The Planning and Implementation of Reasoning Instruction: Science Teachers' Case

Rendi Restiana Sukardi[1], Ari Widodo[2], Wahyu Sopandi[3]

[1]Elementary School Teacher Education Study Program of Cibiru Campus, Universitas Pendidikan Indonesia, Indonesia
[2]Biology Education Study Program, Universitas Pendidikan Indonesia, Indonesia
[3]Chemistry Education Study Program, Universitas Pendidikan Indonesia, Indonesia
[1]rendisukardi@upi.edu, [2]widodo@upi.edu, [3]wsopandi@upi.edu

***Abstract*- The study aims to investigate the planning and implementation differences of learning strategies that stimulate pupils' reasoning skills on the topic of environmental pollution and also the reasons. This was a type of qualitative case study research involving five science teachers selected by purposive sampling technique. The instruments were content representation (CoRe) questions, lesson plan analysis formats, observation sheets, and unstructured interviews. The data were triangulated to get findings in detail. The results of the analysis showed that teachers had pedagogic content knowledge (PCK) about teaching reasoning skills. Unfortunately, it did not appear much in the lesson plan even in the implementation. There were differences between planning and implementation. The investigation through interviews showed that it was caused by the use of innovative teaching models that were less appropriate to pupils' conditions and curriculum content in Indonesia. Teachers could not carry out reasoning instruction ideally. If the strategy was enforced, reasoning instruction would be not effective and it would take a long time. Teachers might have good PCK about reasoning skill development but they have to ensure that chosen learning strategies are appropriate to pupils' condition and the curriculum content of Indonesia. Teachers have to adjust and even create reasoning instruction based on the condition of pupils and curriculum in Indonesia to achieve the learning goals well.**

***Keywords*- Pedagogic content knowledge, content representation, reasoning skill, science class**

Rendi Restiana Sukardi
Elementary School Teacher Education Study Program of Cibiru Campus, Universitas Pendidikan Indonesia, Indonesia
rendisukardi@upi.edu

I. INTRODUCTION

Professional teachers have to understand that scientific thinking skills should be taught to pupils, one of them is reasoning skills. The understanding of reasoning based-instruction is important to be owned by professional teachers because of its significant effect on pupils' cognitive development (Lazonder & Drost, 2014; Chen & She, 2015). Unfortunately, some studies reported the teachers' scientific reasoning skills are not encouraging (Stammen, Malone, & Irving, 2018). To teach reasoning skills to pupils, teachers should have reasoning skills because of their importance. When the teachers develop reasoning skills, pupils are stimulated to think widely so that they earn new knowledge by thinking logically and they relate it to previous knowledge. The reasoning activity is related to the analysis of a topic in a logical, systematic, and organized manner in a sequence that is interconnected to the conclusion. Pedagogic knowledge in teaching scientific reasoning has an important role in creating effective, efficient, and well-targeted learning for professional teachers.

Unfortunately, the results of research over the past 20 years indicate that most teacher education graduates do not understand and are not able to apply pedagogical knowledge learned in carrying out the profession as a professional teacher (Korthagen, 2010). This was also shown by both novice teachers who had no teaching experience and senior teachers who generally chose teaching strategies based on pragmatic reasons such as time allocation, availability of learning resources, and teaching experience (Sukardi, 2017; Rietdijk, van Weijen, Janssen, van den Bergh, & Rijlaarsdam, 2018). Teachers often do not realize that the pedagogical aspects and actions supported by the knowledge base are very important in supporting professionalism to become teachers and make them quality teachers (e.g. Hume, 2010; Aydin et al., 2015). Quality science teachers have a

good combination of pedagogical competence and knowledge of science materials. They can convey material scientifically so that the learning process is right on target and enjoyable for pupils. This knowledge is known as *Pedagogic Content Knowledge* (PCK). In science teaching, the reflection on how to link teachers' PCK with teaching practice is a recent concern in education (e.g. Hanuscin, 2013; Nilsson & Loughran, 2012).

PCK in teaching has an important role in creating effective, efficient, and well-targeted learning (Loughran, Berry, & Mulhall, 2012; Williams, Eames, Hume, & Lockley, 2012; Lazonder & Drost, 2014; Adadan & Oner, 2014; Weitzel & Blank, 2020). This should be reflected in classroom instruction. Futuristic science learning in the classroom should involve pupils in the cognitive process of always thinking and reasoning (Waldrip & Prain, 2012). Scientific reasoning is a thinking skill involved in the process of inquiry, experimentation, evaluation of evidence, drawing conclusions, and arguments carried out to support changes in conception or scientific understanding (Zimmerman, 2007). Besides, scientific reasoning has a role in developing the ability to think and act in inquiry, influencing pupil's academic achievement, and playing an important role in the conceptual change process (National Research Council as cited in Lazonder & Drost, 2014; Adey & Shayer as cited in Chen & She, 2015; Lee & She as cited in Piraksa, Srisawasdi, & Koul, 2014). The reason why reasoning skills must be trained in learning is that the ability is considered as the main objective of science education (abstracted by Furtak, Hardy, Beinbrech, Shavelson, & Shemwell, 2008). Duschl & Gitomer (as cited in Furtak, Hardy, Beinbrech, Shavelson, & Shemwell, 2008) revealed that educational improvement involves the development of thinking, reasoning, and problem-solving skills to prepare pupils to participate in making decisions and to evaluate knowledge claims, explanations, models, and designs of scientific experiments. These important values become a strong reason why teachers must have PCK and be able to teach science material with reasoning strategies based on their PCK. The teachers' PCK on how to teach and stimulate pupils' reasoning is seen explicitly from their lesson plan and *CoRe* answer. Those reflect their reasoning design.

The facts show that the implementation of teaching strategies is aimed at increasing pupils' conceptual knowledge. This affects the teacher's priority in choosing and reviewing the suitability of teaching materials with teaching strategies that will be used in the classroom. Teaching models that stimulate pupils' reasoning skills are rarely implemented by teachers even though they are familiar with pedagogic content knowledge (PCK) which is a knowledge that must be understood and owned by the teacher. Besides, even though teachers understand the importance of strategy in teaching reasoning to pupils or they have designed it, there are always significant differences between lesson plans and their implementation. Previous research generally only discussed how teachers implemented various innovative learning models to improve pupils' reasoning skills. They did not investigate whether PCK contributed to the process of lesson planning and classroom instructions. They also did not investigate the difference between both of them.

The previous explanation has confirmed that ideally, PCK plays an important role in teaching practice. However, the lesson plans made by the teacher will not automatically be the same as the lesson plans prepared for teaching. Teaching plans designed based on PCK are ideal lesson plans while factual lesson plans are always designed based on pupil needs and curriculum demands. One example of a factual lesson plan is that the teacher will prioritize mastering concepts rather than developing reasoning. This is because pupils' mastery of concepts will be measured or tested in the national exam. Therefore, the differences between PCK and teacher lesson plans can be understood. However, the difference between the lesson plans that have been made and the implementation of learning is interesting to investigate.

The previous researches have not discussed the profile of teachers' capabilities to develop pupils' reasoning skills through the investigation of PCK. Most of the researchers develop and discuss in general how to develop and to increase teachers' PCK. The results showed that the quality of learning strategies will be increased by time and experience through guiding, training, or workshop (Adadan & Oner, 2014; Aydin, et al., 2015; Bustamante, 2019; Castéra, et al., 2020; Hanuscin, 2013; Hume & Berry, 2013; Hume, 2010; Irdalisa, et al., 2020; Nilson & Loghran, 2012). Besides, others also only implemented the learning strategies that support teachers' efforts to increase pupils' reasoning skills. Many reported that teaching reasoning skills could be done in many ways. Generally, developing pupils' reasoning skills could be through argumentation activities (Ozden, 2020; Piraksa, et al., 2014; McNeill & Pimentel, 2010; Inch, et al., 2006). The intersection between PCK and reasoning skills is interesting to be investigated because it has not conducted yet by others.

The purpose of study is investigating the difference of planning and implementation learning strategies that stimulate pupils' reasoning skills in the topic of environmental pollution. Besides, the research also investigates the factors that support the differences between planning and implementation. It is a qualitative case study that involves five secondary school Science teachers. The research is very interesting because it compares the planning and implementation of instruction reasoning by analyzing not only learning script and lesson plans but also teachers' PCK through modified CoRe questions. Meanwhile, not many have done the research before. The findings are expected to contribute of how teachers have to teach reasoning skills to pupils with suitable learning strategies. Further, the findings are expected to be a part of material handouts in PCK training with Indonesia context to develop pupils' reasoning skills.

1.1. Science Class

Science teachers must have unique pedagogical knowledge about how to teach science to pupils with a certain level of cognitive development, such as secondary school pupils. Teachers must understand that they do not just teach fundamental science concepts. However, teachers must be better able to teach various thinking skills in science, one of which is reasoning skills. The principle of teaching science that must always be adhered to is that teachers must teach science as a body of knowledge, as a way of thinking, and a way of investigating scientific processes.

Reasoning skills trained by teachers in science class have a synergistic role with the fundamental concepts of science in building the competence of pupils who can understand a scientific phenomenon and solve its problems. The competence of teachers in analyzing and making decisions regarding the strategies chosen to teach the concept is called pedagogic content knowledge (PCK). Ideally, the teacher's PCK should always be up to date because teaching strategies continue to grow and develop. Teachers in Indonesia should understand the unique teaching strategies for Indonesian pupils such as reasoning instruction. Teachers may have many references related to teaching strategies that they can apply in science classrooms, but they must also understand that the teaching strategy chosen must be following the conditions of pupils and the curriculum in Indonesia. Sopandi's research (2017) states that primary and secondary school teachers in West Java, Indonesia had difficulties implementing innovative learning models. Further research revealed that it was because the learning models were created by foreign education experts who in their creation only considered the condition of pupils and the curriculum in their country. These conditions forced teachers to learn and adjust the class instruction so that learning process can run well.

The teaching process in the classroom should be flexible. Teachers may have good PCK in terms of skills development. However, when teachers are welcomed to develop teaching strategies, they will choose teaching strategies that are practical and work well. The main thing they want to make sure that all the fundamental concepts of science have been conveyed perfectly. The difference between planning and implementation can also be found in teaching practice. This is due to unpredictable conditions such as inadequate initial knowledge of pupils so that the teacher has to change the plan from stimulating pupil reasoning to explain the basic concepts of science.

1.2. Pedagogic Content Knowledge (PCK) and Reasoning Skills

Researchers previously highlighted that PCK is a vital competency that must be possessed by teachers. The massive development in technology and information is encouraging teachers to optimize the function of technology in education so that a new framework called TPACK (technology, pedagogical, and content knowledge) was introduced. İt combines three main aspects of technology, pedagogy, and content or material knowledge (Mishra & Koehler, 2006). Various training and coaching programs are conducted to assess and improve competency. Some studies have also developed instruments to investigate the teachers' pedagogical competence and content competence, one of which was conducted by Loughran, Berry, & Mulhall (2012) who developed an instrument called content representation (*CoRe*). Nilsson & Karlsson (2019) also captured teachers' PCK with CoRes and digital technology. Unfortunately, none has investigated the teachers' understanding of reasoning and teachers' strategies in stimulating pupils' specific skills such as reasoning. The massive researches were done on the reconstruction development of the PCK frameworks from Shulman (1986), Grossman (1990), Magnusson, Krajcik, & Borko (1999), to Mishra & Koehler (2006) who introduced TPACK.

Based on the analysis of PCK frameworks, the author adapted and modified the model from Magnusson, Krajcik, & Borko (1999) to describe the PCK of the teacher in developing pupils' reasoning abilities. PCK includes three components, i.e. the choice of ideas or concepts, the presentation of ideas or concepts, and the preparation of assessments. The choice of ideas or concepts is related to the teacher's orientation in teaching science and the teacher's knowledge of pupils' scientific understanding. The presentation of ideas or concepts is related to teacher knowledge about learning strategies. Meanwhile, the preparation of the assessment relates to the knowledge of the assessment.

Content Representation (*CoRe*) is one of the instruments used to access the teacher's PCK which contains several questions (Loughran, Berry, & Mulhall, 2012). The choice of concepts or ideas is related to the ideas or concepts to be taught, their basis for consideration, their reasons for the choices, the difficulties and limitations, and the factors that influence the teacher in teaching them. While the presentation of ideas or concepts is related to the steps of learning, optimization of supporting technology, as well as anticipating the lack of learning support facilities. Meanwhile, the preparation of the assessment is related to the teacher's specific way of measuring pupils' understanding of concepts or ideas.

The development of pupils' reasoning abilities is evident from the learning steps implemented by the teacher in the classroom. Duschl & Osborne (2002) revealed that socio-scientific issues are things that can be considered to involve pupils in argumentation. Pupils in general feel difficulties in the instruction that involves reasoning so that it requires contextual instruction. Pupils find it helpful when the teacher encourages them to develop their reasoning abilities by linking them to everyday life. This activity facilitates pupils to obtain various kinds of data and claims.

Data and claims obtained by these pupils must be supported by logical and valid reasons. This is because learning science requires a strong foundation in understanding concepts (Inch, Warnick, & Endres, 2006). Tytler, Prain, Hubber, & Waldrip (2013) reveal that reasoning can be developed with activities that involve the relationship between evidence and ideas that have been

submitted. These activities can take the form of discussions that involve argumentation. Shemwell & Furtak (2009) mention that the coordination of evidence as a basis for asserting the validity of the claims expressed by pupils is needed in argumentation. This is because reasoning requires the coordination of evidence and theory to expand an explanation, e.g. prediction and evaluation. Inch, Warnick, & Endres (2006) emphasize that the evidence must contain facts and conditions that can be observed objectively, or in the form of beliefs or statements that can generally be accepted as truth or conclusions that have been established as rational links between evidence and claim. This reasoning skill development strategy requires the teacher's role as a stimulator for pupils. This is as mentioned by Osborne, Simon, Christodoulou, Howell-Richardson, & Richardson (2013), that the teacher's role is a stimulator for pupils to express their reasons through the question 'why' or 'what is the reason'. Varma (2014); Widodo, Saptarani, Riandi, & Rochintaniawati (2017) reveal that teachers must consider reasoning learning strategies carefully because of the habit of expressing reasons, evidence, and supporting logical answers can be trained during instructions. It gives pupils opportunities to practice their reasoning skills.

The final step taken by the teacher in facilitating the development of pupils' reasoning abilities is to draw conclusions based on claims. Alshamali & Daher (2015) revealed that the development of reasoning requires the ability to provide information systematically and draw reasonable conclusions from observed patterns. Based on the description, it can be concluded that the teacher's ability to integrate the reasoning aspects into PCK can be seen from the following steps; 1) facilitate pupils to obtain rational data, 2) facilitate pupils to base data with rational reasons, 3) facilitate pupils to support rational reasons with facts or evidence, 4) facilitate pupils to connect between concepts that support reasons and evidence, and 5) facilitate pupils to make conclusions based on data, reason, and evidence.

Meanwhile, the preparation of teacher assessments that facilitate pupil reasoning can be seen from the quality of the questions. These questions are in the form of essays which are the type of person-centered questions that dig the answers from the pupils' point of view (Arends, 2008). This type of question has a function as a measure of pupils' knowledge, understanding, and reasoning abilities. The form of ill-structured questions facilitates pupils to define questions with a variety of interpretations as long as they are supported by valid concepts so that they can measure pupils' informal reasoning abilities.

Teacher's PCK related to the development of pupil reasoning skills is expected to have a significant impact on pupils. However, this impact will be measured from the teacher's ability to implement plans for developing pupils' reasoning skills. Therefore, the comparison between planning and implementation of teaching reasoning skills is very urgent to be investigated as a basis for reflection of teaching in the classroom to find out whether the steps of instruction are practical or complicated to implement in the classroom.

II. METHOD

The purpose of the study was to describe the planning and learning implementation based on the development of pupils' reasoning skills carried out by science teachers in the classroom. It also investigated the reasons for differences between planning and learning implementation through an unstructured interview with teachers. The overall research processes are shown in Fig.1. Because of qualitative case study research, it applied the process of data collection to earn input, data analysis to produce output, and finally data triangulation to produce outcomes.

The research subjects were five secondary school science teachers who had taught for more than five years with the age range of 30-35 years in Bandung, West Java Province, Indonesia. As this study has a specific purpose, the sampling technique implemented was purposive sampling. Specific purposes always have a strong correlation with the purposive sampling technique (Fraenkel, Wallen, & Hyun, 2012).

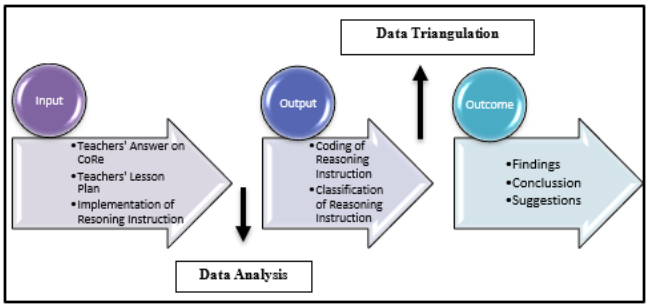

Fig. 1. Research processes

2.1. Instrument and Procedures

The instruments used are divided into two types based on their function. First, classroom instruction video transcription was used to see the emergence of aspects of pupils' reasoning development strategies implemented by the teacher. The probing questions from teachers were coded then classified into the level of reasoning instruction as shown by Table 1. Besides, unstructured interviews are also conducted to find out the obstacles of teachers in implementing the lesson plan.

TABLE I.
THE LEVEL OF REASONING INSTRUCTIONS

Coding	Teachers' Activities
1	Facilitating pupils in getting rational data.
2	Facilitating pupils to base their data on rational reasons.
3	Facilitating pupils to support rational reasons with facts or evidence.
4	Facilitating pupils to relate the concepts that support reason and evidence.
5	Facilitating pupils to make conclusions based on data, reasons, or evidence.

Second, the *CoRe* questions investigate the teachers' plan to teach science material with reasoning strategies, and second the lesson plan analysis format. This instrument consists of some questions that have been through the process of expert and empirical validation (Sukardi, Widodo, & Sopandi, 2017). The lesson plans were

reviewed to recheck teachers' answers on *CoRe*. These instruments were used to capture teachers' planning. The blueprint of instruments is shown in the Table 2.

TABLE II
BLUEPRINT OF INSTRUMENT

No	Aspects	Description	CoRe Questions	Lesson Plan Parts
1	Teachers' choice of ideas or concepts	Teachers' strategy to classify the concept of environmental pollution that supports the pupils' reasoning skills, and teachers' understanding about pupils' misconceptions and the way to prevent them.	1,2, and 3	Teaching Materials
2	The presentation of ideas or concepts	The used approaches, methods, models, learning strategies, or learning media that support, develop, and build pupils' reasoning skills.	4,5,6, and 7	Teaching steps
3	Assessments on reasoning instruction	The used quiz, daily test, middle test, and final test that assess pupils reasoning skill such as giving scientific argumentation.	8	Teaching evaluations

III. DATA ANALYSIS

Coding was used as a technique to analyze the emergence of reasoning indicators both in the planning and the implementation. The emergence of indicators of reasoning in planning was obtained by analyzing the teachers' answers to *CoRe* questions and the lesson plans so that they appear at the stage of selecting ideas/concepts, presenting them, and conducting an assessment. The summary results of the coding process on the emergence of reasoning indicators are then presented in the table to see in which reasoning skills indicators appear both on *CoRe* answers and lesson plan. Meanwhile, the implementation of classroom instructions that develop reasoning strategies were obtained from the video transcription of teaching to see how the teacher conducts classroom instruction that has been formulated in the *CoRe* and lesson plans. Video transcriptions are needed as a reflection aid for teachers to expand or modify their instructional teaching on a particular science content (Nilsson & Karlsson, 2019). The examples of teacher' transcriptions and coding are shown in Table 3.

TABLE III
THE TRANSCRIPTION AND CLASSIFICATION PROCESS

No.	The Examples of Probing Questions from Teachers	Reasoning Level
1	Can you give me an explanation of why plastic trash that is floating on the sea surface hampers the sunlight into the sea?	2
2	Have you ever seen earthworms live in the soil full of plastic garbage? What does it mean?	4

The next step was to compare the planning with the implementation of developing pupils' reasoning skills. The process of data analysis is shown in the Fig.2.

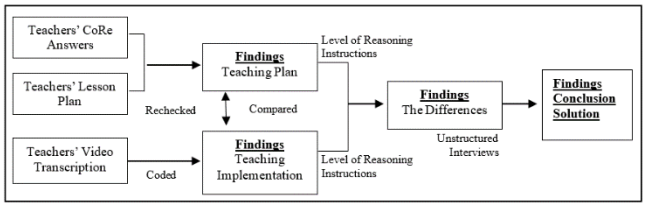

Fig. 2. The Process of Data Analysis

Fig. 2 shows that all entered input such as the teacher's answer to the CoRe questions, the teacher's lesson plan, and the video transcript of the learning must go through the coding process based on reasoning indicators before being analyzed. The data is further classified into five levels of activities to develop pupils' reasoning skills. The output obtained is in the form of a description of teachers' capabilities on teaching practices based on reasoning indicators. The output must be reprocessed by the data triangulation process to obtain a meaningful outcome. Findings, conclusions, and solutions are the expected outcomes in this study of how to develop PCK while improving teachers' skills in teaching reasoning in the Indonesian context.

IV. RESULTS AND DISCUSSIONS

3.1. The Plan of Teachers' Reasoning Instruction

Classroom instruction is a representation of the teacher's ability in developing pupils' reasoning abilities and shows the teacher's understanding and orientation towards teaching strategies. This is in line with a statement of Alshamali & Daher (2016), that the key to developing pupils' reasoning abilities is the teacher's understanding and implementation of teaching reasoning to motivate and develop pupil reasoning. Besides, the instruction also shows the steps taken by the teacher in activating pupils'

thinking skills to connect various data findings with logical evidence and explanations to build constructive concepts.

Pupil reasoning ability is one aspect of teacher PCK. This aspect can be analyzed by identifying the emergence of reasoning aspects in content representation (*CoRe*). This is because the *CoRe* provides information about teacher planning in determining what pupils will learn (Loughran, Mulhall, & Berry, 2012). Table 4 presents data on the emergence of reasoning aspects in teachers' *CoRe* answers and lesson plans. The emergence of these aspects of reasoning is then summarized in the selection of ideas or concepts, the presentation, and the development of assessment. The emergence of aspects of reasoning between 4-12 is not an indication that the teacher has PCK competence regarding poor reasoning teaching. Based on the results of interviews with teachers, teaching reasoning skills is a dilemma for teachers. This is because pupils are not ready to be stimulated by reasoning for several reasons, one of which is the lack of pupil literacy related to environmental pollution material. Teachers need a relatively longer time to prepare pupils with prerequisite material in reasoning. Besides, teachers also have other achievement targets, such as daily tests, midterm tests, and end of semester tests. In question *g* regarding teaching strategies, aspects of reasoning appear most because this question collects teaching strategies flexibly. The teacher presents various data and facilitates pupils to submit reasons and evidence to strengthen their opinions. For example, Teacher Yuli's answers:

> *CoRe* Question: How do you teach air pollution?
> Teacher Yuli : I will show an informative graph of air quality in several major cities in Indonesia, including Bandung (*Reasoning level A: Facilitating pupils to get rational data*). I will also give probing questions to pupils why air pollution causes acidic rain by doing an experiment or demonstration. I asked the pH of water that has been polluted with the smoke or haze then I asked their explanations or reasons (*Reasoning level D: Facilitating pupils to relate the concepts that support reason and evidence*).

A different thing is shown by CoRe question *a* which collects teaching material that will be delivered by the teacher. Almost all teachers answered that the materials to be taught were general materials mentioned in the learning objectives that had been formulated as materials that appeared on school exams and even national exam. Developing teaching materials that facilitate pupils' reasoning abilities is also a dilemma for teachers because it requires relatively much time. The choice of the teacher regarding the types of assessment is only limited to the teacher's efforts to collect data and pupils' reasons for the questions given. A relatively similar thing also appears in CoRe answer *h* which specifically asks the way the teacher measures pupils' reasoning skills.

Based on Table 5, the indicators of how to facilitate pupils' reasoning mostly appear on question *g* and *h*. Those questions ask teachers how do they carry out learning process and do assessment. Although found level 4 in the teachers' answers, but most of them found in level 1 and 2. The findings are similar to Alshamali & Daher (2016), Bati (2019), and Waldrip & Prain (2012) that teachers need big effort in facilitating pupils to support rational reasons with facts, evidence, related concepts, and to make conclusion with data, reason, and evidence.

TABLE IV
THE EMERGENCE OF REASONING LEVELS IN CONTENT REPRESENTATION QUESTIONS

No	Teacher	Reasoning Level	Questions							
			a	b	c	d	e	f	**g**	h
1	Yuli	1	-	√	-	-	-	-	√	√
		2	-	-	-	-	√	√	√	-
		3	-	-	-	-	-	-	√	-
		4	-	-	-	-	-	-	√	√
		5	-	-	-	-	-	-	-	-
2	Zara	1	-	-	-	-	-	-	√	-
		2	-	-	-	-	√	-	√	-
		3	-	-	-	-	-	-	-	-
		4	-	-	-	-	-	-	-	-
		5	-	-	-	-	-	-	-	-
3	Fauzi	1	-	-	-	-	-	-	√	√
		2	-	√	-	-	√	√	-	-
		3	-	-	-	√	-	-	√	√
		4	-	-	-	-	-	-	√	-
		5	-	-	-	-	-	-	√	-
4	Minah	1	-	-	-	-	-	-	√	-
		2	-	√	-	-	-	-	-	-
		3	-	-	-	-	-	-	-	√
		4	-	-	-	-	-	-	-	-
		5	-	-	-	-	-	-	-	-
5	Nunik	1	-	-	-	-	-	-	√	√
		2	-	√	-	-	-	√	√	√
		3	-	-	-	√	-	-	√	-
		4	-	-	-	-	√	-	-	-
		5	-	-	-	-	-	-	-	-

Reasoning levels description:

1 = Facilitating pupils in getting rational data.
2 = Facilitating pupils to base their data on rational reasons.
3 = Facilitating pupils to support rational reasons with facts or evidence.
4 = Facilitating pupils to relate the concepts that support reason and evidence.
5 = Facilitating pupils to make conclusions based on data, reasons, or evidence.

3.2. How Do Teachers Implement Reasoning Instruction

The implementation of learning is the teachers' representation capabilities to develop pupils' reasoning abilities so that can demonstrate the teachers' understanding and orientation towards teaching strategies. This is as revealed by Alshamali & Daher (2015), that the key to

develop pupils' reasoning abilities is the teachers' understanding and implementation of reasoning to motivate and develop pupils' reasoning. Besides, the implementation of learning also shows the teachers' step in activating pupils' thinking skills to connect various data findings with logical evidence and explanations to build constructive concepts. Teachers' interpretations of developing pupils' reasoning abilities are very diverse. Therefore, five level indicators are arranged as parameters to measure the extent to which the teacher implements reasoning. This is because reasoning development strategies affect many things, one of which is pupils' academic achievement (Shefarat, 2015).

Table 5 shows a comparison of the emergence of the stages of reasoning teaching in planning based on information from Table 4 (choosing ideas or concepts, presenting ideas or concepts, and preparing assessments) and their implementation. Stages of reasoning teaching that often arise (mode) in the selection of ideas or concepts and their implementation show that the teacher has tried to facilitate pupils to express rational reasons from the rational data that he presents. Most teachers (except Teacher Nunik) do not facilitate pupils to support the data and reasons with facts or evidence, link the relationships between concepts, and make conclusions based on the data that has been presented. In the presentation of ideas or concepts and their implementation in the classroom, almost all teachers (except Teacher Nunik) only facilitate pupils to obtain rational data. In the preparation of assessment and its implementation, the teacher only facilitates pupils to base the data on rational grounds. Meanwhile, Teacher Zara and Teacher Minah do not even integrate any aspect of reasoning into the questions they made. In general, the stages of teaching reasoning in planning and implementation have not changed. But there are also some changes, for example, Teacher Fauzi in planning (presentation of ideas or concepts) will facilitate pupils to base the facts displayed in the video with rational reasons, but in practice, this is not done. This fact stimulates the prediction that planning and teaching environmental pollution with reasoning teaching strategies is difficult for teachers to do. The difference in planning and implementation of teaching is because teachers prefer factual strategies that might be implemented in the classroom rather than strategies that are ideally designed but cannot be implemented in class.

The interview that was conducted after the implementation of the learning strategy showed that although teachers have PCK about teaching reasoning strategies, they also had pragmatic issues such as the effectiveness of pupils' time and learning styles. The teacher cannot force pupils to provide rational reasons related to their answers because pupils have not yet had the knowledge required to base answers with rational reasons that are filled with data and even evidence. If this happens, it will take time and the learning target will not be achieved. Besides, the teacher did not teach reasoning to pupils because in reality mastery of concepts was more important because it was tested on the National Examination. In the implementation, teachers found that pupils had to vary cognitive capabilities and different learning styles. The results of the lesson plan analysis indicate that the teaching model chosen by the teacher is a teaching model that comes from abroad. They do not make adjustments to the syntax of teaching so the implementation of innovative teaching models from foreign countries has not been able to be applied optimally. These results indicate that teachers need to develop teaching strategies to teach many skills, including reasoning, that are appropriate to the curriculum, characteristics, and learning styles of pupils in Indonesia.

TABLE V
THE COMPARISON BETWEEN INSTRUCTIONAL PLANNING AND IMPLEMENTATION

Study Aspects	**Levels of Reasoning Instruction**																								
	Yuli					**Zara**					**Fauzi**					**Minah**					**Nunik**				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
A	√	√	-	-	-	-	√	-	-	-	-	√	√	-	-	-	√	-	-	-	-	√	√	√	-
B	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	√	-	-	-
C	√	√	√	√	-	√	√	-	-	-	√	-	√	-	√	√	-	-	-	-	√	√	√	-	-
D	√	√	-	-	-	√	-	-	-	-	√	-	-	-	-	√	-	-	-	-	√	√	-	-	-
E	-	√	√	√	-	-	-	-	-	-	-	√	√	-	-	-	-	-	-	-	-	√	-	-	-
F	-	√	-	-	-	-	-	-	-	-	-	√	-	-	-	-	-	-	-	-	-	√	-	-	-
NOTE	N	N	Y	Y	N	N	Y	N	N	N	N	N	Y	N	Y	N	N	N	N	N	N	N	Y	Y	N

A = Choice of Ideas or Concepts in Planning
B = Choice of Ideas or Concepts in Implementation
C = Planning of Presentation of Ideas/concept
D = Implementation Presentation of Ideas/concept
E = Chosen Assessment in Planning
F = Chosen Assessment in Implementation
Y = Changed
N = Unchanged

1 = Facilitating pupils in getting rational data.
2 = Facilitating pupils to base their data on rational reasons.
3 = Facilitating pupils to support rational reasons with facts or evidence.
4 = Facilitating pupils to relate the concepts that support reason and evidence.
5 = Facilitating pupils to make conclusions based on data, reasons, or evidence.

Based on Table 5, the implementation of reasoning instruction dropped from one level to a lower level. For example, Teacher Yuli in the presentation of ideas or concepts dropped from level 4 to level 2 and many more. The differences between the planning and the implementation are caused by many factors. One of them is because of the lack of pupils' understanding of fundamental concepts. Finally, teachers have to deliver lessons with their explanations not with their probing questions. Sukardi (2017) and Furtak et al. (2008) argued that the condition happened because of a lack of understanding teachers' lack of pupils' conditions.

The following passage provides an example of an instructional comparison between the planned and actual implementation of teaching activities by Teacher Nunik, as detailed in Table 6. This comparison reveals a significant discrepancy between what was planned and what was executed, particularly in relation to the facilitation of students in supporting their rational reasoning with concrete facts or evidence. Teacher Nunik, despite her initial intentions, did not manage to implement this crucial aspect of her lesson plan. The primary cause of this shortfall was identified as pragmatic challenges, most notably a lack of adequate time to cover all the planned instructional activities. Sopandi (2017) offered an explanation for this issue, suggesting that the innovative learning model employed by Teacher Nunik may not have been well-suited to the specific conditions and needs of the pupils, nor fully aligned with the curriculum currently in place in Indonesia. This mismatch between the learning model and the classroom reality likely hindered the effective delivery of the intended educational content. As a result, the expected learning outcomes were not fully realized, indicating a need for careful consideration of the suitability of instructional models in relation to the unique context of the pupils and the educational framework within which they are taught.

TABLE VI
TEACHER NUNIK'S INSTRUCTIONAL COMPARISON BETWEEN PLANNING AND IMPLEMENTATION ON PRESENTATION OF IDEA/CONCEPT

No	Stage of Reasoning Instruction	Planning	Implementation
1	Facilitating pupils in getting rational data.	Teacher Nunik is going to present the graph that shows the increase in temperature in the North Pole. One of the reasons is that the greenhouse effect.	Teacher Nunik prepared the simple plastic box with the bulb and thermometer inside. She blew the haze into the box. *Do you see the increase in temperature? How is the temperature if the number of haze is increased? Draw it in the diagram!*
2	Facilitating pupils to base their data on rational reasons.	Teacher Nunik is going to deliver information that the increase of temperature causes the increase of sea level height because of the melting polar ice caps.	*Do you think sea-level rise is related to the greenhouse effect?* *OK, we do believe they have a strong relationship. Which volumes are bigger, the ice or the water? If ice volume is bigger than water volume, why melting ice can increase sea level height?* *We do agree the water in the North Pole should be frozen. How can we keep them frozen?*
3	Facilitating pupils to support rational reasons with facts or evidence.	Teacher Nunik is going to ask for some scientific evidence from pupils. They can be data from observation or data from the internet.	Teacher Nunik did not stimulate the pupils with probing questions. She only delivered information because the time was not enough. Besides, pupils have not been ready to be stimulated because they were lack of informative knowledge.

V. DISCUSSION

The teacher's understanding of PCK in developing pupil reasoning is important and the data can be obtained from the teacher's CoRe answers and lesson plans. But more important is ensuring how the teaching strategy is implemented in the classroom. The teacher may have knowledge about developing teaching strategies that stimulate pupil reasoning. CoRe instruments and lesson plans are used to investigate this. But of course, the implementation of teaching will be different from the planning as shown in Table 5. Besides investigating whether the teacher can maintain consistency between lesson planning and implementation of classroom instruction that stimulates pupils' reasoning skills, this research also investigates the factors that drive the differences. This finding is a reflection of teaching that will be the basis of improvement in the teaching process of reasoning in the future. Most researchers investigate teachers' PCK in general and classify it into specific criteria. Meanwhile, not many studies have investigated the ability of teachers to plan and implement reasoning teaching strategies within the PCK framework specifically. However, this reasoning ability is important to be possessed by pupils so the teacher must stimulate the ability through the instructional activities.

Table 5 provides information that the leves of teaching reasoning that often arise both in the process of ideas/concepts selection and their implementation are stages where the teacher facilitates pupils to base data with rational

reasons. They use the pedagogical context of social scientific issues such as environmental pollution, interdisciplinary knowledge, values, and argumentation skills. Those are good to promote pupils' activities in reasoning (Chang Rundgren & Rundgren, 2010; Klosterman & Sadler 2010; Christenson, Rundgren, & Zeidler, 2014; Bati, 2019). Based on the answers collected through *CoRe*, teachers generally choose concepts that can be seen directly by pupils. This is very essential because concepts that can be sensed by pupils allow them to develop reasoning abilities related to scientific phenomena by involving data and evidence (Falk & Brodsky, 2013; Kuhn, 2010). They chose and implemented many media to present environmental issues to pupils. Most of them chose sea pollutant migration and air pollution to be presented to pupils. Teachers said that household contributes to the big number of wastes. Although Teacher E informed that Indonesia is the second rank of marine wastes contributor after China but she didn't give the data precisely, how many cubics of wastes were contributed from households and factories. She gave only reasons and evidence merely. Teacher Yuli even chose and implemented a demonstration. She put soap liquid gradually into a glass bucket contained small fish. She directly provided rational data to pupils. Pupils were asked to observe how many movements of fish gills per addition of mL liquid soap. Teacher Nunik also planned to deliver the concept of how chemical endangered aquatics organisms.

Meanwhile, in the aspect of concepts/ideas presentation and their implementation, all teachers facilitate pupils to get rational data, both from direct observation, videos, and articles. At the planning stage (presentation of concepts or ideas) some teachers show good PCK quality related to reasoning teaching strategies, for example, Teacher Yuli and Teacher Nunik. They plan to stimulate pupils to provide rational reasons supported by facts and evidence about the opinions they submit. The teacher even plans to stimulate pupils in connecting the interrelationships between concepts. But in its implementation, almost all teachers only facilitate pupils to obtain rational data as shown in Table 5. The questions raised by teachers should be analytical questions that require pupils to be able to construct a theory or concept in explaining the scientific phenomena that they conclude so that it becomes logical. Scoot, Mortier, & Aguiar (as cited in Gillies, Nichols, Burgh, & Haynes, 2014) also revealed that teachers should give high-level questions of 'how' and 'why' pupils express a statement so pupils do not just remember facts. The teacher's step in teaching pupils to ask and answer questions plays a role in stimulating pupils' reasoning skills (Garcia-Mila & Andersen, 2007; Gilies, 2011; Gillies, Nichols, Burgh, & Haynes, 2012; Gillies, Nichols, Burgh, & Haynes, 2014). The transcript interviews of teachers showed that they did it because their pupils' understanding was low because of lack of reading. Teachers needed more time to stimulate producing of reasons and pieces of evidence but factually they had limited allocated times.

In the preparation of the assessment, only three teachers assessed the pupil's reasoning ability to base the data for rational reasons, while the other two teachers did not even assess the pupil's reasoning ability. Whereas questions that are equipped with rational reasons and pieces of evidence can increase the complexity of pupils' logical understanding (McNeil & Pimentel, 2010; Sampson & Blanchard, 2012; Tytler, Prain, Hubber, & Waldrip, 2013). They tended to assess pupils' concept mastery with multiple choice questions or short essays. The results of the interview analysis showed that although teachers had PCK on how to teach reasoning to pupils, they have difficulty in conducting it. Teachers have targets that must be completed each semester, it is concept mastery. Besides, they have to also make sure that pupils can do middle and final exams even national examinations well. In the end, the main target of the teacher in learning is not only to teach reasoning but mastery of concepts. Although Table 5 shows that planning with the implementation of teaching has not changed much, when observed in more detail it appears that a lot of plan was not carried out in terms of the choice of ideas or concepts, the presentation of ideas or concepts, and the preparation of assessments.

Teaching strategies that stimulate pupil reasoning are important to implement because they contribute to the cognitive development of pupils. This is also revealed by Harlen (2010) that teaching science is no longer just a process of remembering facts or theories but it must also encourage pupils to express contextual ideas related to problems of everyday life with strong scientific reasoning and evidence. Besides, the teacher's pedagogical competence not only guides the formation of pupils' understanding or knowledge but also a variety of skills, including reasoning (Karahan & Roehrig, 2016). Reasoning activities are also indicated to stimulate other skills such as critical thinking and creative thinking. Teachers Yuli and Fauzi revealed that pupils who can reason tend to be critical and creative in providing solutions to problems encountered in daily life. The teacher hypothesizes that teaching strategies that stimulate reasoning will go according to plan if pupils have a strong foundation in mastering the basic concepts of science so that they can connect, draw conclusions, even predict effective problem solutions. It is also corroborated by Table 6 that Teacher Nunik needed more time to stimulate pupils in producing rational reasons, facts, or evidence because they did not have enough knowledge. Teacher Nunik preferred to deliver information directly then gave pupils some probing questions because she did not have enough time to do it. This is one example that the instructional strategy chosen is always based on pupil conditions and the availability of time in the curriculum.

Inch, Warnick, & Endres (2006) and Duschl & Osborne (2002) assert that reasoning activities require a strong foundation for understanding concepts so that they can coordinate evidence with theories to broaden explanations, examples, predictions, and an evaluation. To form pupils who are ready to face teaching based on reasoning, the teacher requires more flexible time. Ozden (2020) and Can (2020) also revealed that forming pupils with logical reasoning skills requires a relatively long time because pupils generally use intuitive reasoning. Meanwhile, the results of

interviews with teachers showed that they were constrained by two things, i.e. the condition of pupils and the curriculum. Besides, they had a difficulty in implementing the innovative learning model because of the unfamiliar teaching stages or steps.

Teachers used many innovative learning strategies to teach reasoning. But under certain conditions, those learning strategies are not going well because of some reasons. The innovative teaching model they use does not fit into the conditions in Indonesia, such as curriculum content and pupils' learning habits. For example, pupils are not used to conveying scientific arguments and reasoning skill is not the major goal of the learning process. The most innovative teaching models are created by foreign education experts who do not consider the condition of Indonesian pupils. Therefore, there are obstacles to synchronizing the teaching steps with the learning habits of Indonesian pupils. The curriculum content in Indonesia is also more numerous compared to countries that have advanced education. To achieve teaching objectives, teachers must pay attention to the selection of innovative models that are appropriate to the curriculum and conditions of pupils in Indonesia (Sopandi, 2017). If innovative models originated from other countries were to be used, then the steps must be adjusted to the conditions of pupils and curriculum content in Indonesia so that it runs in harmony and balance.

The parameter used by the teacher to assess learning success is a test score so that aspects of reasoning are often overlooked. The teacher believes that conventional teaching is more practical because it can meet the learning targets in the curriculum. Teaching strategies that stimulate reasoning are seen by teachers as strategies that require a relatively long time and require a lot of adaptation. The results of deeper interviews with five teachers show that although the reasoning is an ability introduced from the West, it also needs to be possessed by Indonesian pupils. Therefore, the selection of teaching strategies is a dilemma for teachers because they are faced with ideal and factual learning conditions. The discussion at the end of the lesson with the five teachers resulted the conclusion that no matter how complex the reasoning skills that pupils had to master, it would be more practical to implement if the teaching strategy had been adapted to suit pupils' conditions and the curriculum in Indonesia. The difficulty of the teacher in implementing innovative teaching strategies or models from abroad leads the teacher's opinion that the teacher can design a teaching strategy that is suitable to be applied in the classroom with external teaching principles such as constructivism by Piaget and Vygotsky. If this strategy is successfully formulated by the teacher, cognitive aspects will emerge in the answers to the teacher's CoRe questions. One of the CoRe questions highlights how teachers relate teaching objectives to the selection of models and teaching methods (Padilla & Garritz, 2011). The teacher's perception that a good teaching strategy must be from abroad has also started to change.

The key step obtained when collecting teaching strategies from teacher discussions is that pupils must be forced to read before learning that exercises reasoning. In this way, pupils are indirectly provided with the conceptual knowledge needed to reason. Pupil activity in reasoning is analogous to an activity that connects wires in an electrical installation so that it can light a light bulb that shines brightly. Pupils are ultimately able to produce answers (claims) that are supported by data, backing, warrant, evidence, and even counter argument with a rebuttal. The preparation of teaching strategies based on pupils' cognitive conditions and curriculum in Indonesia can also be used to stimulate other skills such as critical and creative thinking. The problem of lack of time can be overcome by the use of online teaching platforms, thus forcing teachers to understand and use technology in education in the 21st century. Because of the vital role of technology in education, it is not surprising that researchers encourage the development of PCK into TPACK, where technology is a supporting tool and has a strong link with pedagogical and content knowledge aspects (Irdalisa, Paidi, & Djukri, 2020; Özgen & Narlı, 2020; Castéra et al., 2020). PCK even TPACK are very important for teachers because they can help teacher to conduct good learning process. But the most important is the conditions of pupils and national curriculum should be supporting the implementation of teachers' PCK or TPACK. The condition that less support them will be barrier for teachers to conduct innovative and qualified learning process in the classroom (Bustamante, 2019). The research is expected to give the benefit and positive impact to teachers' PCK and their skills in developing reasoning instructions. Teachers have to be equipped with pedagogical competencies on how to adjust the innovative learning strategy with the factual conditions. Hence their PCK even TPACK will be developed optimally and will help them to carry out the proper learning strategies in the science classroom.

CONCLUSION

The results showed that although the teacher had PCK related to reasoning strategies in the planning and classroom instruction, the teacher did not bring up all the steps of teaching reasoning skills because of some factors. Even during the classroom instruction, there are some changes where the teacher does not implement all the plans that have been made. The results of the investigation through interviews provide information that it is caused by pragmatic reasons such as time availability and the planned innovative learning models did not work well due to the different conditions of pulis. The curriculum structure that requires teachers to carry out various tests such as semester exams and national examinations makes the teachers prioritize pupils' mastery of concepts over reasoning skills. This indicates the need for innovative teaching models used by teachers must be under the conditions of pupils and the contents of the curriculum in Indonesia so that teachers will not experience difficulties applying it.

Recognizing that quality didactic activities will have an impact on learning outcomes, it must be ensured that the teaching strategies implemented by teachers must be appropriate and under the conditions of pupils and the

curriculum in Indonesia. The teachers need a forum as a medium of reflection to maintain the quality of undergoing teaching to stay on the track. Apart from the teaching targets that must be achieved, the forum can be in the form of training and mentoring of teaching strategies. This forum not only provides new knowledge related to teaching strategies but also is a didactic guide on how idealistic teaching strategies can work practically in the classroom. Therefore, these training and mentoring need to be implemented for teachers. These are the opportunities to open the research in the future that brings benefit for education in Indonesia, for example developing instructional reasoning based on Indonesia context or coaching to enhance teachers' PCK in developing pupils' reasoning skills.

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