Teachers, pre-service teachers, and students understanding about the heat conduction

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Abstract. The purpose of this study is to analyze teachers, pre-service teachers, and students conceptual understandings related to heat conduction in macroscopic and sub-microscopic (verbal and visual). This description research involves 15 teachers, 33 pre-service teachers, and 39 students. Data were collected by using a conceptual understanding diagnostic test. The result shows that almost the participants know about the macroscopic level. However, most of them have a few understanding at the sub-microscopic level in verbally and no one of them can draw or represent the scientific conception about the sub-microscopic level. This study suggested that the sub-microscopic level of the science concepts must be learned and taught to students to make science more easy to understand and explained.

1. Introduction

Science has been regarded as a difficult subject for young students by the teachers, researchers, and educators [1]. In learning science, students have various conception/ideas/understanding about phenomena and sometimes their conceptions is not matched with the scientific concepts [2], their understanding constructed in learners’ mind could be called as a misconception, alternative conception, alternative framework, naive conceptions, children’s science, and common sense understanding is used [3]. There are three levels of understanding in science lesson there is a macroscopic or a concrete level, sub-microscopic or an abstract level, and symbolic to represent the macroscopic phenomena by using mathematical, equations, graphs, analogies, etc [4]. In macroscopic level students have no problem to understand that because they can see/touch/feel that, but in sub-microscopic level, many students have misconceptions/don’t understand about this level, and when they don’t understand this so the symbolic level they just remember not understanding. But, for the elementary students do not learn until this level.

Because students in elementary school are not introduced the sub-microscopic level it makes the students can't give a reason why it could happen in some science phenomena. For examples of conduction, many students know that if metal heated in one side of tip another tip will be hot too, the reason because the metal is a heat conductor. Even elementary students’ learn a concrete phenomenon but they must know the reason why it could happen. One of the solutions to make sub-microscopic can be taught to elementary students is with teachers’ representation. representation is used to describe and explain a scientific phenomenon and can facilitate the delivery to the students [5]. Teachers have an
important role to make students understand the sub-microscopic level. However, the research about comparing students and teachers understanding has not been done before.

Because of that, the purpose of this study is to analyze understandings of students and teachers in macroscopic and sub-microscopic level. And adding pre-service teacher to know are they have a same problem with the students or not in understanding of conduction concepts furthermore pre-service teachers are set to play a significant role in science teaching to future generations [6]. This research used a descriptive method to analyze the teachers, pre-service teachers, and students answers and pictures to represent they understanding about the heat transfer concepts by giving them a test. So the main question of this research is “how the comparison of understanding between teachers, pre-service teachers, and students about heat transfer concepts?”

2. Research Method
This research is a descriptive research. The subjects of the study were 15 teachers in elementary school, 33 pre-service teachers in elementary school, and 39 students in elementary school. The instrument used in this research is to know about the macroscopic and sub-microscopic level of understanding in conduction concepts. The instrument consists a two-part there are multiple choices and drawing part. Multiple choices are to know about the two level of understanding from the concrete level and abstract level based on the everyday phenomena. A concrete level is a something that we observer/feel/taste/see and the abstract level is to describe how the movement of particles when it heated in solid. The drawing part is to know what are the participants thinking/representation about the phenomena in their minds and useful tools to reveal the level of comprehension by not constraining the participants’ response. The results of the data obtained will be analyzed and compared between the three participants to know their understanding.

3. Result and Discussion
The results of participants’ understanding of the heat conduction concepts are divided into three parts macroscopic, sub-microscopic verbally and visually (representation). The conduction topic participants were given a phenomenon about the metal spoon before and after inserted into a hot water. These phenomena have two questions about what will happen in the metal spoon and the particles. Figure 1 and 2 giving our information about the comparison of three kinds participants.

![Figure 1. Understanding at macroscopic level on conduction topic](image)

Figure 1 can we see that in macroscopic level all the participants almost answers the correct answer. In teachers and students just one person who give wrong answers but in pre-service teachers, there are three people who answer wrong. But, at this level all the participants don’t have any problem because the answers are the temperature of another tip will increase caused by the metal is a heat conductor. However, in sub-microscopic level the data changes just a few participants can give a correct answer of this level we can see it at figure 2.
At this level, just a few participants can choose the correct answers of why it could happen in a metal spoon. The correct answers that have a scientific conception are the heat can conduct in metal spoon because the vibrating particles in nearest particles in heat sources vibrate, and then crash into other particles. The crash and vibrating particles are continued until all part of the metal spoon. So this is can be some proof that the sub-microscopic level does not introduce or learn in the participants' from the elementary school until colleges in elementary school teachers. Another provable evidence that even all three players can choose a correct answer but actually they just guess it is from the representations of the answers that they choose. The answers and the representations do not match. We can see the examples in figure 3, 4 and 5.

**Figure 2.** Understanding at sub-microscopic level on conduction topic

Teacher 1 have a correct understanding of the particles of metal will vibrate when it heated but the representations don’t clear it seems that when heated the particles will closer and become more than before.

Teacher 2 think that when metal heated the particles will be enlarged and have more positive ion that before and this phenomena make the metal spoon be a heat conductor.

**Figure 3.** Example of teachers representation
Pre-service teacher 1 taught that when metal heated the particles will be more unity and become more than before

Pre-service teacher 2 think that when metal heated the particles will be increased and more bonding

Figure 4. Example of pre-service teachers representation

Student 1 have no clear representation about this phenomena

Student 2 think that when metal heated the particles will be enlarged and have more particles

Figure 5. Example of students representation

Based on the samples of teachers, pre-service teachers, and students we can see that all the participants have a lack of knowledge about the sub-microscopic level of understanding. However, this sub-microscopic level is the basis of science concepts [1], to know more about the sub-microscopic concepts firstly students must learn about the particulate nature of science [7]. These misconceptions can occur to the participants because they confusing with the characteristics of particles and the characteristics of solids. It is widely known that students tend to describe the observable macroscopic characteristics of matter to its particles in the microscopic level as well [8] [9]. But in this study not only students but also the pre-service teachers and teachers who don’t know so well about the characteristic of solid particles and what happens if the solid particles are heated?

From data of this study can be concluded that all the participants’ confusion between the characteristics of particles and the characteristics of matter played a substantial role in developing the misconception [6]. This also signifies that the sub-microscopic level should be studied from the elementary school to give the scientific conception of what really happened in accordance with the scientific conception. And teachers have a significant role to introduce and teach the sub-microscopic level understanding. Because in another study shown that teacher has many misconceptions about conduction like the particles when heated will enlarge, spread, and move upwards [10] and the pre-service teachers could not explain the phenomena at sub-microscopic level, their understanding was still largely in categories of partial understanding, misconception, and does not understand [11].

To make science more easy to understand and explain the teachers must know about the sub-microscopic level of understanding and show it with the suitable representation to the student. Because, students in grades 4, 5, and 6 of elementary school, students who study the nature of particles (sub
macroscopic) gain better achievement than students who do not learn about particles at all [1]. With the use of representation in science learning, science learning can be more visual, since the visualization of this science includes complex processes with which scientists develop or produce images, schemes, and graphical representations. Visual representation in science can refer to objects believed to be some kind of material or physical existence comparable to mental constructs, conceptual, and abstract constructs [12].

Understanding of the sub-microscopic level can enhance the students’ high-level thinking. This ability is to make explanations or reasoning can also involve the following processes: analyzing/solving problems, integrating/synthesizing, hypothesizing/predicting, designing/plotting, drawing conclusions, generalizing, evaluating, and justifying. Because this ability is one of the skills needed in the 21st century [13]. If students learn the sub-microscopic level they science is not only a memorize the phenomena but also they can give the reason and more deep understanding about the science phenomena in their daily life.

To cultivate reasoning ability, students must first understand the concept of the phenomenon they learn. To make students understand a concept of science, they need to be given a scientific representation in accordance with their development [12]. Representation is an entity that is related with one's mind in thinking or imagining things, therefore representation is central to the learning process and the consequences of the teaching process [13]. In the learning process, students who have more representation with the help of external representation will have more effective cognitive configurations [14].

4. Conclusion
The analysis data show that the teachers, pre-service teachers, and students don’t have any different understanding of the macroscopic and sub-microscopic level in conduction. The participants can give the correct answers in macroscopic level, but in the sub-microscopic level, just a few of them can give the correct answers moreover in drawing part most of them can’t give a correct representation about they understanding about the conduction concepts. These sub-microscopic level can make science not only to memorize but also can make students more understand the phenomena and these level understanding can increase the students high-level thinking ability. So, this sub-microscopic level and representation must be introduced and taught in the elementary school to make science easy to explain and understand.

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