Pedagogical content knowledge (PCK) of science teachers based on content representation (CoRe)

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Abstract. Pedagogical Content Knowledge (PCK) has been one of the chief frameworks that widely employed by educators and researchers in order to examine and develop teachers knowledge of integrating content into the right pedagogy. In this article authors purposes to describe PCK of science teachers using an instrument developed by John Loughran, well known as Content Representation (CoRe). A core is constructed by asking teachers to identify “the big ideas” associated with teaching a topic to students. Participants were science teachers from a secondary school and have different ages from 21 until 34 years old. They were completed Content Representation to gain the data about their ability in PCK. Our results reveal that the teachers have different knowledge of PCK. Teachers knowledge of their PCK is related to working experience and professional development.

1. Introduction

Teachers are most important agent in education. The teachers’ involvement in the curriculum development process is essential in meeting the needs of society [1]. They bring a change and innovation in their instruction. To accomplish those innovations, teachers required to shift their belief away from traditional centre to student centre view [2, 3]. At all levels in the teaching profession, there is always a need for teachers, and this need goes hand in hand with the need for quality in teaching and learning.

There are two components to support teacher’s perform, namely pedagogical knowledge and content knowledge. Originating from the idea of Shulman in research of teaching in the 1980s, pedagogical content knowledge (PCK) has become a highly popular and influential concept in promoting teachers competencies. PCK not just using for professional development but it has also been associated in teaching design and assessment [4-6].

Moreover, PCK is knowledge of pedagogical representations, of instructional strategies, and of students’ prior knowledge and learning difficulties pertaining to the teaching of a particular topic to students of various backgrounds and experiences[7, 8]. With the marshalling of this knowledge and by way of pedagogical reasoning, a teacher transforms the content he or she possesses into pedagogical forms such as representations, instructional tasks, and classroom activities that make content comprehensible for students [9, 10].

This study selected global warming material because this material still often creates misconceptions for students [11-13]. An example of a conceptual error that often occurs is related to the greenhouse
effect. Students think that the average increase in temperature of the earth is due to the many buildings that use glass on Earth. Another example is related with ozone layer. People thought that ozone layer is directly affected global warming. Whereas, ozone layer and global warming occur in different place. Ozone layer in troposphere and global warming in stratosphere. This study wants to re-examine the subject of global warming in order to get a clear picture of the teachers of what concepts are important to be taught in this material. Therefore, the primary purpose of the study was to use a Content Representation (CoRe) questionnaire developed by John Loughran [14] for secondary school science teachers to describe teachers PCK in global warming topic.

2. Methods
Descriptive method was utilized in this research [15]. It used to describe science teacher’s PCK. Convenience sampling was used in this study. The participants were science teachers from three districts in Indonesia and have different ages from 21 until 34 years old. Table below show the background information of the participants

| Teacher Code | Gender | Age (Years) |
|--------------|--------|-------------|
| G1           | Female | 24          |
| G2           | Female | 34          |
| G3           | Female | 21          |

They were completed questionnaire to measure their ability to sync content and pedagogy in global warming topic. We applied Content Representation (CoRe) developed by [14]. Basically Content Representation offers a way that is able to correct teacher knowledge about strategies to teach certain content and reflect on pedagogical knowledge of the teacher so that it can be implemented on target in the classroom.

There are eight questions in the CoRe instrument, namely:
1) What will you teach students about this concept?
2) Why are these concepts important for students to learn?
3) Ideas / concepts related to what you think is not the time to be known by students?
4) What difficulties / limitations might you experience to teach the concept?
5) What are the conditions of students (initial knowledge / ways of thinking / interests) / what are the considerations in teaching this concept?
6) What factors are your considerations in teaching the concept?
7) What sequence / path do you choose to teach the concept?
8) How do you know that students understand or not?

After the teachers filled out the CoRe instrument, the researchers described the PCK the teacher.

3. Result and Discussion

3.1. Result
Before answering the eight question items, each teacher first determines the essential concepts related to the theme of Global warming. The concepts selected by the teacher are listed in the table below:

| No | Concepts                      | G1 | G2 | G3 |
|----|-------------------------------|----|----|----|
| 1  | Definition of Global warming  | -  | √  | √  |
| 2  | The process of global warming | -  | √  | √  |
| 3  | Factors global warming occur  | -  | -  | √  |
| 4  | The process of greenhouse effect | -  | -  | √  |
### 3.2. Discussion

PCK of science teachers can be seen from their ability to develop concepts that are considered important by the teacher, the ability to describe important concepts and the ability to choose the right pedagogy to teach those concepts. The ability to master concepts and the ability to decipher concepts can be seen from CoRe (Content Representation). Each teacher filled in the questions on the CoRe instrument.

#### 3.2.1. What will you teach student about this concepts?

The first question about teacher knowledge about what will be taught to students. Teacher are required to be able to do lesson planning, practice the learning and receive input from other teachers or researcher [16]. The teacher's knowledge in identifying big ideas is seen from the consideration of the selection of essential concepts by answering CoRe questions number 1, 2, 3 and 4. If reviewed from the 2013 curriculum, the topic of Global warming is taught under Basic competence "Analyzing climate change and its impact on the ecosystem".

Teacher G2 and G3's answers have similarities in the selection of essential concepts, and they constructed their CoRe based on the syllabus. The concepts outline start from the understanding of Global warming, the greenhouse effect, greenhouse gases, the impact of Global warming, and the solution to the problem of Global warming. All the concepts raised by teacher B and C are adjusted to the material in the student handbook. This is in accordance with the results of [17], which shows that the order of teachers in describing essential ideas and topics is largely influenced by textbooks and syllabi. So that it does not represent the Content Knowledge of teachers in particular.

G1 begins by describing essential concepts in the subject of Global Warming. These concepts are selected based on indicators on the syllabus. Despite its slightly wider concept, teacher G1 considers that the concept will make it easier for students to understand the topic of Global Warming compared to just relying on the sub-topics listed in the book.

#### 3.2.2. Why are these concepts important for students to learn?

The second question about the benefits of studying the concept. This CoRe question shows the teacher's expectations to students after studying Global Warming. Based on these answers teacher B and teacher C bring up arguments about students understanding. Teacher G2 emphasizes the environmental awareness that students will have after studying Global warming. Knowing the concepts of ozone and UV light related to how cosmetics are used must function properly counteracting the adverse effects of UV light on the skin. Teacher G2 has included things that are more applicable than Teacher G3.

The teacher's statement regarding the benefits of learning the concept of Global Warming is to bring environmental awareness to students. Although not directly taught, but the essential thing that students should get after studying Global Warming is how to protect the environment to avoid damage and how to encourage prevention of global warming.

#### 3.2.3. Ideas / concepts related to what you think is not the time to be known by students?

The third item from CoRe's question would be to know the teacher's consideration of the level of depth or wide of the teacher's knowledge. But it is not the time to be studied by students. The answer to this item is very unique because it is influenced by the teacher's educational background, Teacher G2 has a Biology education background, so it discusses the balance of the ecosystem. While G3 did not mention the
concept which was not yet time to be known by students. The important thing about this question is the teacher's ability to determine the breadth and depth of a concept and sort out which parts will be taught and not taught to students.

G1 describes the concept that is not yet time to be known by students. The concept of the atmospheric layer requires a chemical reaction in each layer. Even so, G1 chose not to teach this, because the important thing in the concept of atmospheric layer is that students know where the greenhouse effect or global warming is. Next to the concept of heat transfer, the G1 limits the concept to understanding and examples only, so that the G1 does not explain the mathematical formula in each type of heat transfer. In the concept of black matter radiation and electromagnetic wavelengths, G1 did not discuss it too deeply.

3.2.4. What difficulties / limitations might you experience to teach the concepts? The fourth item from CoRe's question wanted to know the difficulties faced by the teacher. The difficulties encountered by the teacher come from the concept itself or from outside such as the media used. Teacher G2 explained that the difficulties obtained were lack of material Global warming on student books, as well as the limitations of internet networks in schools that made information acquisition reduced. But teacher G2 did a simple experiment to overcome this difficulty. While teacher G3 has difficulty teaching Global Warming because of differences in the concept of teacher books and student books and the difficulties associated with chemical reactions.

G1 describes the difficulties that may be faced and how to overcome them. In the concept of atmospheric layers, heat transfer and blackbody radiation G1 explained the difficulty of teaching the concept lies in how to visualize it. It is difficult for G1 to provide a clear picture of the height of each layer of the atmosphere, or how heat moves based on the medium or visualize the amount of radiation emitted. However, to overcome these difficulties G1 used layers of images accompanied by information to make students understand about the atmosphere layer. In addition, G1 used simulations to explain heat transfer and blackbody radiation.

3.2.5. What are the conditions of students (initial knowledge / ways of thinking / interests) / what are the considerations in teaching this concept? The fifth item from CoRe wants to see other considerations in selecting essential concepts. The selection of essential concepts should not only consider the achievements of the syllabus, but also the condition of the students including their initial knowledge. The condition that is considered by teacher G2 to teach a concept is the way of thinking of students who are not familiar with analysing, so that most concepts are conveyed directly by the teacher. While teacher G3 explained that the consideration in choosing a concept is the students' initial knowledge about environmental pollution. G1 consideration for learning by explaining the concept of atmospheric layer is the way of thinking of junior high school students that is still concrete, so students need to know the place where global warming takes place. After that, it was continued by teaching about the concept of heat transfer which is a repetition material, only to be discussed again because it has a connection with the material of global warming. Furthermore the concept of blackbody radiation is taught with consideration of the students' initial knowledge who have never studied this material at all, so that it will be taught in a simpler form. It's the same as the concept of electromagnetic wavelength, because it only studies vibrations and waves, so matter is limited to the wavelengths of visible and infrared light. Whereas the concept of the impact and solution of global warming is taught with the consideration that students have gadgets so that it will facilitate access to information about the concept.

3.2.6. What factors are your considerations in teaching the concept? The sixth item from CoRe wanted to know about other factors that were considered by the teacher in teaching the concept. The factors that are considered by the teacher should be related to the material, time, supporting facilities and the condition of the students. This will affect the teaching strategy so that it will be adjusted to the characteristics of each concept and competency to be achieved. Factors that are considered by G2 are students' curiosity regarding the concept itself, an adequate learning environment and the media to be used. While G3 explained the students’ initial knowledge, interests, ways of thinking and facilities and infrastructure as factors that were taken into consideration in teaching the concept. This is in accordance
with the research conducted by [18], who said that the reason for limited facilities and infrastructure made the teacher continue to implement learning using conventional methods.

This question also provides information about other considerations besides the condition of students. G1 explained other factors in teaching concepts because of their relation to other concepts. The concept of heat transfer is taught because it is closely related to the increase in the average temperature on Earth. Besides that the concept of reflection and scattering, which is a key concept in the process of global warming, so that it is still taught even though the delivery is tried as simple as possible.

3.2.7. What sequence / path do you choose to teach the concept? The seventh item from CoRe wanted to see how the teacher organized the concept in the classroom. The order in which the material is presented should consider the needs of students and the conditions in the classroom. In teaching a concept it can be started by teaching concrete concepts first and then to concepts that are more abstract in nature. G2’s order in explaining the concept of global warming is to start by showing videos, then simulating global warming, after that, doing an experiment to observe the global warming process and then assigning it. While G3 chooses to explain the process of global warming first and then the causal factors, then marking the greenhouse process. After that the impact is explained and the solution offered.

Questions about the flow of teaching concepts have begun to lead to teacher's pedagogical abilities. In the concept of the atmospheric layer, the G1 begins the explanation by displaying images of the atmosphere layer and explaining the characteristics of each layer. The concept of heat transfer and the concept of black body radiation are explained by using virtual simulations that show how heat moves from the Sun to Earth so that the Earth is also able to emit the heat it receives. As for the concept of electromagnetic wavelength, G1 only display graphs of Wien without including equations and explaining their physical meanings. For the concept of scattering and reflection, G1 will teach it by using simulations, where students can see behavior of greenhouse gases against radiation of wavelengths of visible and infrared light. Impact of global warming G1 teach by demonstrating melt glaciers at the poles that cause sea levels to rise by several meters, after which ask students to predict what disasters are caused by rising sea levels. The solution of global warming is taught by displaying the source of greenhouse gases and its disappearance, so that from these data students can think about the right solution to reduce greenhouse gas emissions into the atmosphere.

3.2.8. How do you know that students understand or not? The last item from CoRe wants to see how the teacher knows that students understand or not. This process can provide teachers with information relating to students' understanding of the material or feedback from the methods used. So that the assessment process will always be integrated with learning. To check students' understanding, teacher G2 conducts an assessment by using tests, assigning mind mapping, evaluating performance while teacher G3 only uses traditional assessment techniques, namely question and answer / quiz.

Questions about how to know students understand or do not lead to the assessment techniques used by the teacher. The concept of the atmosphere layer will be tested to students by asking students to name and height each layer of the atmosphere. The rest of concepts G1 assessed it through student answers to the worksheets in each lesson.

4. Conclusion
The primary purpose of the study was to use a Content Representation (CoRe) questionnaire for secondary school science teachers to describe teachers PCK in global warming topic. Our results reveal that the teachers have different knowledge of PCK. Teachers knowledge of their PCK is related to working experience and professional development.

5. References
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