Profile of prospective primary school teachers’ mental model in the subject matter of change

N Hermita 1*, M Alpusari 1, E Noviana 1, O Kurniawan 1 and N Islami 2

1Program Studi PGSD, Universitas Riau, Pekanbaru 28293, Indonesia
2Studi Pendidikan Fisika, Universitas Riau, Pekanbaru 28293, Indonesia

*Corresponding author’s email: neni.hermita@lecturer.unri.ac.id

Abstract. This study aimed to obtain an overview of the profile of the mental model (MM) of prospective primary school teachers in the concepts of change in the state of matter. The mental model (MM) categories reviewed in this study includes scientific MM, synthetic MM, and initial MM. A descriptive quantitative method was selected in this study. Among 30 of prospective primary school teachers at one university in Riau Province who had attended the science course were involved in this study. Lectures on the essential concept of science are carried out by lecturers using traditional (teacher centered). A test was used to collect the information of conceptual understanding, which is consisting of three question fragments (explanatory and depictions responses). The results demonstrated that the mental model profile of primary school teachers on phase transition (melting phenomena) are: scientific MM (0%), synthetic MM (27%) and initial MM (73%); related to the concept of freezing are: Scientific MM (0%), Synthetic MM (20%) and Initial MM (80%); related to the concept of evaporate are: Scientific MM (0%), Synthetic MM (23%) and Initial MM (77%); and related to the concepts of condense are: Scientific MM (0%), Synthetic MM (17%) and initial MM (83%). These results indicated that lectures on the basic concept of science carried out by lecturers had not facilitated the achievement of a scientific mental model for prospective primary school teachers.

1. Introduction

Understanding the whole subject matter is the main thing that must be owned by a prospective teacher, including prospective primary school teachers. A teacher who does not understand the subject matter as a comprehensive will transmit misunderstanding or misconceptions to his students. An understanding of the subject matter of a prospective teacher will be reflected in his mental model. The scientific mental model reflects a sound or comprehensive understanding. A prospective teachers’ understanding of the macroscopic and symbolic aspects is directly identifiable, but the understanding at the sub-microscopy level is observable if the student’s mental model is recognized.

Johnson-Laird in [1] stated that a mental model is a description of what the student thinks of a particular situation that can be seen in his/her way of delivering reasons and explanation. Gentner & Stevens also proved that the mental model is a person’s representation in understanding and clarification a phenomenon [2]. The mental model is also used to support a person’s understanding and logic explanation of a certain condition and formed spontaneously when dealing with a particular
situation, but the mental model can also be stored as long-term memory [3]. Students’ mental models are formed when they learn new concepts and make connections between information received, either in the form of texts or images [4]. The same thing was expressed by Stains & Sevian that mental models can be formed when a person is facing a particular problem [5]. Gentner & Stevens revealed that mental models are shaped due to a certain process and repeated certain conditions [3]. This suggests that the mental model may vary according to students’ experiences and understanding.

Students’ mental models are important to be recognized by teachers since it could useful for them to distinguish how the students learn and understand a concept, whether or not there is a mistake in their understanding. Several studies on mental models on learning physics have been done before [6][7][8][9].

Among the science concepts of graduate level, the change in the state of matter requires an understanding of the three levels of representation. Related current studies have been conducted and revealed that a number of students’ misconceptions still found in this concept [10]. This study was attempted to identify mental models of forthcoming primary school teacher in the concept of change in the state of matter. The mental model categories used in this study included scientific mental models, mental synthetic models, and initial mental models.

2. Methods
A descriptive quantitative method was employed in this study. 30 of prospective primary school from one of the PGSD Universitas Riau were selected as a sample of study. The Conceptual Understanding Test (CSMCUTest) was carried out to obtain the information of conceptual understanding of the changes in the states of matter. Each CSMCUTest item consists of three parts of the question, two questions require a verbal explanation response and one question requires a description response in a microscopic pictorial representation. Conceptual understanding tests are used to identify the state of conceptual understanding of prospective primary school teacher at the time after taking lectures are carried out by the lecturer. The number of conceptual understanding test items is four items, each related to the concept of melting, freezing, evaporate and condense (Table 1).

| Item number | Concepts   | Indicator of test item                                                                 | Test item                                                                 |
|-------------|------------|---------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| 2           | Freezing   | A. Explain the definition of freezing                                                 | A. What is meant by freezing? Explain!                                   |
|             |            | B. Explain the physical mechanism of the liquid freezing process                      | B. Explain how water can freeze into ice when cooled!                     |
|             |            | C. State in the representation of microscopic pictorial changes in the molecular bond structure when the liquid is frozen | C. Illustrate in the pictorial representation of the change in molecular bond structure of H₂O when the water (liquid) change into ice (solid)! |
| 4           | Condense   | A. Explain the definition of condense                                                 | A. What does it mean to condense? Explain!                               |
|             |            | B. Explain the physical mechanism of the condensation process                        | B. Explain how water vapor can condense into drops of water when release heat into the environment! |
|             |            | C. State the representation of microscopic pictorial of changes in molecular bond structure when water vapor condenses | C. Describe in the pictorial representation of the changes in the structure of H₂O molecular bonds when the water vapor (gas) changes into water droplet (liquid)! |
The students’ mental models Saglam Arslan & Devecioglu methods was used in this study to fit understanding levels to the rubrics [11]. Rubrics are frequently used in the recent literatures[12][13][14], and one of them was developed by Abraham et al.[15], that determined understanding levels through descriptive questions[6]. It also can be suitable to identify students’ answer to the question that required drawing. Besides, the students’ answers (given by the third question) was carried out by means of instruments developed by Saglam Arslan [16].

Table 2 shows the students’ mental models related to transition in the state of matter that fitted with the reference to define their understanding levels (see Table 2). To ascertain the model of understanding for any given student about change in the state of matter, their understanding and reasoning levels on “change in the state of matter”, especially on “the state of H₂O molecules during the transition state” were carefully classified into Scientific, Synthetic, or initial mental model [17]. In this stage, the understanding level of 3 and 4 were categorized as sufficient, while understanding levels of 0, 1, and 2 were corresponded to insufficient.

3. Results and Discussion

Table 3 and Table 4 shows a sample of the score achieved by a prospective primary school teacher for each part question of the CSMCU Test related to the concepts of melting and evaporate. Based on the achievement data score of each part question of the CSMCU Test in Table 3 and Table 4, it can determine the category of mental models achieved by each future primary school teacher for each concept of change in the state of matter, that is melting, freezing, evaporate and condense. Here after, the number of a prospective primary school teachers in each category of mental models can be quantified. Figure 1 and figure 2 show number of prospective primary school teachers in each mental model category on melting and freezing concepts, and evaporate and condense concepts, respectively. It can be inferred that none of them can accomplish to the scientific mental model category for those concepts. Most of teacher is in the synthetic and initial mental model category.

Table 2. The rubrics for mental model evaluation

| Model Mental Categories | Contents | Score for every part question of CSMCU Test |
|-------------------------|----------|-------------------------------------------|
| Scientific              | Opinions that correspond to scientific knowledge: answers at level 3 (PU or PCD) or 4 (SU or CD). | Score for question A, B, and C everything is high (3 or 4) |
| Synthetic               | Opinions which partially concur or do not agree with scientific knowledge. | Score for question A, B, and C (some are high (3 or 4) but some are low (0 or 1 or 2)) |
| Initial                 | Opinions which differ to scientific knowledge: answers at level 0 (NU or ND), 1 (AC or ID) or 2 (PU-AC or CD-ND). | Score for question A, B, and C everything is low (0 or 1 or 2) |

Table 3. The score for each part of the conceptual understanding test related to the concept of Melting

| Prospective primary school teacher | Part of conceptual understanding test | Q1 | Q2 | Q3 |
|-----------------------------------|--------------------------------------|----|----|----|
| P5                                | Q1                                   | 3  | 2  | 1  |
| P15, P24                          | Q1                                   | 3  | 2  | 0  |
Prospective primary school teacher | Part of conceptual understanding test
--- | ---
| Q1 | Q2 | Q3 |
P19, P28 | 3 | 1 | 1  
P8, P16, P30 | 3 | 1 | 0  
P12 | 2 | 1 | 1  
P1, P7, P10, P18, P20, P23, P27 | 2 | 1 | 0  
P4, P13, P25 | 2 | 0 | 0  
P2, P3, P9, P11, P17, P22, P26 | 1 | 1 | 0  
P6, P14, P21, P29 | 1 | 0 | 0

Table 4. The score for each part of the conceptual understanding test related to the concept of Evaporate

Prospective primary school teacher | Part of conceptual understanding test
--- | ---
| Q1 | Q2 | Q3 |
P5 | 3 | 2 | 1  
P15, P24 | 3 | 2 | 0  
P19, P28 | 3 | 1 | 1  
P8, P16, P30 | 3 | 1 | 0  
P12 | 2 | 1 | 1  
P1, P7, P10, P18, P20, P23, P27 | 2 | 1 | 0  
P4, P13, P25 | 2 | 0 | 0  
P2, P3, P9, P11, P17, P22, P26 | 1 | 1 | 0  
P6, P14, P21, P29 | 1 | 0 | 0

The results above indicate that the use of traditional lectures approaches is less able to facilitate the achievement of the scientific category of mental models. The conventional method of teaching/lecturing concept consists of the following steps; giving the student the word that expresses the concept, specifying the definition of the concept, and identifying and distinguishing qualities needed to understand the definition, to ensure that students find examples related and unrelated to the concepts. This traditional approach is not effective enough in the learning of concepts[18]. However, it is not appropriate, since the students not only required to identify and to memorize the concepts on understanding concepts but also to understand the the relationship between those concepts. The traditional lecturer tends to be carried out monologically.

In a one way lectureship, the lecturer is a central and knowledge is delivered from the lecturer to students, resulting in rote memorization. As opposed to, the appropriate learning situations should be created for students where they can learn and invent their scientific knowledge as scientists. Thus, they will be able to conceptualize learning. Teaching should be done by involving interaction between teacher and students or among fellow students in a dialogue format. In a discourse, the authority is shared between the teacher and students, and both teacher-student and student-student interactions result in the meaningful construction[19].

In order to teach the physical content containing microscopic phenomena, it is necessary to help the microscopic visualization media that can be modeling invisible microscopic situations into a macroscopic situation that can be observed by the students' sense of sight [20]. According to Siriswadi and Siriporn, students will more easily understand a physical phenomenon or physical event when they can observe it rather than just listening to the lecturer and imagining it [21].
4. Conclusion
It can be concluded that only a few prospective primary school teachers demonstrated a scientific mental model. The results showed that, in general, teachers have remarkable weaknesses in understanding the terms of fundamental knowledge of state transition of matter. The traditional lecture approaches cannot be relied upon to promote them in achieving sound understanding, because their lectures activities do not actively involve students to think, discuss and discover the physical meaning of each learned concept.

5. References
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