Analysis of pedagogical content knowledge (PCK) ability of science teachers in planning and reflecting on environmental pollution content

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Abstract. Pedagogical Content Knowledge (PCK) is a blend of content knowledge and pedagogy knowledge, which can illustrate the ability of teachers to design and to teach a content by accessing what they knows about the material, students, curriculum and how best to teach the content. Description of PCK ability of science teachers can be accessed through an analysis of their ability to plan and reflect on learning. This study aims to provide an overview of teachers’ PCK skills on environmental pollution materials through use of Content Representation (CoRe) and Pedagogical and Professional-experience Repertoires (PaP-eRs). Descriptive method used in this study with six of science teachers on 7th class from three different schools as subject. The results show that teachers' PCK skills in planning through CoRe and reflecting through PaP-eRs are in fairly good category. The teacher’s ability in implementing environmental pollution learning materials is in good category. However, there is still a discrepancy between planning through CoRe and the implementation of classroom learning. The teacher's PCK is influenced by teaching experience and educational background.

1. Introduction
Teachers are one of determinants of success in learning process. Improving the quality of teachers can have a positive impact on the quality of education. In general, science teachers who have extensive subject matter knowledge have a tendency to give lessons that pay less attention to how students learn [1]. This suggests that having broad subject matter knowledge is not the ultimate assurance a teacher can implement the learning process effectively. The ideal teacher should mastery material that he will learn and how to teach it well. This means that teacher has task of packing and presenting the knowledge it possesses in such a way that it can be understood by the students [2].

Pedagogical Content Knowledge (PCK) is a form of representation of ideas, parables, explanations, example, and ways of formulating and conveying material in order to be understood by others. The PCK as a combination of content knowledge and pedagogy that is a special form of professional understanding of teachers [3]. This combination requires a combination of concepts that are in the process, using and adapting teaching procedures, strategies and approaches for use in the classroom. PCK is an idea that is rooted in the belief that the learning process requires more than just providing learning content to students, and students learn more than simply absorbing information. Therefore,
teachers should have good PCK ability because PCK will greatly assist in the development of more
professional teacher competencies [4].

Ability of teacher's PCK can be seen through the CoRe (Content Representation) and PaP-eRs
(Pedagogical and Professional-experience Repertoires) instruments. CoRe and PaP-eRs are PCK
formats has been developed which was able to describe how the PCK on a topic [4].

CoRe can provide an overview of how teacher perceives the material being taught. CoRe was
developed by asking teachers to think about what they perceive as "big ideas" relating to teaching
certain topics based on their teaching experience. CoRe is usually written in tabular form. The
horizontal direction contains "big ideas" or important concepts in teaching certain topics. The vertical
direction contains considerations and thinking of the teacher in teaching the topic along with
instructions listed so that specific information about great ideas of they taught content will be
obtained.

PaP-eRs is a narrative of implementation of CoRe aspects. PaP-eRs are deliberately designed to
expose what the teacher thinks about certain aspects of PCK on a learning material and mostly based
on learning process in the classroom. PaP-eRs are intended to represent teachers' reasoning, ie the
thoughts and actions of teachers in teaching. The presence of CoRe and PaP-eRs not only helps to
capture the ability of the teacher's PCK but can also describe this knowledge to others.

Teacher's PCK on a topic that illustrated in CoRe and PaP-eRs can help teachers think about new
things about how to plan and organize their learning and use a more appropriate and meaningful
approach to teaching the topic [4]. This suggests that CoRe and PaP-eRs can be used and understood
because these two formats can not only make teachers think about their teaching practices but also
how they can influence how their teaching becomes more productive.

One of the learning materials presented in science is environmental pollution. This material is a
matter of contextual or related to daily life. This material can be learned and developed by the teacher
to build a deeper understanding and especially its application in the daily life of students. With the aim
that students can understand and apply this material in daily life, the way that teacher packs
environmental pollution material will greatly determine the success of delivery of this material to the
students. Through development of CoRe and PaP-eRs, teachers can view the material of
environmental pollution more deeply by paying more attention to the student's condition so that the
teacher's PCK ability can be used more optimally.

Seeing how important PCK as the main tool of teachers in teaching a learning material as described
above, it is necessary to do research about how the PCK science teachers currently in the field. Based
on this, research was conducted with the aim of providing an overview of PCK teachers' ability in
planning and reflecting environmental pollution learning using CoRe and (PaP-eRs).

2. Methods

This study describes PCK teachers in learning environmental pollution materials. The use of
descriptive method is intended to be able to describe the teacher's PCK in the learning of
environmental pollution material in accordance with real condition. The subjects covered six science
teachers in three MTsN schools, with each school represented by two science teachers. Teacher data
based on Gender, teaching experience & educational background are presented in Table 1.

| Code   | Gender | Teaching experience (year) | Educational background       |
|--------|--------|----------------------------|------------------------------|
| Teacher A | Female | 10                          | S1/ Akta IV Biology          |
| Teacher B | Female | 19                          | S1 Physics education         |
| Teacher C | Female | 11                          | S1 Biology education         |
| Teacher D | Female | 5                           | S1 Physics education         |
| Teacher E | Male   | 27                          | S1 Physics education         |
| Teacher F | Female | 20                          | S1 Biology education         |
2.1. Instrument
The instruments used consist of CoRe and PaP-eRs. After the teacher determines what are the big ideas taught on environmental pollution materials, teacher is asked to answer the questions in CoRe and this instrument is written in tabular form. The horizontal direction contains "big ideas" or important concepts in teaching environmental pollution material. The vertical direction contains the consideration and thought of the teacher in teaching topic along with instructions listed so that specific information about the big idea of environmental pollution material is obtained.

PaP-eRs is a narrative related to the implementation of teacher’s PCK that highlights certain sections or aspects of the material being taught. The contents of PaP-eRs vary. It depends on what you want to portray. In this study, teachers were asked to create a PaP-eRs which was a narrative of the learning situation that consisted of preliminary activities, core activities and closing activities.

CoRe document completed by teacher, then analyzed using CoRe analysis format. The analysis is done by scoring on each component described by the teacher. CoRe component scoring criteria adjusted to the rubric made. Scoring is given between 1-4 for each component. The number of scores obtained by teachers of each component divided by the maximum score of 32. The percentage is determined by the following equation.

\[\text{Percentage} \% = \frac{\text{acquisition score}}{\text{maximum score (32)}} \times 100\% \]  

(1)

The PaP-eRs document was analyzed using scans based on the PaP-eRs components contained in PaP-eRs scoring rubric. Scoring is given between 0-3 for each component the teacher narrates. After scoring for each component then done sum of scores from each component then the number of scores obtained by each teacher divided by a maximum score of 39. The ability of teachers in reflecting the learning in form of narration is indicated by percentage. The percentage is determined by following equation

\[\text{Percentage} \% = \frac{\text{acquisition score}}{\text{maximum score (39)}} \times 100\% \]  

(2)

The ability to develop CoRe, and develop PaP-eRs on environmental pollution learning materials are categorized according to the assessment criteria shown in Table 2.

| Criteria (%) | Letter | Level          |
|--------------|--------|----------------|
| 85-100       | A      | Very good      |
| 70-84,9      | B      | Good           |
| 55-69,9      | C      | Adequate       |
| 40-54,9      | D      | Less           |
| 0-39,9       | E      | Failed         |

3. Results and Discussion
3.1. Ability of Teacher to Plan through Develop of Environmental Pollution CoRe
Data on the ability of teacher’s PCK to plan learning seen under the CoRe developed, was derived from an assessment of the CoRe teacher’s answers. The percentage of teachers’ ability in constructing CoRe is shown in Table 3.
Table 3. Percentage ability of teacher to develop CoRe

| No | Teacher | Ability of teachers to develop CoRe (%) | Category |
|----|---------|----------------------------------------|----------|
| 1. | A       | 50                                     | Less     |
| 2. | B       | 51                                     | Less     |
| 3. | C       | 59                                     | Adequate |
| 4. | D       | 52                                     | Less     |
| 5. | E       | 46                                     | Less     |
| 6. | F       | 77                                     | Good     |
|    | Average | 56                                     | Adequate |

The ability of teacher to develop CoRe shows in Figure 1.

Figure 1. Ability of teacher to develop CoRe

Table 1 and Figure 1 show that teachers' ability to develop CoRe is good (average 56%). Based on the table it was also found that no teachers failed in preparing CoRe but the majority of teachers were still in the less category, although on average they were in adequate category. This happens because there is one teacher who has been able to develop CoRe with good category (teacher F) and there is one teacher who is in adequate category that is teacher C. The results show the diversity of ability of teacher PCK. This diversity is due to differences in the way teachers perceive environmental pollution material as evidenced by the difference in determining number of big ideas from environmental pollution material and different answers to CoRe questions.

A great idea is a picture that teachers show as an important concept for developing students' understanding in a particular concept [4]. The difference in determining number of big ideas still occurs even though the demanded curriculum demands are the same i.e. Basic Competence No. 3.9. The number of great ideas raised by six teachers ranging from four to five great ideas. The big idea that teacher raises as a whole includes understanding of environmental pollution, the factors causing environmental pollution, the types of environmental pollution, the impact of environmental pollution, and efforts to overcome environmental pollution.

The determination of big idea is a reflection of teacher's understanding of environmental pollution material. More clearly the teacher translates demands of curriculum, more obvious big idea is formulated. Based on interview, revealed that each teacher has its own way in determining big idea. For example, teacher A determines a great idea based on a teacher's handbook. Teacher formulates four great ideas, but in the four great ideas there is an essential concept that has not been raised that is the impact of environmental pollution. In contrast to teacher F who determines the big idea based on curriculum demands that is Basic Competence No. 3.9. Teacher F formulated five great ideas that included the essential concepts of basic competence.
Although most teachers' ability in developing CoRe is in the less favorable category, but in this study we found teachers who have the ability to develop CoRe with good category (77%) ie teacher F. There is a relationship between mastering concept (content knowledge) with mastery of PCK, good mastery of content will be obtained mastery of a good PCK also [5]. Teachers with mastery of good biological content (teacher F), will certainly more mastery the material of environmental pollution than teachers from other educational background. Based on it, can be seen that the educational background may affect the ability of a teacher PCK.

However Not all teachers with Biology Education background are able to develop CoRe with good category. There are two under-served and inadequate teachers (teacher A and teacher C) who are inferior to teachers F with 20 years of teaching experience. With this fact it can be stated that other important factors that affect a teacher's PCK in addition to educational background, as well as length of teaching experience. This is in accordance with the statement that one PCK source is a teaching experience [6]. Teachers who have experience teaching and processing experience that helps them in making the right decision when responding to the situation in the classroom. This is in line with the research undertaken by which shows that teachers who are just beginning their careers in teaching them are more influenced by the experience during the lecture and their past experience of education [7]. To know the achievement of every aspect in CoRe, it can be seen in Table 4.

Table 4. Percentage of achievement in every aspect of CoRe

| No | Aspect of CoRe                                      | Average (%) | Category |
|----|-----------------------------------------------------|-------------|----------|
| 1  | A statement of concepts to be taught to students    | 75          | Good     |
| 2  | A statement about why students need to learn the main idea | 51          | Less     |
| 3  | Statement about concepts known by the students not yet | 60          | Adequate |
| 4  | A statement about the difficulty in teaching of the main idea | 49          | Less     |
| 5  | A statement about possible misconceptions that happen in students | 43          | Less     |
| 6  | Statement of the factors to be considered in teaching the main idea | 65          | Adequate |
| 7  | A statement of the sequence or path chosen to teach the main idea | 63          | Adequate |
| 8  | A statement on how to assess students’ abilities in learning the main idea | 51          | Less     |

Average 57 Adequate

Table 4 shows that the average achievement of each aspect is 57% with good enough category. The teacher's lowest aspect in constructing CoRe is a statement about a misconception that may occur to the student (43%). While the highest aspect of the teacher is a statement about the concept that will be taught to students (75).

Based on above description, it can be seen that the ability of PCK teachers in planning environmental pollution learning through the development of CoRe is in enough category. Among the eight PCK aspects present in CoRe, the aspect of determining misconceptions that may occur in the student is the aspect most not raised by the teacher, while determining the concept to be taught is the aspect of the teacher's most attention in developing CoRe. Teachers with good PCK skills in planning learning through CoRe are teachers F. The ability of PCK teachers F is supported by the educational background and teaching experience it has.
3.2. Teachers ability to develop PaP-eRs

Data on teachers' ability to reflect on the lessons learned through the development of PaP-eRs were obtained after the implementation of the Environmental Pollution Study process. The ability of the teacher's PCK in developing PaP-eRs is shown in Table 5.

Table 5. Ability of Teacher to develop PaP-eRs.

| No | Teacher | Ability of teachers to develop PaP-eRs (%) | Category    |
|----|---------|------------------------------------------|-------------|
| 1. | A       | 56                                       | Adequate    |
| 2. | B       | 59                                       | Adequate    |
| 3. | C       | 67                                       | Adequate    |
| 4. | D       | 54                                       | Less        |
| 5. | E       | 54                                       | Less        |
| 6. | F       | 64                                       | Adequate    |
|    | Average | 59                                       | Adequate    |

Table 5 shows that the average ability of teachers in developing PaP-eRs is 59% with good enough category. Most of the teachers developed PaP-eRs quite well and no teachers failed in developing PaP-eRs. Based on the table it is also known that the ability to develop the highest PaP-eRs is obtained by teacher C with sufficient category (67%). In this study, no teacher has the ability to develop PaP-eRs with good category. The teacher's ability to develop PaP-eRs still reaches the category of less and good enough. The ability of teachers to reflect on learning through the making of PaP-eRs is still not maximized. This is probably because PaP-eRs making is the first experience for teachers so teachers are not used to making reflections in narrative form.

Ability to develop PaP-eRs with the highest category achieved by teacher C by narrating eight of the 13 assessed aspects. Aspects that are perceived by teachers are related to apperception activities. Teacher C performs an apperception activity by displaying two images on the board, ie pictures of a clean environment, and a polluted environment, then students respond to the differences between two images. Students have been able to express their opinions on both images and can know that both images consist of a clean environment and a polluted environment. In the aspect of the delivery of motivation, teacher C provides motivation by providing understanding to students about the difference of natural environment and polluted environment so that students can understand that the environment around us is very important to be kept clean for the convenience of human life itself.

In observation activities, teacher C gives students the opportunity to observe images of the differences between the natural environment and the polluted environment. The teacher explained that students seemed enthusiastic to observe some of events described by teacher. With these observing activities students can develop creativity, curiosity, the ability to formulate questions to form the critical mind that is necessary for intelligent life and lifelong learning.

Based on the results of the study also can be stated that there are some aspects of PaP-eRs failed to narrate by the teacher that are the second, fifth, and thirteenth aspect. For the second aspect, narrating the delivery of cognitive conflict related concepts taught (if there is misconception) is not narrated by the teacher (0%). This is because in the implementation of teacher learning does not bring these activities. The difference between preconceptions and observations leads to cognitive conflicts in students' cognitive structures. Misconceptions can occur because each student has an early conception of an observed event or phenomenon but contradicts the concept of a scientist. Therefore, teachers should try to know the initial conception of students in learning and clarify to fit the concept of science.

The fifth aspect is narrating the activity of asking questions from students (17%). In the learning process, only a small proportion of teachers are luring students to ask questions. So this is what causes the low value of these aspects in the preparation of PaP-eRs. For the questioning activity, only one teacher who narrated that is teacher F. Teacher F stimulate students to ask questions. Teachers narrate
that when he displays some images related to environmental pollution events, the teacher gives students time to ask any questions that appear in the students’ minds related to the image. Most students dare to ask questions. A few others remain motivated by teachers to ask their questions.

The thirteenth aspect relates to the material to be learned next and what to prepare (22%). In the learning process only a small percentage of teachers follow up for further learning. Based on this, the value of this aspect is low. There are two teachers who narrate this aspect of teachers B and C. But the teacher is only limited to deliver the material that will be studied next, the teacher has not conveyed what should be prepared for further learning. Informing the material to be learned next to the students is an important activity in the implementation of learning. This is because, students are given the opportunity to prepare themselves to learn. Therefore, teachers need to pay attention to this aspect for the success of next learning process.

Based on that explanation, in general we can be stated that the teacher has ability to reflect on environmental pollution learning. Although the average teacher’s ability to develop PaP-eRs is still in adequate category, it is hoped that developing PaP-eRs activities can have a good impact on teachers. As states that through reflection on the learning activities on certain subjects can be used as a means to develop the PCK teachers towards the better [8].

4. Conclusion
The teacher's ability to develop CoRe can illustrate ability of teacher's PCK in planning environmental pollution learning while the teacher's ability to develop PaP-eRs can illustrate ability of teacher's PCK to reflect on environmental pollution learning. In general, the ability of teacher's PCK in planning the learning of environmental pollution materials through CoRe is quite good. Teachers have been able to determine important concepts to be taught. However, teachers have not been able to predict misconceptions that might occur to students. The ability of teachers to develop PaP-eRs is still in enough category. Teachers are able to narrate core activities, preliminary activities well enough but still lacking in narrowing closing activities. This is because there are several aspects of PaP-eRs that have not been raised, so in general the teacher has not narrated the learning activities in the classroom overall.

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