Improving the mental model of high school students related to the concept of global warming through the implementation of the context based learning (CBL) model combined with the CM2RA strategy

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Abstract. The aim of this study was to improve the mental model of high school students related to the concept of global warming through the application of the CBL model using the CM2RA strategy (context, microscopic models, macroscopic phenomena, and analogy representation). The mental model categories reviewed include scientific, synthetic and initial mental models. This mental model category is determined based on the test results data level of conceptual understanding. A pre-experiment method with one group pretest-posttest design was used in this research. The number of research subjects was 40 students consisting of 24 female students and 16 male students, in one of the high schools in the Tasikmalaya district of West Java province. The instrument used to collect data is a test of understanding the concept of global warming in the form of essays covering three parts of the question. The results showed that before the application of CBL, the number of students in each mental model category was: scientific mental model (5%), synthetic (40%), and initial (55%), whereas after the application of CBL, the number of students in each category of mental models becomes: scientific mental model (78%), synthetic (15%), and initial (7%). These results indicate that the implementation of CBL with CM2RA strategies has high effectiveness in facilitating the achievement of the scientific mental model.

1. Introduction
Some results of research in the field of science learning show that the use of traditional learning approaches fails in facilitating the achievement of the category of scientific mental models [1-4]. This failure shows that traditional learning can not facilitate the achievement of a sound understanding of physics concepts by students. This failed due to the traditional learning model which less emphasizes the submicroscopic level [1]. In line with this, Talanquer [2] said that traditional learning refers much to the macroscopic and symbolic levels. Yet to form a proper mental model, requires a thorough understanding of the three levels of representation namely the macroscopic representation, symbolic representation, and sub-microscopic representation. Because the mental model is closely related to the
three levels of representation, in order that the learning held by the teacher can facilitate the achievement of sound understanding and category of scientific mental models, needed a learning model that emphasizes the three levels of representation [5].

One learning model that can meet these needs is the context based learning (CBL) model. Concept, scientific aspect, and its role in our lives should be combined and should be considered as an implementation of the real world [6, 7]. According to context based learning theory, individuals make associations based on the examples of daily life. By gaining experience, they start to learn [8]. What distinguishes context based learning from other theories that adopted constructivist approach is this philosophy. The main purpose of this theory, which was started to be employed in 1980, is to raise the attention of students towards science and to make them realize the association between real life issues and science [9].

The CBL model has the following syntax: student orientation in context, reading scientific articles and answering questions/proposing problem solutions, class discussions discussing the answers of each group, constructing conception through demonstration activities, visualization, practice and discussion, discussing contexts, and strengthening and enrichment on relevant events/phenomena [10]. The stages of conceptualization through demonstration, visualization, practice and discussion on CBL models are seen to facilitate students to be able to achieve sound understanding. Whereas the use of the CM2RA strategy which includes the explanation of the context at the macroscopic and sub-microscopic level which is supported by the representation of dynamic model and analogies done with hope that students can have conceptual understanding up to sub-microscopic level. The dynamic analogy for long wave scattering by particles of greenhouse gases used in this study is in the form of scattering various types of balls of different sizes by basketball hoops. With the presence of three levels of representation in physics learning, it is expected that high school students can achieve a scientific mental model. Appearance visual representations of knowledge, concepts or ideas may help to guide the thoughts in the learner’s mind [11].

One of the physics content at high school that requires an understanding of the three levels of representation is the global warming. This study was conducted to obtain an overview of the effectiveness of the use of the CBL model combined with the CM2RA strategy in facilitating the achievement of the scientific mental model among high school students related to the concept of global warming.

2. Methods
The method used is a pre-experiment method with one group pretest-posttest design. The number of participant was 40 students (24 female and 16 male), in one of the high schools in the Tasikmalaya district of West Java province.

The instrument used is a test of conceptual understanding related to concept of global warming in the form of essays covering three parts of the question. This test is named Global Warming Concept Understanding Test (GWCUTest), which stands for a test of conceptual understanding related to concept of global warming. Question-1 (Q1) requires an answer about the concept of global warming, question-2 (Q2) requires about the causes of global warming, and question-3 (Q3) requires a response in the form of a state of the representation of microscopic pictorial of the mechanism of confinement of long-wave radiation by greenhouse gases. For scoring conceptual understanding test for part of questions 1 (Q1) and question 2 (Q2) was used rubric by Kurnaz [12], as shown in Table 1.

| Levels of Understanding (LU)                 | Score | Criteria                                      |
|----------------------------------------------|-------|-----------------------------------------------|
| Sound Understanding (SU)                     | 4     | Responses containing all components of the scientifically accepted response |
| Partial Understanding (PU)                   | 3     | Responses containing some components of the scientifically accepted response |
3. Results and Discussion
Table 4 shows the scores achieved by high school students for each part of the GWCUTest question at before and after the implementation of CBL.
Based on Table 4, it can be determined the categories of mental models achieved by each student related to the concept of global warming. Furthermore, it can be calculated the number of high school students in each category of mental models by knowing the categories of mental models reached by each student. Table 5 shows the number of students in each category of mental models related to the concept of global warming before and after the implementation of CBL.

### Table 5. Number of students in each mental model category related to the concept of global warming before and after implementation of CBL

| Category of mental model | Before CBL | After CBL |
|--------------------------|------------|-----------|
|                          | Number of students | Percent (%) | Number of students | Percent (%) |
| Scientific               | 2          | 5         | 31         | 78          |
| Synthetic                | 16         | 40        | 6          | 15          |
| Initial                  | 22         | 55        | 3          | 7           |
| Total                    | 40         | 100       | 40         | 100         |

Based on Table 5, there was a change in the mental model category between before and after the implementation of CBL. The number of students who reached the category of scientific mental models increased while the number of students who reached the category of synthetic and initial mental models decreased. The pattern of changes in the category of mental models achieved by students from before to after following the CBL activity is shown in Figure 1.

The results of this study show the great potential of CBL in facilitating the achievement of understanding concepts in depth and comprehensively. This potential is possible because the processes in CBL lead to the construction of conceptions in the minds of students through their own construction process. CBL engages students in learning that demands activating their thinking and metacognitive skills, motivates students, and encourages them to be scientifically literate [14]. Reading adapted scientific articles as part of a context-based approach helps students develop an understanding of scientific concepts and how these concepts are connected to real-world problems [15]. The results of this study are in line with those obtained by Dori et al [16] which shows that the application of CBL in science learning can improve students' understanding of concepts and metacognition.
4. Conclusion

Based on the research data, the implementation of the CBL model combined with the CM2RA strategy has high effectiveness in facilitating students in achieving the scientific mental model category. This indicates that the integration of the CM2RA strategy with the CBL model can facilitate the process of conceptual development that leads to the formation of a sound and comprehensive understanding of the concept of global warming in the minds of high school students.

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