, the most of imagination generated by the students are a cloud of smokes, followed by the bubbles and no images while the movement of hydrogen gas is imagined as a moving up balloon from a slow to fast motion. For the hydrogen gas bond, the students generated the image of something that resembles a rope that exists between the atoms. In contrast, for the hydrogen electron, no images are produced. Next, 'white' is imagined for the hydrogen molecules collision situation. Other than that, the students generated the image of hydrogen molecules are floating slowly and releases more smokes and heats. After the collision, the students are imagining the stars and hydrogen and oxygen breaks into four circles. Water molecules formation is studied from the aspects of water molecules combination and condition of molecules during the formation. It can be concluded that the majority of the students generates macro imagination with a tendency to hydrogen gas image (7.14 percent) followed by water molecules formation (5.61 percent) and hydrogen molecules collision (3.06 per cent) while no macro imagination are produced on the hydrogen electron.

8. Implications

Overall, the finding shows that the students tend to produce the alternative framework imagination in macro imagination category on the concept of matter at submicroscopic level. The sequence of this trend, several strategies has to be applied by the teachers during the teaching and learning process to overcome the macro imagination production at the same time generating the scientific imagination. One of the strategies are the teachers need to associate the students' imagination with the related science concepts so that even they are imagining based on their ability and interest, they are maintaining the scientific perspectives in their imagination journey. By applying this strategy, it is hoped that the students are able to produce not only an attractive and creative imagination, but also precise and scientific. Teachers' exposure on the aspect of imagination during the teaching and learning process among the students also must be enhanced. It is important for the students to understand the phenomenon in details during the imagination process without ignoring the scientific concepts. This situation will allow the students to generate the imagination beyond the boundaries but at the same time retaining the science concepts as a basis. For instance, during imagining the particles' movement, the students must know the gas particles' movement basis; Brownian motion. Hence, the imagination generated will be based on the basic concept and becomes more precise and scientific.

References

Al-Balushi, SM 2003, 'Exploring omani pre-service science teachers' imagination at the microscopic level in chemistry. and their use of the particulate nature of matter in their explanations' PhD thesis, University of Iowa.

Ayas, A, Özmen, H, & Çalik, M 2009, 'Students' conceptions of the particulate nature of matter at secondary and tertiary level', *International Journal of Science and Mathematics Education*, vol. 8, no. 1, pp. 165-184.

Barke, HD, Al Hazari, & Yitbarek, S 2009, *Misconception in chemistry*, Springer, German.

Bouldin, P 2006, 'An investigation of the fantasy predisposition and fantasy style of children with imaginary companions', *The Journal of Genetic Psychology: Research and Theory on Human Development*, vol. 167, no. 1, pp. 17-29.

Bucat, B & Mocerino, M 2009, 'Introduction: macro, submicro and symbolic representations and the relationship between them: key models in chemical education', in: Gilbert, JK & Treagust, D (ed.), *Multiple representations in chemical education*, Springer, London.

Canpolat, N 2006, 'Turkish undergraduates' misconceptions of evaporation, evaporation rate, and vapour pressure', *International Journal of Science Education*, vol. 28, no. 15, pp. 1757-1770.

Demircioğlu, G, Ayas, A, & Demircioğlu, H 2005, 'Conceptual change achieved through a new teaching program on acids and bases,' *Chemistry Education Research and Practice*, vol. 6, pp. 36-51.

Fraenkel, JR & Wallen, NE 2008, *How to design and evaluate research in education,* 7th edn, McGraw-Hill, New York.

Gilbert, JK & Treagust, DF 2009, 'Introduction: macro, submicro and symbolic representations and the relationship between them: key models in chemical education', in: Gilbert, JK & Treagust, D (ed.), *Multiple representations in chemical education*, Springer, London.

Haidar, AH & Abraham, MR 1991, 'A comparison of applied and theoretical knowledge of concepts based on the particulate theory of matter, *Journal of Research in Science Teaching*, vol. 28, no. 10, pp. 919-938.

Harrison AG & Treagust DF 1996, 'Secondary students' mental models of atoms and molecules: implications for teaching chemistry', *Science Education*, vol. 80, no. 5, pp. 509-534.

Hittleman, DR & Simon, AJ 2002, *Interpreting educational research: an introduction for consumers of research*, Merrill, Upper Saddle River, N.J.

Johari, Surif 2010, '*Kajian perbandingan pemikiran saintifik pelajar Malaysia dengan United Kingdom*', PhD thesis, Universiti Teknologi Malaysia.

Johnson, P & Papageorgiou, G 2010, 'Rethinking the introduction of particle theory: a substance-based framework', *Journal of Research in Science Teaching*, vol. 47, no. 2, pp. 130-150.

Johnstone, AH 1991, 'Why is science difficult to learn? things are seldom what they seem', *Journal of Computer Assisted Learning*, vol. 7, pp. 75-83.

Leahy, W & Sweller, J 2005, 'Interactions among the imagination, expertise reversal, and element interactivity effects', *Journal of Experimental Psychology: Applied*, vol. 11, no. 4, pp. 266-276.

Mellou, E 1996, 'Can creativity be nurtured in young children?', *Early Child Development and Care*, vol. 119, no. 1, pp. 119-130.

Merriam, SB 1998, *Qualitative research and case study applications in education*, Jossey-Bass Publishers, San Francisco:

Merriam, SB 2002, *Qualitative research and case study application in education. revised and expanded from case study research in education*, Jossey-Bass Publishers, San Francisco.

Meyer, K 2013, *Improving imagination skills in order to assist abstractive learning*, viewed 15 January 2015, http://hdl.voced.edu.au/10707/252114

Mulford, DR & Robinson, WR 2002, 'An inventory for alternate conceptions among first-semester general chemistry students', *Journal of Chemical Education*, vo. 79, no. 6, pp. 739-744.

Nakhleh, MB, Samarapungavan, A & Saglam, Y 2005, 'Middle school students' beliefs about matter', *Journal of Research in Science Teaching*, vol. 42, no. 5, pp. 581-612.

Nelson, PG 2002, 'Teaching chemistry progressively: from substances to atoms and molecules, to electrons and nuclei', *Chemistry Education: Research and Practice in Europe*, vol. 3, no. 2, pp. 215-228.

Oloruntegbe, KO, Ikpe, A & Kukuru, JD 2010, 'Factors in students' ability to connect school science with community and real-world life', *Educational Research and Reviews*, vol. 5, pp. 372-379.

Onwu, G & Randall, E 2006, 'Some aspects of students' understanding of a representational model of the particulate nature of chemistry in three different countries', *Chemistry Education: Research and Practice*, vol. 7, no. 4, pp. 226-239.

Pabuçcu, A & Geban, Ö 2006, 'Remediating misconceptions concerning chemical bonding through conceptual change text', *Hacettepe University Journal of Education*, vol. 30, pp. 184-192.

Patton, MQ 2002, *Qualitative research and evaluation methods,* 3rd edn, Sage, Thousand Oaks, CA.

Rahayu, S & Kita, M 2010, 'An analysis of Indonesian and Japanese students' understandings of macroscopic and submicroscopic levels of representing matter and its changes', *International Journal of Science and Mathematics Education*, vol. 8, no. 4, pp. 667-688.

Russ, SW 2003, 'Play and creativity: developmental issues', *Scandinavian Journal of Educational Research*, vol. 4, no. 3, pp. 291-303.

Taştan, O, Yalçınkaya, E & Boz, Y 2008, 'Effectiveness of conceptual change text-oriented instruction on students' understanding of energy in chemical reactions', *Journal of Science Education and Technology*, vol. 17, no. 5, pp. 444-453.

Tindall-Ford, S & Sweller, J 2006, 'Altering the modality of instructions to facilitate imagination: interactions between the modality and imagination effects', *Instructional Science*, vol. 34, no. 4, pp. 343-365.

Wright, T. (2003). Images of Atoms. *Australian Science Teachers Journal*. 491: 18-24.

Yezierski, EJ & Birk, JP 2006, 'Misconceptions about the particulate nature of matter. using animations to close the gender gap', *Journal of Chemical Education*, vol. 83, no. 6, pp. 954-960.