Mapping Science Teachers' Pedagogical Content Knowledge In Classroom Interaction Through Transcript-Based Lesson Analysis: A Case Study

Indra Budiman, Anna Permanasari, Ida Kaniawati, and Iwa Lukmana
Science Education Program, School of Postgraduate Studies
Universitas Pendidikan Indonesia,
Jl. Dr. Setiabudhi No. 229, Kota Bandung, Jawa Barat 40154, Indonesia
indra.budiman@upi.edu, anna.permanasari@upi.edu, kaniawati@upi.edu,
iwa.di.bandung@gmail.com

Abstract

Many factors influence student learning outcomes, one of which is teachers' pedagogical content knowledge (PCK) in classroom interactions with students. The purpose of this research is to investigate the mapping of science teachers' PCK in science classroom interaction. Bring about data from video-recording and semi-structured interviews; this present case study explores the mapping of science teachers' PCK in classroom interactions between the participant and the students through the transcript-based lesson analysis (TBLA). The principal findings of this research illustrate that the mapping teachers' PCK could at least be summed up in four main lines of learning, namely the purpose of learning, the student's understanding of static electricity learning, learning strategies for appropriate teaching materials, and how the students' understanding of learning can be assessed. This empirical evidence implies that it could help the teachers reflected on their learning outcomes through investigation transcript based on lesson evidence to focus on PCK mapping, and also used as a motivation to be open to learning improvement.

Keywords
Case study, Classroom interactions, Pedagogical content knowledge, Transcript-based lesson analysis.

1. Introduction

Students' learning outcomes are influenced by the quality of their reflective process and the acquisition of new knowledge through planning, monitoring, and reviewing learning activities. Research on classroom interactions has shown that the types of activities teachers engage in classrooms will affect their learning outcomes. However, the combination of individual and collective approaches will benefit teachers' learning in a rather complex field of classroom interactions (Solheim et al., 2018). On the other hand, while many good science teachers are academically qualified in their subject areas, getting a strong Bachelor's degree in a science subject or merely developing subject knowledge where it is lacking does not guarantee that anyone can effectively teach that subject.

To that help students integrate science knowledge into evidence-based thinking and reasoning in a given context, teachers must develop pedagogical know-how and practice in classrooms, known as pedagogical content knowledge (PCK). PCK is believed to be a necessary body of knowledge for science teachers to implement educational reform (Durdane et al., 2019).

Shulman (1986) listed *unseen areas* in terms of subject matter material, referring to the popular focus on how teachers organized their classes, arranged activities, ascribed praise and blame, formulated the levels of their questions, and so on. Shulman claims that what was lacking were concerns about the content of the lessons, the questions posed, and the explanations provided. As a result, he described Pedagogical Content Knowledge (PCK) as a type of content knowledge that extends beyond subject matter knowledge to the dimension of subject matter knowledge for teaching.

After conducting a learning process, the science teacher is expected to reflect on the results of learning. This method of reflection can be done with analysis methods on transcripts. Learning is known for the method of transcript-based lesson analysis (TBLA). TBLA is useful for reflecting and increasing learning carried out by the teacher by analyzing teacher questions, good feeds, and student responses in class (Janah, N. et al., 2019; Kumpulainen, K., & Mutanen, M., 1999).

There has been much research on classroom interactions. Recent studies have shown that instructions, the teaching script, and the structure of lesson practice, including dialogical interactions are closely related to students' academic performance (Muhonen et al., 2018; Sarkar Arani et al., 2019; Janah, N., et al., 2019). However, a few studies dealt with transcript-based lesson analysis (TBLA), a type of analysis focusing on science teachers' PCK mapping as self-reflection and encouragement for future science learning activities.

The gap of this study is how to map the elements of teachers' PCK in science classroom interaction using the TBLA method based on exposure to teachers' PCK and TBLA. This study is significant because it allows science teachers to reflect on implementing their students' learning by analyzing the elements of PCK themselves using TBLA. After determining which PCK elements are lacking or weak, this information will be used to improve the PCK elements. The benefits of this research are that science teachers can discover the mapping of PCK elements in the science classroom interaction and use it as a stimulus to keep science teachers open to change. As a result, science teachers will be able to improve the next science learning process.

2. Literature Review

2.1 Pedagogical Content Knowledge (PCK)

Shulman proposed the idea of "pedagogical content knowledge" (PCK) as a potential solution to the "missing framework" of teaching study and practice. Teaching was either approached solely based on material or solely based on pedagogy. Neither strategy, according to Shulman, captured every element of a teacher's knowledge base. As a result, he described PCK as "that unique amalgam of content and pedagogy that is solely the domain of teachers, their unique type of professional understanding." (Shulman, 1986). He identified two key components in PCK: the most useful ways of describing topics in one's subject area on the one hand, and an understanding of what makes studying these topics simple or challenging for students on the other. He looked at material knowledge (CK), general pedagogical knowledge (PK), curriculum knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational ends, aims, and values, among other categories in teachers' knowledge base (Shulman, 1987).

Since Shulman implemented PCK, it has been implemented by several scholars, resulting in both theoretical and empirical advances. Several authors expanded on Shulman's initial PCK structure. Magnusson et al. developed a model that has been very influential in the field of science education. The orientation to teaching science (i.e., knowledge and beliefs about the aims and objectives of teaching), knowledge of science curricula, and knowledge of scientific literacy evaluation were all applied to Shulman's original model (Magnusson et al., 1999)

Magnusson et al. add three more components to Shulman's description of PCK, making their model the most widely cited. Four of these components relate to the following content-specific pedagogical elements (referred to in M1 to M4): the objectives and goals for teaching the subject (M1), the understanding of this topic by the students (M2), the educational strategies relating to this topic (M3) and the ways in which the students understand this topic (M4). These four elements are universal in that they can be found in a wide range of general pedagogical models in literature and teacher education materials (e.g., Van Gelder et al. 1973). Due to their pedagogical completeness and simplicity, Magnusson et al.'s M1 to M4 will be used to characterize content-specific pedagogy elements and corresponding PCK elements.

PCK had already been recognized as a knowledge base needed for successful science teaching by the 1990s. This viewpoint has been articulated in a number of educational policy documents (e.g., American Association for the Advancement of Science 1994), which has resulted in a number of attempts to evaluate teachers' PCK and classroom actions as part of a professional development program or to implement standardized evaluation procedures. One of them, PCK, is used in the science teacher professional development program (Wang and Buck 2016).

2.2 Transcript-Based Lesson Analysis (TBLA)

The importance of social interaction in the transition from interpersonal to intrapersonal functioning is emphasized in socio-cultural perspectives, which look at learning from a cultural perspective (van der Veer & Valsiner, 1994; Vygotsky, 1962, 1978; Wertsch, 1985). Within a context of socio-cultural perspectives and numerous language and meaning theorists (e.g., Bruner, 1990; Halliday & Hasan, 1989; Lemke, 1990; Vygotsky, 1962), the interaction involves communication and the building of social meaning. As a result, investigations into the relationship between interaction and learning must focus on the understanding of meanings and intentions in interaction situations. This understanding should take into account both the immediate social situation and the activity's socio-cultural context (Bakhtin, 1986; Vygotsky, 1978; Wertsch, 1991).

Teachers should teach contextual problems at the beginning of the course to teach meaningful science lessons, help students explore and test their ideas in the lessons. The questioning of teachers and feedback in the science lessons help to make a dialogic discourse in the classroom more meaningful. The video transcription of the lesson can assist the teacher in reflecting on justice in order to show its teaching practice, whether it is authoritative or dialogical. Teachers tend to establish the form of knowledge, transmit fixed information, be recognized, and demand students' loyalty in authoritative speech. While in a dialogic classroom, students' statements are viewed as ideas to be openly questioned, the conversation is free, establishing a line between ideas from others and individual sense-making (Tytler, R. and Aranda, G., 2015). The transcript-based lesson analysis is available for a deeper understanding of students' communication, understanding, and construction of information in the teaching-learning process, as well as educators' perspectives in post-lesson discussions about improving teaching quality (Sarkar Arani et al., 2014). In this study, transcript-based lesson analysis will be used to analyze PCK elements, according to Magnusson.

3. Methods

This paper reported a case study on the TBLA method of making the mapping of the PCK of experienced junior high school teachers. The research was situated at a junior high school in West Java, Indonesia, and it involved 120 science teachers with undergraduate and master’s degrees (86 females, 34 males; 25-58 years old; 5-25 years of teaching experience). Some of them were not backgrounded as science teachers, but they always participated in development programs for science teachers. Conducted in an Indonesian context, this contextualized case study will enrich research on the PCK of science teachers and give lessons to science teachers in making the guidance for the next learning and development.

This article reports on some preliminary findings of a bigger teacher professional development program initiative. The focal person, Inna (female pseudonym), was a junior high school science teacher from West Java Province, Indonesia. She is forty years old and has 13 years of teaching experience.

The tools provided useful data to determine the patterns of the teacher's PCK development. For this qualitative analysis, the researchers followed four procedures. First, the researchers recorded the lesson in the classroom about static electricity. Second, data collected from the video recording were transcribed. Third, the data ware analyzed based on some structures for the PCK of teachers. For this matter, the researcher adopted the PCK framework of Durdane Baryam (2019), which was shown in Table 1. Last, four students to triangulate Innas’ classroom interaction were also interviewed. She agreed to have all the data used for publication during the study debriefing.

Matsubara (2010) study transcript analysis activities include recording, transcripts, word protocols, word protocol articulation, and articulation relationships. At the time of the learning process, use a video camera to record how the teacher teaches and engages students to learn recorded student interactions and class communication during learning. After the learning process is recorded through learning videos, it is translated into writing in accordance with all teaching activities and students in the learning process through learning videos. This increases the teacher's ability to analyze transcripts, and there is evidence that can be seen from learning that might be missed. In the protocol to that word, Lesson Analysis was carried out by recording the order of comments, the time, and the content of the statement. After analysis of the protocol data, the articulation needs to be done. There is a relationship between one transcript that was analyzed using the PCK framework analysis approach.

4. Data Collection

This paper draws on the data collected by the researcher in a qualitative case study aimed at mapping the components of PCK science teacher in classroom interaction through transcript-based lessons analysis in West Java, Indonesia, as outlined in the three phases below.
First, a secondary school (nine grades) science lesson on the subject of "Static Electricity" at West Java Secondary School in Indonesia, conducted by Mrs Inna (February 5 2019), was recorded with a video camera by the researcher.
The process of the lesson:
Learning took place from 1 to 3 sessions on Tuesday. The teacher agreed to choose the static electricity material to be used in class 9 A. The learning model would be implemented with a scientific approach to the Discovery Learning model. The learning plan has been as follows: After airing motivational videos related to static electricity material, students were expected to be more interested in learning more about static electricity. In addition, students were divided into groups to conduct static electricity experiments in accordance with the worksheets that were shared. After the internship, the students displayed the results of the observations. The group representatives presented the practicum results—discussions between friends in groups and continued discussion in the classroom. The teacher facilitated class discussions and directed students to discover the concepts of static electricity. The activity ended with the reinforcement of the teaching material with practical questions relating to learning objectives.

Second, rather than having the researcher/author alone analyze the lessons as they have done in the past. First, based on the teaching recordings, the teacher gathered at West Java Secondary School on June 25, 2019, to examine the transcript and video recording of the lessons. We analyzed the lessons and gave their impressions, opinions, and criticisms for discussion and debate. The content discussed and the results of the analysis were recorded, and a variety of data (e.g. student interviews, student worksheets) were compiled.

In the third stage, a transcript of the analysis of lessons by the teacher and the researcher was discussed. A discussion meeting was held at West Java Secondary School with the teacher, principal, and their colleagues (July 16, 2019). It focused on the analysis of lessons from the PCK Component framework.

Table 1. The framework of the PCK component Adapted by Durdane Baryam (2019)

Components	Codes
Goals (GO)	Personal objectives (PO) • Getting in touch with students, motivating students • Promoting scientific literacy, engaging in scientific concepts • Applying scientific knowledge to decision-making/societal issues • Guiding social-emotional and moral development • Motivating unmotivated/uninterested students • Showing links between science and real life • Teaching students to think critically • Educating responsible students Learning objectives (LO) • The content of science (e.g., particles model, the evolution of stars, development of planets, sources of energy, atmospheric pollution, combustion and emission, etc.) • Skills (e.g. physical/motor skills, communication, reflection, argumentation, critical thinking, decision-making) Importance for the students (IS) • Curriculum/Exam • Future • Critical thinking • Combining knowledge of science with everyday life. Reason choosing the material (RM) • Suitable for the curriculum • Suitable for students' interests/personal life • Social relevance

	• Teacher's personal interest
Students Understanding (SU)	Student difficulties with (SD): • Science concepts • Previous knowledge Misconceptions or Faith (MF) • Misconceptions or beliefs of students on the subject • Alternative ideas of students
Instructional Strategies (IS)	Approach to teaching (AT) • For example, make changes to the lessons, add concepts, skip activities, etc. Adaptation of activities (AA) • For example, additional content, emphasis on social aspects, link to personal life, the addition of instructional video Teaching activities used (TU) • Group work, full-class discussion, discussion in small groups, debate, Argumentation Teacher's difficulties faced (TF) • In teaching activities (argumentation, discussion) • In content Managing Time (MT) Adaptation ideas • Grouping students differently • Using different teaching strategies
Assessments (AS)	Ideas about what is a successful lesson (IL) • For example, fun for students, students are interested, and goals are met. Ways of evaluation used (WE) • Observing students • After discussion • Assessing student learning products: student report, essay, video, presentation, personal reflection • Peer assessment: students assess each other's products. Further ideas for assessment (FA) • Formulation of learning objectives in a measurable manner

5. Results and Discussion

5.1. Result

Table 2 below shows the sum of student and teacher talk in the lesson based on the transcription. At that table, student conversation about the lesson took precedence over teacher talk. This means that the teacher gives the student an effective space and time to express their ideas despite the fact that the answer was still not appropriate to the science concept.

Table 2 Number of student talk and teacher talk

Personal Talks	Number of Talks
Students Talk	109
Teacher Talk	79

A graph of the number of words is obtained based on the complete transcript analysis of the lesson, as shown in Figure 1. The top portion depicts a teacher-led talk session, while the bottom depicts a student-led talk session. The talk indexing reported in the complete transcript is the horizontal line that limits the teacher and student talk sessions on the graph. This index also reflects the time sequence (in minutes) during which learning takes place.

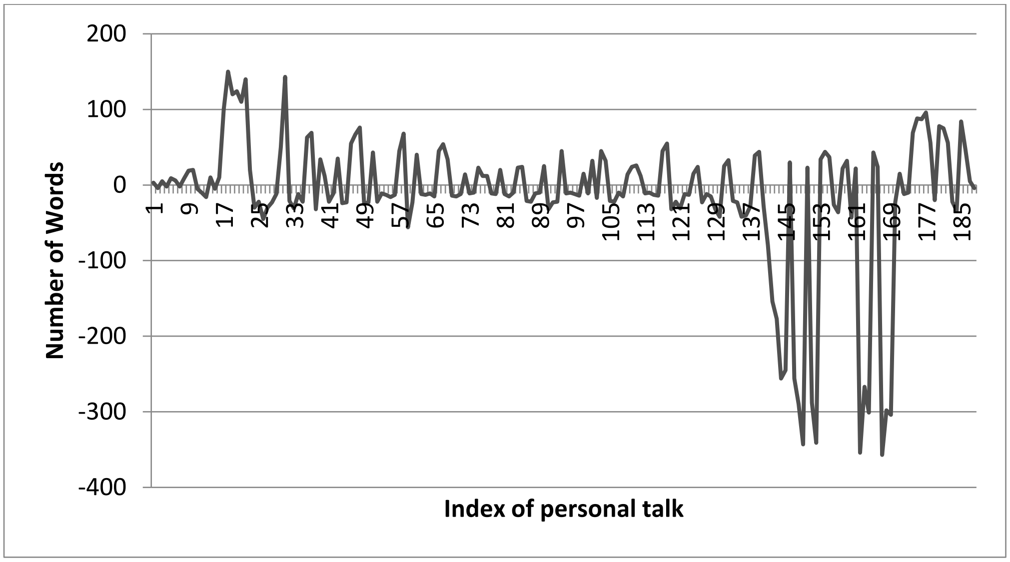

Figure 1. Transcript analysis based on number of words

The analysis of teacher talk was given below to show the mapping teacher's PKC components of that talk. The transcription of the lesson was analyzed using system PCK components, and the mapping PCK component tendency was represented in Figure 2.

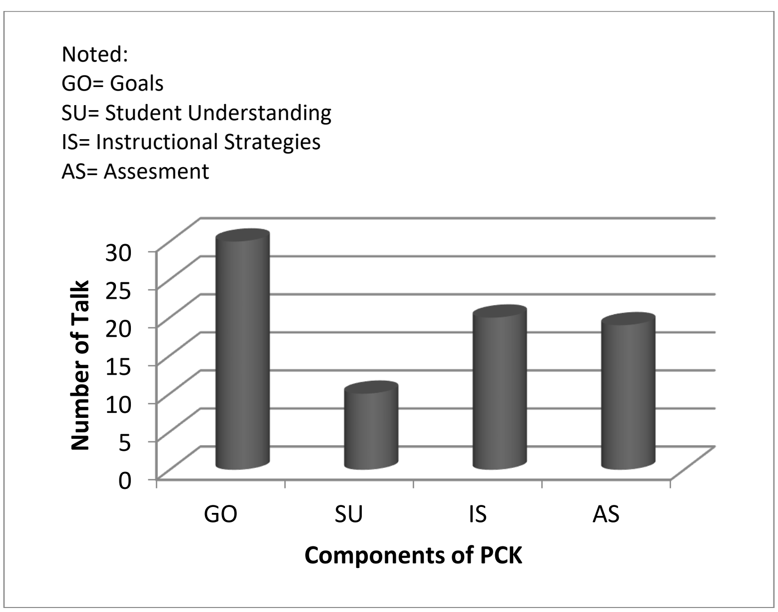

Figure 2. Mapping science teachers' PCK

5.2. Discussion

The majority of what occurs in the classroom is governed by working habits. As a result, changing teachers may or may not result in changes in instruction. This is why we require a lesson analysis approach to gain a better understanding of this teaching script, as well as a framework to bring together family, community, policymakers, and educators to strengthen the teaching habits (Elliott, 2018; Sarkar Arani, Tomita, Matoba, Saito, & Lassegard, 2012).

Based on Figure 1, the teacher dominated discussions at the beginning of learning and the end of learning. This showed that the teacher, at the beginning of learning, was trying to communicate the goals to be accomplished and, at the end of the teaching, was trying to provide students with a better understanding of static electricity. Whereas when students studied from the 15th minute to the 75th minute, the teacher just worked out understanding and urged students to work together.

During the reflection meeting, the participant mentioned that she talked a lot during the lesson and asked if she was familiar with "listening pedagogy" (Sarkar Arani, 2016; Saye, Stoddard, Gerwin, Libresco, & Maddox, 2018), which entailed "eavesdropping" on student conversations and making their learning visible. Students listen and repeat as the teacher demonstrates (interview).

PCK is characterized as a type of teacher knowledge that aids in the transition of content knowledge into classroom practice (Kulgemeyer & Riese, 2018). When teachers apply their expertise to classroom practice, they participate in nuanced reasoning processes, such as selectively retrieving knowledge that they believe is most important and applying that knowledge in a variety of ways to solve a specific situation. Teachers may combine their skills in new ways as they use their PCK in practice, resulting in the creation of new PCK (Beyer & Davis, 2012). When a teacher plans to use various teaching techniques while taking into account her students' scientific comprehension (including their difficulties; Alonzo & Kim, 2015) and plans to measure learning using appropriate methods/tools, both of these are in line with the goals of the lesson.

The findings (based on figure 2) revealed that the interactions between Inna and the students in the classroom fulfilled the PCK component of Magnusson's models, which is to explain the purpose of learning, the students understanding of static electricity learning, learning strategies appropriate teaching materials, and how to assess the students' understanding. At the beginning of learning the results of the transcript stated that there was a dialogue between the teacher, Inna and students discuss the learning objectives, the material to be delivered, getting in touch with students, motivating students, promoting scientific literacy, engaging in scientific concepts, applying scientific knowledge to decision-making/societal issues, guiding social-emotional and moral growth, motivating unmotivated/uninterested students, and demonstrating links between science and other disciplines, and material adjustments to student characteristics. This shows the criteria for PCK components, the goals (GO) of almost everything is done by participants.

On the second PCK criteria about Students Understanding (SU), Inna mentioned that after the learning took place, she found it difficult to teach static electricity, "the material is considered abstract static electricity for the children" (interview). This is in line with the results of the transcript, which states about the lack of students and errors of the concept of students when the exploration session and motivation about 'why the paper tear can stick to the plastic crossbar that has been rubbed by wool cloth'.

On the third PCK criteria, instructional strategies (IS), transcripts show participant statements about making changes to the lessons, adding concepts, group work, full-class discussion, small group discussion, teacher's difficulties in teaching activities (argumentation, discussion), grouping students differently but not adapting activities, for example, additional material. Other comments focused on this criteria and made part of the reflection, "reflection is the most important part of learning to be used as the next teaching" (interview). This reflects that the relationship between the teacher PCK and what the teacher does in the classroom is inherently complex, as their interaction involves both knowledge-on-action and knowledge-in-action. (Barendsen and Henze, 2017).

The fourth PCK criterion is assessment (AS) in general; the transcript mentions suggestions for making learning enjoyable for students, keeping students engaged, achieving goals, observing students, evaluating student learning materials, and developing measurable learning objectives.

Based on the findings, it is noteworthy that the TBLA can qualitatively map the PCK of Inna. Difficulties to made learners keep focusing on static electricity concepts, and learning strategies presented a challenge for Inna. Two other components of PCK that explain the purpose of learning and assessing the learning outcomes of students do not pose a problem.

6. Conclusion

Although the case study report only looked at the case and was carried out in the context of West Java, Indonesia, these findings have implications for practical pedagogical feedback for teachers and also for the professional development programs. We know that teachers' high levels of PCK will lead to better learners. This study thus provides evidence that teachers' weakness in the PCK components will be seen more easily by themselves because teachers learn to use the learning and investigation transcript based on evidence of lessons to focus on describing, understanding, interpreting, and checking the framework components during the process transcript-based lesson analysis (Sarkar et al., 2019). TBLA can be used not only to know PCK mapping science teachers during learning but can also serve as a stimulus for teachers to open themselves to change. Therefore, this case study suggests teaching practices that can be substantiated through empirical studies should be focused on teacher training methodology as a priority.

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Biographies

Indra Budiman is School of Postgraduated Student in Science Education Program, Universitas Pendidikan Indonesia. He graduated Bachelor and Master from Science Education Universitas Pendidikan Indonesia. He has taught at the Faculty of Teacher Training and Education, University of Singaperbangsa Karawang, Karawang, Indonesia.

Anna Permanasari is Professor of Chemistry Education Faculty of Mathematics and Science Education Universitas Pendidikan Indonesia. She earned Doctor of Analytical Chemistry**,** ITB Bandung, Master of Chemistry**,** ITB Bandung, and Bachelor of Chemistry Education, UPI Bandung, Indonesia. Her teaching interests have an introduction to Analytical Chemistry and School Observation. She has published journal and conference papers, for example, are Stem learning in the material of temperature and its change to improve the scientific literacy of junior high school and Uji Kinerja Adsorben Kitosan-Bentonit Terhadap Logam Berat dan Diazinon Secara Simultan.

Ida Kaniawati is currently a lecturer Physics Education Study Program, Universitas Pendidikan Indonesia. She has earned Bachelor in Physisc Education IKIP Bandung, Master in Physics ITB Bandung, and Ph.D. in Science Education in UPI Bandung. She was pursuing the field of learning physics for prospective teachers, developing physics skills for prospective teachers, and developing the abilities of prospective teachers through lesson study.

Iwa Lukmana is currently a lecturer English Language Education Study Program, Universitas Pendidikan Indonesia. He has earned Bachelor in English Education IKIP Bandung, Master in TESOL Deakin University, and Ph.D. in Linguistics Monash University. He has taught courses in Critical Discourse Analysis Pragmatics.