Analysis of two-level representation about the heat convection between teachers and pre-service teachers

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Abstract. The aims of this study are to analyse and compare the two-level representation (macroscopic and microscopic) about the heat convection concepts. This research involves 15 teachers and 33 pre-service teachers. Data gathered using the diagnostic test to explore the two-level representation through verbal and drawing tests. The result shows that at the macroscopic level many respondents have a correct answer but decreased in microscopic level even more at the visualization test, just a few respondents can give a correct visualization according to scientific conception. This research found that all participant is well known about the macroscopic level but they have a lack of knowledge about the microscopic level. This research suggests that to make students more understand about science the learning must give multiple representations to make they understand about scientific phenomena.

1. Introduction
Heat transfer is a concept that related to everyday life. We can found and experienced that in our activity like cooking, boiling water, or the sunlight. Although this concept is close to us, however, it is difficult to relate it to the process of learning science in the classroom [1]. One of the causes of this difficulties is the lack of understanding of teachers to understand the concepts of heat according to the scientific conceptions. In this concepts, many teachers are in the misconceptions category and of course, this will impact on the process of the learning and understanding of students [2]. Even heat transfer is very related to everyday life and the concepts may already exist in the minds of children since early childhood, but there are often misconceptions or alternative conceptions in these concepts [3].

Understanding in science is not only at the macroscopic level but also in microscopic level too, because the macroscopic level people already know about that. For example, in heat convection, we all know that boiling water is caused by the different density between the hot water and the cold water. But, not everyone knows the current of this phenomena and why it could be like that? So, in this study we are going to figure it out what are the teachers and pre-service teachers thinks about the two-level representation of the heat convection. This study wants to investigate where is the missing link in concepts and we knew that one factor of that problem it teachers understanding of the content that they teach [4]. The teachers who do not have a good understanding of the content will not be able to deliver a quality lesson [2, 5]. And this problems not only happened in teachers but also in pre-service teachers too, most of them knew at the macroscopic level but lack of knowledge at the microscopic level [6].
But we can’t blame it only to the teachers, we must see clearly where is that misconception come especially in microscopic level because the microscopic level is a basic concept to understand the advanced concepts [7]. This microscopic level is an important thing and always be the part that always discusses to diagnose the understanding science to student [8-10]. Because the microscopic level is important this study tries to analyze how the understanding teacher in two-level representation. The macroscopic level is to know that what they know about something that can see, touch, and feel. In microscopic level is to figure it out what they know in verbal and visualization about the phenomena. So, the research question is “how the understanding about the heat convection between teachers and pre-service teachers?”

2. Method
The study is a descriptive research. The subject of the study involved 15 teachers in elementary school and 33 pre-service teachers in elementary teacher education. The instrument used in this study is a diagnostic test to explore two-level representation in macroscopic and microscopic (verbal dan visual). In macroscopic level ask about what would happen if we boiling water that very close with everyday life and the microscopic level asking about why it could happen like that (in macroscopic level) and the responders must give a visualization about the microscopic level to make it more real and represented what exactly in the mind about the concepts. The visualization or drawing by all respondent will be input into six categories: 1) Scientific Drawing (SD); 2). Partial Drawing (ParD); 3) Misconception Drawing (McD); 4) Undefined Drawing (UnD); 5) Non-Microscopic Drawing (NmD) and 6) No Drawing (ND). The results of this diagnostic test will be compared and analyzed in three level of respondents.

3. Result and Discussion
The results of the study by using the diagnostic test show a two-level understanding of all respondents. First the macroscopic level about the convection heat and second about the reason why it could happen with their drawing about the microscopic understanding to explain what is going on. In Figure 1 we can see the results of the respondents understanding at the macroscopic level.

![Figure 1. Understanding at the macroscopic level of convection topic](image)

Figure 1 shows that almost teacher can give a correct answer, in pre-service teachers only a few give a wrong answer. That’s can be a proof that teacher and pre-service teacher don’t have a problem with this. But on the other hand, if we ask the students about this, just a few students can give a correct answer. Based on student’s responses they just know the examples of the heat convection phenomena
like boiling water, movement of winds, and smoke. They do not know about the movement of water/gases because of the different temperature that makes a different density. That’s what makes the students give incorrect answers at the macroscopic level.

Now, we see understanding the responders at the microscopic level in verbal to make sure that respondents have an understanding of the phenomena more clearly. And this microscopic level is to diagnose the reason why it can happen from some phenomena. The results of this microscopic level are decreased from the macroscopic level in all responders we can see it in Figure 2.

**Figure 2. Understanding at the microscopic level of convection topic**

Based on Figure 2 teachers and pre-service teachers who have a scientific conception about microscopic level is decreased. This can happen because the microscopic level never be a focus on learning in science and it affects to students understanding, they can’t explain why it could happen. The results of this microscopic level must be more than that because they have learned it in a more deep and long time from the elementary school until the university. But the results seem not represented that they learn more than students. That can prove that the microscopic level or particulate nature of matter is not well learned by teachers and pre-service teacher. Even though this microscopic level needs to be taught and learn by students because if don’t science will be a remember not to understanding [8]. Impact of this problem is the students will hard to understand the scientific concepts in another concept and higher level. because of that science learning must be based on valid scientific conceptions [10].

According to the scientific conceptions, the hot water will move up and the cold water will go down because of the different density. Hot water will be more light than the cold one. Particle in hot water will be expanding, so in the same volume particle in hot water are less than a cold water. To see the visualization of those conceptions in respondents mind, this study adds a drawing section on the test because drawing is a useful tool to know common misconceptions or alternative conceptions [11]. And drawing can be an approach to probe understandings in students’ learning and can reveal the child and teacher qualities of understanding that can be hidden through other research procedures [12].

To see the respondents category in visualization concepts or in the drawing section. First, we see the general description of that. In figure 3 below we will know where is the most common responses that respondents give to make sure are they know comprehensive or not. Second, we take the sample of respondents visualization or drawing.
From Figure 3 we can see just a few correspondence can give a scientific visualization about the heat convection phenomena on the microscopic level. Commonly they are in Undefined Drawing and Misconceptions Drawing, this proves that for students to teachers have a problem to represent the microscopic level of understanding. This corresponds to previous studies that elementary school teachers’ understanding is low [13, 14]. But this study shows that the pre-service teacher has the same understanding as teachers. Based on an unstructured interview with the teachers and pre-service teachers they say that they do not learn into this far when they were at school and college. Some teachers said that they just teach follow the curriculum and books. So, they think that the microscopic level is not important to teach. An argument like this is a kind of some defend on teachers to cover their lack of knowledge. Even there is no minimum standard in requirements for elementary teachers. But, teachers need to have a good understanding of the basic concepts they are expected of the teacher [2, 15].

Pre-service teacher is the closest level with the teachers they are the next generation teachers. They must change paradigm that teaches an elementary student is easy do not need a scientific conception or just teach the macroscopic at the general truth. So, if they think that our students will take the misconceptions understanding or they can increase the skill in science learning. Many studies found that the teacher has a similar understanding with their students [16]. If the teachers have the same understanding of the students’ so the quality of learning science can be low. Next, we are going to see the examples of all respondents in the visualization of heat convection in Figure 4 and 5.

**Figure 3.** Percentages Category of Drawing

|        | Teachers | Pre-service Teachers |
|--------|----------|----------------------|
| SD     | 7        | 6                    |
| ParD   | 27       | 15                   |
| McD    | 27       | 24                   |
| UnD    | 45       | 40                   |
| NmD    | 0        | 0                    |
| ND     | 0        | 3                    |

**Figure 4.** Examples of Teachers’ Drawing (a) The teacher with a Scientific Drawing, (b) Teacher with an Undefined Drawing
Figure 5. Examples of Pre-service Teachers’ Drawing. (a) Pre-service Teacher with a Misconception Drawing (b) Pre-service Teacher with a Partial Drawing

Drawing section/visualization test is used to see the mental model of the respondents. Based on this study the visualizations of all respondents are very diverse. Almost all of them draw with their analogy in macroscopic level into the microscopic level and this makes misconceptions [9]. In the previous study found that many people assume that understanding in microscopic is same as macroscopic [17]. With these kinds of understanding, of course, will affect students’ learning [18]. The teacher who holds a misconception is not only unable to facilitate students’ learning but they will pass their misconception to their students [2]. These studies show that teachers’ and pre-service teachers’ do not have a strong understanding of the basic concepts of science. Based on previous studies students who get the basic concepts of the nature of matter have a good understanding at the microscopic level and reduce the misconception [19].

The results of these study may give information that to make the best quality of learning is science teachers and pre-service teachers are more to increase their understanding of the content knowledge not just in pedagogical. Because teaching need two types of skills there is pedagogical and content knowledge if one of that it doesn’t strong of the teachers not be ably delivering an effective learning to the students [20] and if teachers don’t have a strong understanding of what they teach it could be influenced by their confidence [2]. So, if teachers want gives an effective learning, they must combine the pedagogical dan content knowledge.

4. Conclusion
This study shows that the understanding of teachers and pre-service teachers at the microscopic level of understanding is a decrease from the macroscopic level. and just a few respondents can give a scientific drawing most common the respondents drawing/visualization is in misconception and undefined drawing. With these kind understanding of teachers and pre-service teachers, students will not get an effective learning from the teachers. So, to make learning more effective teachers and pre-service teacher must have a good understanding of the content knowledge and pedagogical skill to teach students not only in macroscopic level but in microscopic level too. Because with multiple representations, students will be more understanding about the scientific phenomena.

5. References
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