Lesson study as a means of transforming classroom discourse and student cognitive engagement in science classroom

M U Hajar* and S Hendayana
1Sekolah Pascasarjana, Universitas Pendidikan Indonesia, Jl. Dr. Setia Budhi No. 229, Bandung 40154, Indonesia
2Departemen Pendidikan Kimia, Universitas Pendidikan Indonesia, Indonesia

*mayau@upi.edu

Abstract. This study deals with the impact of lesson study focused on classroom discourse and student cognitive engagement in science classroom. Lesson study has been used as a professional development program where teachers will be able to improve on teacher instructional practices. In this study, lesson study was conducted in two junior high schools for two cycles which a cycle starts from build a lesson design, implementation lesson design in science classroom, reflection, and revise the lesson design. A qualitative approach design in this study provides a detailed look at each aspect of lesson study which showed the impact on classroom and student cognitive engagement in science classroom. Classroom discourse and student cognitive engagement analyzed form transcribed video recordings and measured by EQUIP (The Electronic Quality of Inquiry Protocol). The result showed an increase in student cognitive engagement and the following aspect of classroom discourse: questioning level, complexity of questions, and communication pattern. In general, lesson study was effective to help teacher reflect the lessons and revise the lesson design as a part of lesson study was effective to improve classroom discourse. This study contributes to upgrade teacher instructional practices and student cognitive engagement in the science classroom.

1. Introduction
Student outcomes such as achievement, motivation, and efficacy have been associated with multiple aspects of teacher instructional practices in the classroom. Verbal communication between teachers and students in classrooms shapes the learning environment by influencing the type of talk that students engage in during instruction [1-3]. This classroom discourse often guides students in making meaning of science concept [4-7]. Specifically, teacher questioning has been identified as a critical factor in facilitating effective classroom discourse during instruction [8-11]. Teachers’ questions can establish a learning environment that promotes student learning and collective sense-making. Teacher question, can help student understand the reason for using particular scientific practices.

The evidence in previous research based on larger samples has consistently shown that teachers ask students a large number of questions that are mostly closed-ended or certain answers are seen as correct and it is the students’ task to produce these answers. These questions are typically characterised by a low level of cognitive demand, requiring students merely to show that they remember subject matter presented to them earlier. Student answers are short and simple and are usually lists of learned facts, corresponding to the requirements of the teacher's questions. The teacher's feedback is usually a brief response to the correctness or otherwise of the student's answer. The development of a student's answer
or suggestions for further consideration are generally absent [12-14]. It is important to bear in mind that classroom interaction is shaped by cultural norms “limiting the times at which students can talk, the topics they can legitimately address, and the ways in which they can express themselves” [15-17]. The only way that can be used to break its cultural norms is guidance the teachers through professional development programs.

A professional development program where teachers will be able to improve on teacher instructional practices especially teacher question in the classroom is lesson study or collaborative lesson research and development. In lesson study, research lessons will be refined and improved through a question as part of the improvements on teacher instructional practices in the classroom [18-20]. Repeated lesson implementations coupled with post lesson discussions can provide opportunities for the teachers to improve their question as part of the improvements on teacher instructional practices in the classroom [21-24]. The next question is, how utilizing lesson study can improve classroom discourse especially teacher question and student cognitive engagement in junior high school science classroom. The aims of current study explored how the lesson study process can be instrumental in equipping teachers in facilitated effective discourse and developing their question as part of the improvements on teacher instructional practices and student cognitive engagement in the science classroom.

2. Method
A qualitative case study approach used to explore how the lesson study process can be instrumental in equipping teachers in developing their question as part of the improvements on classroom discourse, teacher instructional practices and student cognitive engagement in this study. Participants of this study are 2 science teacher and 128 students. Each teacher teaches at two junior high schools in Sumedang, West Java (School A & School B). The topics that taught by different teachers are about the food chain (School A) and cells (School B). Its difference topic that used in the study is intended to let researchers compare the results of teacher question and student cognitive engagement in the different science topic. The teacher selected for this study because they have participated in lesson study as learning community that sustained professional development program that focused on improving quality of instructional practice in science education. The lesson study starts with build a lesson design, implementation lesson design in the science classroom, reflection and lesson analysis to get information about the teacher’s question and student cognitive engagement and revise the lesson design.

![Lesson study pattern](image)

Figure 1. Lesson study pattern in this study.

In each lesson observed by lesson study team. Lesson study team consisted of two science teacher educator, math teacher educator, two science master student and teachers who teach at the school. During the lesson process, all students and teacher activity recorded using voice recorder and video recorder. The video recordings were transcribed and divided into several episodes. Teacher discourse included in classroom discourse measurement. Classroom discourse and student cognitive engagement analysed form transcribed video recordings and measured by EQUIP (The Electronic Quality of Inquiry Protocol). The Electronic Quality of Inquiry Protocol (EQUIP) is a valid and highly reliable instrument designed to measure the quantity and quality of inquiry-based instruction. The discourse scale and
teacher question is comprised of the following factors: questioning level, complexity of questions, and communication pattern. The EQUIP was also used to measure the cognitive level facilitated by the teacher at 5-min intervals as part of the Time construct [25].

3. Result and discussion

3.1. Classroom discourse and student cognitive engagement on learning about food chain topic through lesson study

3.1.1. Lesson study stages on learning about food chain topic. The first lesson study stages that undertaken in this lesson about food chain topic is made a lesson design. Lesson design are made by a joint discussion between teacher who taught the lesson, two science teacher educator, math teacher educator, two science master student and teachers who teach at the school. Lesson design that made in this research is different from lesson design in general. The design consists of lesson activity or deductive situation created by the teacher, prediction of student’s response, and teacher’s anticipation. The objective of the lesson in this topic is the student be able to analyze the role of producers or autotrophs and consumers or heterotroph in the food chain surrounding their environment. In the learning stage some students’ role played performed about food chain in rice fields and the food chain maps are described by students in group discussion. After the lesson design completed, Teacher implemented the learning and lesson study team conducted learning observations. At first reflection as third stages on lesson study, lesson study team and teacher who taught the lesson discuss about how student learn in the classroom and how teachers facilitated students to learn. At this reflection stages, they discussed about how students can be more active in discussions by raising questions that given by teachers. It is due to the discovery of a learning observation that only a few students are active in the discussion. In the revise lesson design as next stage of lesson study, they discussed about teacher question and how teacher delivered the question in the classroom based on the student characters. In this stage, learning media is discussed by the lesson study team. They found that the media used in the learning did not make it easier for students to create a food chain map. they replaced the media of learning with Styrofoam and pins that easier to remove and rearrange than the glue and paper as media in the learning before. After revise the lesson design, Teacher implemented the second learning and lesson study team conducted learning observations. The second learning are used to explore how the revised lesson design can improve learning quality. This learning used the same topic on the revised lesson design but with different student. On the second reflection, they found that student more active in group discussion than previous learning.

3.1.2. Classroom discourse and student cognitive engagement on learning about food chain topic through lesson study. After the first and second implementation, data in figure 2 obtained after transcripting and applying the recorded sound and video into EQUIP format.

Based on the results of data analysis, it is known there has been an increase of student cognitive engagement in the second implementation. Student cognitive engagement on average was the first level (receipt of knowledge) in the first implementation in which the teacher's explanation of the food chain is heard by the students and it has increased one level (recall, remember, understand) in the second implementation. the highest increase occurred in minutes to 35-40 in which student cognitive engagement students increased from level 1 to level 3. At the 30-45 minutes in the first implementation, the students delivered the results of the group discussion. while the second implementation, students analyzed the role of components in the food chain.
Figure 2. Student cognitive engagement on learning about food chain topic in the first and second implementation (School A).

Based on the results of interviews with teachers who taught in the learning, the improvement of student cognitive engagement is caused by the revise the lesson design which is part of the lesson study. at the time of reflection in the first implementation, there were some passive students in the group performance where it became one of the reference factors during the process of revise lesson design. The process of revising the lesson design together with used the reference of previous reflection result is very effective to improve student cognitive engagement. Therefore, student cognitive engagement in subsequent learning is better than previous learning. Whereas, the analysis of classroom discourse (indicator: questioning level, complexity of questions, and communication pattern) obtained the following results (figure 3).

Figure 3. Classroom discourse on learning about food chain topic in the first and second implementation (School A).

Based on the results of data analysis, it is known there has been an increase of classroom discourse (indicators: questioning level, complexity of question and communication pattern) in the second implementation. Significant increase in classroom discourse is shown in episodes of time in minutes 20-
25, 25-30 and 30-35. The following transcript classroom discourse in minutes to the second implementation:

**Teacher**: Now this group, if phytoplankton is gone, who does not eat?

**Student 1**: Zooplankton

**Teacher**: Then, who will not eat?

**Student 2**: Big fish and Small fish

**Student 3**: Human will die

All Student: All will die mom

**Student 4**: Because there is no food

**Teacher**: Well, all already understand?

Based on the results of interviews with teachers who taught in the learning, the increased level of questions of teachers in the second implementation caused by the reflection of learning on the first implementation. In reflection of the first implementation, it is found that the students tend to be passive because the questions given by the teacher are short closed ended questions so that the students are not tried to think of the answer (the recall level). Therefore, in the second implementation, the teacher took the initiative to change the questions that given to the students by writing questions before they were implemented and questions are higher than the recall level (applying or analyse level). Increasing the level of questions and the complexity of questions by teachers in the second implementation leads to an increase in the communication pattern in which previous learning is only controlled by the teacher into a student-led discussion. Reflection is one part of lesson study where the teacher can know the description of learning experienced by the student based on the observer’s note during the observation of learning. It can be used by the teacher as a reference for further learning [26].

3.2. Classroom discourse and student cognitive engagement in cells topic through lesson study

3.2.1. Lesson study stages on learning about cells topic. The objective of the lesson in this topic is the student be able to describe cells as the smallest part of life. In the learning stage some students made a plant preparation of Rhoeo discolor and drew its cell shape. After the lesson design completed, Teacher implemented the learning and lesson study team conducted learning observations. At the reflection of first implementation, discussed about how students can be more active in discussions by raising questions that given by teachers. In the revise lesson design as next stage of lesson study, discussed about teacher question and how teacher delivered the question in the classroom based on the student characters. In this stage, learning objective is discussed by the lesson study team. Learning objectives used in previous learning are very comprehensive, so students are difficult to accept the learning. they replaced it into a simple learning objective and learning stages. After revise the lesson design, Teacher implemented the second learning and lesson study team conducted learning observations. On the second reflection, they found that students are more actively answered questions given by teachers and performed practical work in classroom.

3.2.2. Classroom discourse and student cognitive engagement on learning about cells topic through lesson study. Based on the results of data analysis, it is known there has been an increase of student cognitive engagement in the second implementation. It occurred because of the differences in syntax that used in the first and second implementations. In the first implementation, students made plant preparation without examples given by the teacher, whereas in the second implementation, teacher demonstrated how to make plant preparation first before students have the discussion. After a demonstration by the teacher, the construct of a cell description is made by the student. The change is based on the first implementation reflection that students have difficulty to make plant preparations and is used as a reference for revise of lesson design. Reinforced by result of interview, student cognitive engagement improvement is caused by the revision of lesson design as part of lesson study.
Based on the results of data analysis, it is known there has been an increase of classroom discourse in the second implementation. Significant increase in classroom discourse is shown at 40<sup>th</sup>–75<sup>th</sup> minutes with questioning level and complexity of question aspect and communication pattern has increased from 20<sup>th</sup> minute to the end of learning. Based on the interview result, the improvement of communication pattern in the second implementation is caused by the demonstration of how to make a plant preparation by the teacher at the beginning of the learning. The student's knowledge leads to changes in communication patterns previously dominated by teachers being student-centered. The following transcript classroom discourse in minutes to the second implementation:

**Teacher**: From the results of your observations had different results, what is the cause?

**Student 1**: Its incision is thickness sir

**Student 2**: No light

**Student 3**: Incisions of preparations must be more thin

**Teacher 4**: Why it makes a difference?

**All Student**: Because the tissue is drawn, not the cells

**Teacher**: Okay, the difference is caused by some of the factors you mentioned earlier, so after this study you can make a good preparation of plant and can be observed under the microscope well.
Based on the results of interviews that have been done, the increase in the level of questions and the complexity of question teacher is directly caused by the discussion conducted by lesson study team on the lesson design revision. In the discussion the teacher gained feedback on how to make questions with higher level questions to make students more thoughtful to answer the question and teachers are shown how to ask the question to be accepted by the students well. During the discussion the teacher practiced how to ask questions in front of the lesson study team. Therefore, in the second implementation, the question given by the teacher has a higher level and complexity than before. Reflection and revision of lesson design as part of lesson study is an important factor to improve the effectiveness of classroom discourse in learning.

4. Conclusion
Lesson study can be used as tool to improve classroom discourse and student cognitive engagement. The most part of lesson study that can improve classroom discourse and student cognitive engagement was reflection and revise the lesson design. Through reflection activities in lesson study, the teacher can be aware of how the learning process has been done, how the teacher interaction with students or students with the students during the learning process in classroom discourse. In revise of lesson design, teachers can also overcome the problems that occur during the learning process, either in terms of classroom discourse and student cognitive engagement.

Acknowledgments
We want to express our gratitude to team of lesson study learning community (LSLC) in Sumedang who are listening to the journey and help of research process. The retrospective nature of this research reminds us of all the wonderful teachers, colleagues, and students we’ve worked with over the past several years.

References
[1] Connor C and Michaels S 2017 Supporting Teacher in Taking up Productive Talk Moves: The Long Road to Professional Learning at Scale International Journal of Education Research 30 40
[2] Kawalkar A and Vijapurkar J 2013 Scaffolding Science Talk: The Role of Teachers’ Questions in The Inquiry Classroom International Journal of science education 35 12
[3] Smart J and Marshall J 2013 Interaction between Classroom Discourse, Teacher Questioning, and Student Cognitive Engagement in Middle School Science International Journal of Science Education 13 24
[4] Dantionio M and Paradise L 1988 Teacher question-answer strategy and the cognitive correspondence between teacher questions and learner responses Journal of Research and Development in Education 21 3
[5] Morge L 2005 Teacher-pupil interaction: A study of hidden beliefs in conclusion phases. Research report International Journal of Science Education 27 8
[6] Pehmer A, Groscher A and Seidel T 2015 How Teacher Professional Development Regarding Classroom Dialogue Affects Students Higher-Order Learning Journal of Teaching and Teacher Education 47 108
[7] Tan R 2015 Improving The Use of Physical Manipulatives in Teaching Science Concept through Lesson Study International Journal for Lesson and Learning Studies 25 67
[8] Chambers A, Kademian S, Davis E and Palincsar A 2017 Guiding Student Towards Sense making: Teacher Question Focused on Integrating Scientific Practices with Science Content International Journal of Science Teacher Education 39 15
[9] Chin C 2007 Teacher questioning in science classrooms: Approaches That Stimulate Productive Thinking Journal of Research in Science Teaching 44 6
[10] Marshall J, Smart J, Horton R, 2010 The design and validation of EQUIP: An instrument to assess inquiry-based instruction International Journal of Science and Mathematics Education 8 2
[11] Smart J and Marshall J 2013 Interaction between Classroom Discourse, Teacher Questioning, and
Student Cognitive Engagement in Middle School Science *International Journal of Science Education* 13 24

[12] Kiemer K, Groschner A, Pehmer A, Seidel T 2015 Effect of a Classroom Discourse Intervention on Teachers’ Practice and Student’s Motivation to Learn Mathematics and Science *Journal of Learning and Instruction* 35 94

[13] Reinsvold L and Cochran K 2012 Power Dynamics and Questioning in Elementary Science Classrooms *International Journal of Science Education* 10 23

[14] Roth W 1996 Teacher questioning in an open-inquiry learning environment: Interactions of context, content, and student responses *Journal of Research in Science Teaching* 33 7

[15] Forman E, Deltoro V, Brown L and Passmore C 2017 Discursive Strategies that Foster an Epistemic Community for Argument in a Biology Classroom *Journal of Learning and Instruction* 48 32

[16] Sedova K, Sedleck M and Svaricek S 2016 Teacher professional Development as Means of Transforming Student Classroom Talk *Journal of Teaching and Teacher Education* 57 14

[17] Trilling B and Fadel C 2009 21st Century Skills, Learning for life in our times (San Fransisco: John willey & Sons, Inc) p 31

[18] Dudley P 2011 *Lesson Study: A Handbook*, University of Leicester Retrieved February 2018 from www.lessonstudy.co.uk.

[19] Edyani A, Supriatna A, Komalasari L 2017 Utilization of Lesson Analysis as Teacher Self Reflection to Improve the Lesson Design on Chemical Equation Topic *Journal of Physics: Conf. Series* 8 12

[20] Tan R 2015 Improving The Use of Physical Manipulatives in Teaching Science Concept through Lesson Study *International Journal for Lesson and Learning Studies* 25 67

[21] Kumpulainen K and Rajala A 2016 Dialogic Teaching and Students Discursive Identity Negotiation in The Learning of Science *Journal of Learning and Instruction* 19 1

[22] Lotter C, Rushton G and Singer J 2013 Teacher Enactment Patterns: How Can We help Move All Teacher to Reform-Based Inquiry Practice Through Professional Development *International Journal of Science Education* 10 24

[23] Rowe M *Teaching Science as Continuous Inquiry: A Basic* (USA: McGraw-Hill Pub)

[24] Trilling B and Fadel C 2009 21st Century Skills, Learning for life in our times (San Fransisco: John willey & Sons, Inc) p 31

[25] Marshall J, Smart J and Horton R 2010 The design and validation of EQUIP: An instrument to assess inquiry-based instruction *International Journal of Science and Mathematics Education* 8 2

[26] Hendayana S, Suryadi D and Muchtar A 2007 *Lesson Study: suatu strategi untuk meningkatkan kepaprofesionalan pendidik* (pengalaman IMPSTEP-JICA) (Bandung: UPI PRESS) Chapter 3 p 47-55