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THE ANALYSIS OF BIOLOGY TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE DEVELOPMENT IN LESSON STUDY IN WEST JAVA INDONESIA

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ABSTRACT

The study aimed to analyze the development of biology teachers' Technological Pedagogical Content Knowledge (TPACK) in lesson study and to describe the role of the observer in developing teacher's TPACK during the activity. The lesson study was carried out in two from, school-based lesson study and biology teacher association based lesson study. The method used in the study was descriptive involved teachers in one school located in Bandung and member of biology teacher association in West Bandung District West Java, Indonesia. The development of TPACK was focused on five components; they are: learning objective, concept, pedagogy, evaluation, and technology. The information of teachers' TPACK was gain from CoRe + technology, and the result was categorized in pre, growing, and maturing TPACK. The study revealed that the teachers' TPACK in school-based lesson study was more in the aspect of pedagogical knowledge meanwhile teacher TPACK in biology association lesson study improved their TPACK in pedagogical knowledge, content knowledge, and technological knowledge. The development of teachers' TPACK was varied for each indicator from pra to maturing and from growing to maturing. The overall result, the development of teachers' TPACK in the two types of lesson study (school-based lesson study and Biology association lesson study) was more to the pedagogical aspect. The research suggests that teacher association based lesson study is more useful to develop teacher TPCAK than school-based lesson study, and the role of the observer is essential in developing teacher TPACK.

Keywords: TPACK, lesson study, biology teacher

INTRODUCTION

Teachers are professionals who have an essential role in shaping society to be more competitive. The task of the teacher is not only giving the lesson but also to pack the experience to be more interesting that can make student easily understand the lesson. Schulman in 1986, introduced specific teachers' professional knowledge known as *Pedagogical Content Knowledge* (PCK). According to Schulman (1986), PCK consisted of two aspects, content and knowledge (CK) that covers knowledge of the concept, theory, idea, thinking framework, the method of proven and the proof.

Further, PCK relates to the instructional process that includes classroom management, task, plan of the lesson, and lesson of learners. Teachers not only need to understand the content knowledge, but they also need to understand the specific and unique knowledge. These include how to interpret the content, problems, an issue

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that has been constructed which appropriate with students' interest and ability as well as how it presented in the teaching-learning process.

In the current situation, the technology and information improve rapidly. The movement to the digital era is not only giving effect to the social system but also the educational system. Koehler & Mishra (2009) stated that technology is one of the essential components of teaching. The use of technology in the classroom is in line with the indicator of pedagogical competency and professional competency.

The technology used in the classroom has also been developed in teachers' PCK, known as *Technological Pedagogical Content Knowledge* (TPACK). TPACK is believed as more and robust, comprehensive strategies to explain teachers' activities in the classroom (Liang et al., 2013). Liang et al. (2013) stated that the inclusion of technology gives new three dimensions of teachers' knowledge, they are *technological pedagogical knowledge* (TPK), *technological content knowledge* (TCK) and *technological pedagogical content knowledge* (TPCK or TPACK). The framework of TPACK can be seen in Figure 1.

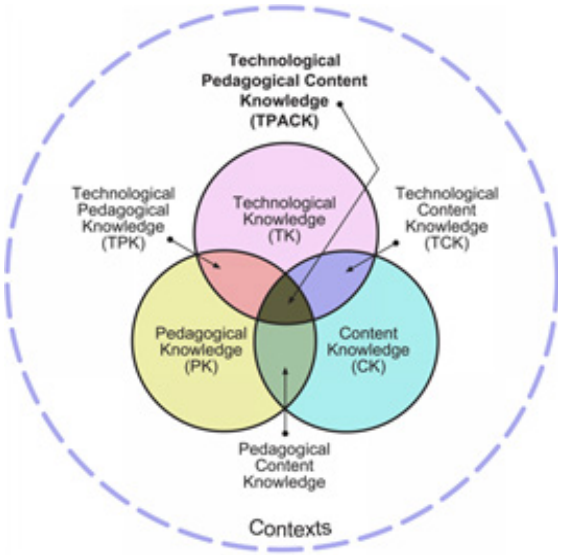

Figure 1. Framework of TPACK (Rosenberg & Koehler, 2015)

Development of TPACK begin with the use of simple technology which familiar for both teacher and student and gradually developed to the more advanced. Teachers in all area of discipline should learn how to do the planning and develop the technology to support students' achievement in their learning (Keengwe, Onchwari, & Onchwari, 2009). Further, the teacher should be able to use better technology to accompany the development of biology teaching, which appropriates with the improvement of the digital era and students' characteristics. However, the research found there are still concerns that teachers do not have enough knowledge to use technology in their classrooms (Ertmer& Ottenbreit-Leftwich, 2010; Bakir, 2016). This becomes a reason why teacher still have difficulty in using technology in their learning (Harris, & Hofer, 2011; Sahin, 2011; Muslim, 2014).

Many strategies have been done to improve teachers' professional development, including the use of technology in teaching. One of the plans that have been widely introduced in Indonesia to develop teachers' professionalism is Lesson Study. Lesson study is an activity that can be used to encourage consistent and systematic learning community aiming at self-improvement (Rusman, 2010). According to Zubaidah (2010) and Susilo (2013) lesson study continues teachers' professional development approach which carried out collaboratively in constructing the lesson plan, implementing the lesson plan, observing the lesson, and reporting the experience.

Birel and Cairloglu (2018) researched preservice mathematics teachers' TPACK in microteaching lesson study. The study resulted that the awareness of preservice mathematics teachers' TPACK changed and developed through microteaching lesson study. The increasing of preservice awareness of virtual manipulative during microteaching lesson study period showed that preservice teachers TPACK developed in line with the control over the use of technology.

The activity of the lesson study consisted of three stages; they are: plan, do, and see. "Plan" is the stage when teachers collaboratively construct the lesson plan to be implemented in the next phase of Lesson Study. The implementation of the lesson plan was carried out in the "do" step. In this stage, one teacher provides the teaching known as teacher model and other teachers becoming an observer for students' learning. The stage of "see" is the activity of reflection on the learning process. In the reflection stage, observer comments on the student learning process, and she/he also can provide a recommendation. The feedback of the observer in lesson study should be focused on students' learning, not to teachers' teaching. The reflection is essential when the teacher can analyze whether their lesson plan has been well prepared and well implemented.

Lesson study is the activity for teachers to do self-reflection. Through lesson study, teachers will able to identify the weakness and the strength of their teaching to improve the quality of their education. Daryanto & Karim (2017)

promote several advantages of lesson study, they are: (a) help to teacher to observe and criticize their learning; (b) help teacher to strengthen the content including the scope and the curricular sequence; (c) strengthen teachers' collaboration in their teaching; and (d) improve teachers' competence which promotes students' achievement. Rizki (2014) stated that Lesson Study could help teachers to make better preparation for their teaching. Research from Sumarti et al. (2015) revealed similar result that lecture model Based on Lesson Study in Chemistry can improve the chemistry teacher candidates' professionalism, primarily in preparing, presenting and being responsible for their work by learning from their learning experience.

This study was carried out to develop teachers' TPACK in Lesson Study and compared the effectivity of two types of lesson, school-based lesson study and biology association lesson study in improving teachers' TPACK. Furthermore, the study also identifies the role of the observer in the lesson study related to teachers' TPACK development.

METHODS

The study used the descriptive method. Gall and Borg (2007) stated that descriptive research aimed to describe the phenomenon and its characteristics. Descriptive analysis is more concerned with what rather than how or why something has happened. In this study, the descriptive method is used to describe the teachers' TPACK development during the activity of lesson study.

Data on teachers' TPACK development was gathered by using the instrument CoRe + technology. The instrument was given to the teacher before the teaching of the topic in the lesson. The data was analyzed by using rubrics developed by Anwar et al. (2014) to determine the category of teachers TPACK. The teachers' TPACK was categorized into three groups: pre, growing, and maturing based on the indicators developed in the rubrics. There were five aspects of learning determined as the focus of the study: 1) learning objective; (2) determining the big ideas; (3) pedagogy; (4) evaluation; and (5) technology.

Lesson study involved the teacher as a model teacher who carried out the teaching and observers who observed the lesson and gave feedback to the experience. There are two types of Lesson Study: school-based lesson study and association based lesson study. School-based lesson study involved teachers who teach various subject, and those teachers are registered as a teacher in one school. Association based research involved a group of teachers who teach a similar issue. That member of teachers in association based Lesson Study comes from a different school in one area/districts where of schools are located.

The schools involved in the study are located in West Java, Indonesia. The school-based lesson study was carried out in one public school located in Bandung included one biology teacher as a teaching model and five other teachers as an observer who teach various subjects (mathematics, Sundanese language, Indonesian, English and Physic). Meanwhile, biology teacher association lesson study was carried out in West Bandung. In this type of lesson study, three teachers become model (we name the as teacher A, teacher B, and teacher C) and nine biology teachers as observers. The lesson study also involved five lecturers from Biology Education Universitas Pendidikan Indonesia as an expert who comes in turn in each cycle of lesson study. The lesson study was carried out in two periods for school-based lesson study for the topics of virus and three periods for biology association based lesson study for the issues of diversity, classification of living things and digestive system. The problems were chosen based on the analysis of curriculum that was running in school and based on the agreement of teachers in the planning stage of Lesson Study. The whole activities of the two type of lesson study take for one semester (6 months) started from January 2018 until July 2018.

We analyze teachers TPACK in 3 learning of school-based lesson study and six learning of biology teachers association. Furthermore, we analyze the role of lesson study to the teachers' TPCK development.

RESULTS AND DISCUSSION

Teachers' TPACK Development in School-Based Lesson Study

The activity of school-based lesson study occurred in three cycles for the topic of virus for a 10th grader. The subtopics covered were: the characteristics of the virus, the role of the virus for the environment, and virus reproduction. Development of teachers' TPACK can be seen in table 1.

Table 1. Teacher's TPACK Development in School-Based Lesson Study

No	Aspect	Indicator	TPACK Category			
			Before the Lesson Study	After Cycle 1	After Cycle 2	After Cycle 3
1	Objective	Identification of the aim	*Pra*	*Growing*	*Growing*	*Growing*
		Learning objective	*Growing*	*Growing*	*Growing*	*Growing*
2	Concept	Big idea	*Growing*	*Growing*	*Growing*	*Growing*
		Content coverage	*Growing*	*Growing*	*Maturing*	*Maturing*
		Identification to the misconception	*Pra*	*Growing*	*Maturing*	*Maturing*
3	Pedagogy	Teaching consideration	*Growing*	*Maturing*	*Maturing*	*Maturing*
		Teaching strategy	*Growing*	*Maturing*	*Maturing*	*Maturing*
		The sequence of the content	*Growing*	*Growing*	*Growing*	*Growing*
4	Technology	The utilization of Technology	*Pra*	*Growing*	*Growing*	*Growing*
		The alternative of the technology	*Pra*	*Maturing*	*Maturing*	*Maturing*
5	Evaluation	Measure students' understanding	*Growing*	*Growing*	*Growing*	*Growing*

Table 1 shows that teachers TPACK develop in several aspects, they are identified the learning objective, the content coverage, identification to the misconception, teaching consideration, teaching strategy, utilization of the technology and the alternative of technology. The development of teachers' TPACK occurred from pra to growing for Identification of the objective and usage of Technology, pra to maturing for identification to the misconception and the alternative of the technology and from developing to evolving for the indicators of content coverage, teaching consideration and teaching strategy.

Three factors have influenced the development of teachers TPACK. They are: (1) as a result of discussion with the expert during the activity of lesson study; (2) as a result of other reflection, the issue raised in the reflection session so that there were some recommendation from the observer; and (3) as a result of self-reflection, teacher realizes that she has to make self-improvement of her teaching. The indicators that developed as a result of discussion with expert were identifying the learning objective and content coverage. These two issues were not raised as an important issue in the reflection, but the model teacher discussed these both issue with the expert (lecturer). The result of the discussion was a teacher could adjust learning objective with the standard of the curriculum as well as determine the breadth and depth of the content. Other development found in the model teacher's TPACK was the identification of misconception. The model teacher's ability for this indicator developed form pra to growing in cycle one and progressed to maturing in cycle two. The development of misconception identification found as the teacher put the action to discuss the misconception in her lesson plan as a result of discussion with the expert. The development of indicator teaching consideration and teaching strategy from growing to maturing were due to other reflection from observers. The model teacher changed her teaching strategy and took comments and suggestions given in the first cycle reflection as a granted to improve her second meeting lesson plan. This made the second teaching, which was more appropriate with the characteristics of the content in the second cycle.

Both indicators identify the aspect of technology; the utilization of technology and the alternative of technology are developed from pra to maturing in the three cycles of lesson study due to self-reflection. Teacher finds herself for the most appropriate technology to be used in teaching the topic of the virus.

Model teacher's TPACK in indicator of learning objective, determining big ideas, the sequence of the teaching and evaluation were not developed because the model teacher considers those aspects already been appropriate for her schooling. Furthermore, those aspects were not raised as an issue in reflection so that there was no recommendation from the observer for the improvement.

Teachers' TPACK Development in Biology Association Based Lesson Study

The development of teacres'TPACK in biology association based Lesson study were observed from three model teachers. The activity of lesson study was carried out in West Bandung Districts involved three schools for the implementation of lesson plans for the topics of diversity, classification of a living thing, and digestive system.

Lesson study for teacher A was carried in two cycles for the topics of diversity. The activity of lesson implementation was carried out in one of Islamic high school located in West Bandung District. The result of the teacher's TPACK development can be seen in Table 2.

Table 2. Development of Teacher A TPACK in Topics of Diversity

No	Aspect	Indicator	TPACK Category		
			Before the Lesson Study	After Cycle 1	After Cycle 2
1	Objective	Identification of the aim	*Growing*	*Growing*	*Maturing*
		Learning objective	*Growing*	*Growing*	*Growing*
2	Concept	Big idea	*Growing*	*Growing*	*Growing*
		Content coverage	*Pra*	*Pra*	*Pra*
		Identification to the misconception	*Pra*	*Pra*	*Pra*
3	Pedagogy	Teaching consideration	*Pra*	*Growing*	*Growing*
		Teaching strategy	*Growing*	*Growing*	*Growing*
		The sequence of the content	*Pra*	*Growing*	*Maturing*
4	Technology	The utilization of Technology	*Growing*	*Growing*	*Growing*
		The alternative of the technology	*Growing*	*Growing*	*Growing*
5.	Evaluation	Measure students' understanding	*Growing*	*Growing*	*Growing*

Table 2 shows teachers' TPACK developed for the indicators: the identification of learning objective, teaching consideration, and sequence of content. These developments occurred as these indicators raised as issues in the reflection. In another word, the development of teacher A TPACK for this indicator is influenced by different reflection and discussion with the expert. As a result, teacher A was able to revise her lesson plan for the next teaching and resulted in more effective teaching. The ability of teacher A in the identification of learning objective developed from growing to maturing. In the second lesson plan, teacher A gives an argument in her CoRe that learning objective was constructed on only because of curriculum consideration, but also should consider students' need. The indicator of the sequence of the content is one of the most developed in teachers TPACK. The development of this indicator occurred from pra to maturing at the end of lesson study was influenced by other reflection. At the observation, the observer raised this issue that made teachers changed the sequence of her content to teach in the next lesson.

The TPACK development of teacher B was analyzed from two cycles of lesson study. The result can be seen in Table 3.

Tabel 3. Development ofTeacher's B TPACK in the Topics Classification of Living Things

No	Aspect	Indicator	TPACK category		
			Before the Lesson Study	After cycle 1	After cycle 2
1	Objective	Identification of the aim	*Maturing*	*Maturing*	*Maturing*
		Learning objective	*Maturing*	*Maturing*	*Maturing*

		Big idea	*Growing*	*Growing*	*Growing*
2	Concept	Content coverage	*Pra*	*Growing*	*Growing*
		Identification to the misconception	*Pra*	*Growing*	*Maturing*
		Teaching consideration	*Pra*	*Growing*	*Maturing*
3	Pedagogy	Teaching strategy	*Growing*	*Growing*	*Growing*
		The sequence of the content	*Maturing*	*Maturing*	*Maturing*
4	Technology	The utilization of Technology	*Growing*	*Growing*	*Growing*
		The alternative of the technology	*Maturing*	*Maturing*	*Maturing*
5.	Evaluation	Measure students' understanding	*Maturing*	*Maturing*	*Maturing*

Table 3 shows that the development of teacher's B TPACK occurred in most of the indicators. The overall progress can be found in indicators of content coverage, misconception identification, teaching strategy, and measuring students' understanding. The development for those indicators of teacher B TPACK due to the other reflection and discussion with the expert. From Table 3 it also can be seen that his TPACK for several signs started from growing and maturing. Educational background of teacher B, who has been graduated from a master degree influences his ability in constructing lesson plan and implement the lesson. Research stated that teacher professionalism is influenced by educational background (Moeini, 2008).

Lesson study for teacher C was carried out in two cycles. The result of teacher C TPACK from *CoRe* analysis can be seen in Table 4.

Table 4. Development of Teacher C TPACK in Topic of Digestive System

No	Aspect	Indicator	TPACK Category		
			Before the Lesson Study	**After Cycle 1**	**After Cycle 2**
1	Objective	Identification of the aim	*Maturing*	*Maturing*	*Maturing*
		Learning objective	*Maturing*	*Maturing*	*Maturing*
2	Concept	Big idea	*Growing*	*Growing*	*Growing*
		Content coverage	*Growing*	*Growing*	*Growing*
		Identification to the misconception	*Growing*	*Maturing*	*Maturing*
		Teaching consideration	*Growing*	*Maturing*	*Maturing*
3	Pedagogy	Teaching strategy	*Growing*	*Growing*	*Growing*
		The sequence of the content	*Growing*	*Maturing*	*Maturing*
4	Technology	The utilization of Technology	*Growing*	*Growing*	*Growing*
		The alternative of the technology	*Growing*	*Growing*	*Maturing*
5.	Evaluation	Measure students' understanding	*Maturing*	*Maturing*	*Maturing*

Table 4 shows that teacher C TPACK developed in indicators of identification to a misconception, teaching consideration, the sequence of content, and technology utilization. This four development was caused by other reflection and discussion with an expert.

Role of Lesson Study in Teachers' TPACK Development

Lesson study is an activity where teachers analyze the teaching-learning process. Lesson study promotes a learning community resulted in

continues teacher improvement (Daryanto & Karim, 2017). The recommendation is given from observer and expert change the model teacher's CoRe to be more developed in the next cycle. This study identifies that issue raised in reflection (see) stage of Lesson study. There were three aspects issues raised in the reflection stage, and they were: pedagogy, content, and technology.

The main issue raised in the reflection stage for both types of lesson study (school-based lesson study and biology association based lesson study) more focused on the pedagogical aspect. In the School-based lesson study, the observers' recommendation related to pedagogy was about the strategy of teaching used in learning virus. The role-playing was considered not appropriate for the topic of the virus as only a few students involved in the role. This recommendation, or known as other reflection, was used by the teacher model to change into discussion strategy for the next lesson plan. In the second and third cycles of school-based lesson study, the teacher model got a positive comment from the observer related to the implementation of her pedagogy. The reflection from the learning showed that teachers were more involved students in her teaching and student more engaged in their learning. The observer commented that the student develops their learning; they actively ask questions and answer the question in their discussion.

Compared with school-based lesson study, the comment from the observer (other reflection) in biology association based lesson study was more varied. The observation was not only put to the aspect of pedagogy but also the element of technology and the content. The use of the application in smartphone, google map, and virtual lab became the issue raised beside the point of pedagogical aspects. In educational elements, the issue raise was also more varied, not only the indicator of teaching strategy but also covered other signs. In short, the difference between school-based lesson study and biology association lesson research was on the observers' comment and recommendation in the reflection stage, which influences the development of teachers' TPACK. In school-based lesson study, the overall advice for three cycles of lesson study was given to the improvement of one indicator of pedagogical aspect; meanwhile, in biology association lesson study, the recommendation was given to more than one indicator for all elements (pedagogy, technology, and content). The different advice occurred because, in school-based lesson study, the observer comes from a separate area of the subject with the model teacher. The observer of the school-based lesson study were teachers who teach the subject of mathematics, physics, and languages so that the teacher does not concern the issue of biology. Whereas in biology association lesson study, the observers are biology teachers, therefore their comment covered all of the aspect of teaching, including the content and technology. Although data show that Biology association based lesson study contributes to more aspect of teachers' TPACK development compared with school-based lesson study, in general, it can be concluded that both of type lesson study can develop teachers' TPACK.

Guiterez (2015) claimed that the idea of lesson study is teachers collaboration from the stage of inquiry to the stage of research on the lesson. The collaborative occurs by using the principle of legality to construct a lesson plan, observe the teaching, and reflect the lesson. The collaboration happened when a teacher creates the lesson plan that gives benefit to enrich teachers' ideas of the lesson and resulted in the improvement of teacher creativity in conducting students' learning. The legality principle applied in lesson study when the teacher does not consider superior or inferior from others. This phenomenon occurs because the observation in lesson study should focus on students' learning, not teachers' teaching so that the teacher does not feel being evaluated by the observer. A study from Rahayu et al. (2012) concluded collaboration in junior high school science teacher association lesson study helps the teacher to improve their ability in constructing lesson plan, students' worksheet, evaluation instrument, and the develop content of teaching. Lesson study help teacher for better implementation of the plan in the teaching-learning process.

According to Koehler et al. (2013), TPACK is an understanding that built from the interaction among content, pedagogy, and technological knowledge. The more varied issue raised in reflection, the more teachers can develop their TPACK. Futhremore Koehler et al. (2013) stated that the aspects of technology and pedagogy are closely related to the understanding of the content knowledge to create effective teaching.

This study suggests that the overall comment from the observer give good impact in improving the learning process in the next cycle. Widodo et al. (2007) stated that participation in Lesson Study gives both observer and teacher observed (model teacher) to learn each other (Jang et al., 2010). The Observer revealed that with seeing ones' teaching, they could provide an ad-

vantage from his/her benefits and shortcomings. This can motivate them to improve her/his skill in teaching.

Data in table 1 to table 4 show that the prior teachers' TPACK ability of teachers' model were varied. Teachers who got involved in biology association based lesson study has better TPACK strength in more indicators comparing within teacher who got engaged in school-based lesson study. Moeni (2008) stated that teachers' background and experience influence teachers' teaching competency. Research of lesson study from Lewis (2002) to prospective biology teacher showed that besides developing students' thinking skill and their ability to practice teaching, lesson study could also build their knowledge to content, learning, ability to observe the process of teaching and learning and improve quality of collaboration in constructing the lesson plan.

The integration of technology in teaching is essential to respond to the 21st era challenge (Pusparini et al., 2017). In improving the quality of teaching, the teacher should not only be able to integrate technology in his/her instructional, so that allow students to be more engaged and take a role in their learning because technology helps the teacher to motivate students' learning — teachers' TPACK influence successful teaching. Srisawasdi (2014) argues that TPACK gives a contribution to the teaching strategy used by the teacher in their teaching. This study suggests that lesson study is a way to develop teachers' TPACK. Lesson study is an activity where the teacher can discuss to construct a better lesson plan that creates active learning. In this activity, teachers can give constructive suggestion to the content, pedagogy, and technology. This finding is in line with Akerson et al. (2017) that lesson study resulted in improving teachers' skill in planning the lesson, creating a positive learning environment, empower the student to learn and assess the student appropriately.

Further, this study suggests that the Biology teacher association based Lesson study give more contribution to teachers' TPACK development. Comment and suggestion from another teacher who teaches similar subject will be more effective as the member of the group understands a related issue or content very well. Therefore they also can suggest the appropriate technology used when they teach specific topics as the aspects of technology and pedagogy are closely related with the understanding to the content knowledge (Mishra & Cain, 2013). Rus'an (2014) strengthens the idea that association teachers based lesson study is the most appropriate activity to develop teachers' professionalism. Lesson study can be used as a discussion forum where teacher collaboratively constructs the planning for the lesson, exchange their knowledge and experience to improve teachers' skill. Purwoko et al. (2017) stated that teachers' collaboration in preparing the lesson enhance the quality of teaching that made the student interested in teachers' performance. The development of teachers' TPACK in this study was due to discussion with the experts (facilitator), self-reflection, and reflection from the observer (other observation). The activity of lesson study builds a partnership between university-based teacher education who act as a facilitator of the learning process (Guiterez, 2015). The action also focuses on drawing a practical lesson from the actual classroom setting that provides promising teachers to develop a culture of reflection (Guiterez, 2015). Self-reflection occurs when teachers review their previous classroom outcomes and use these as information to improve teachers' next instructional practices (Guiterez, 2015). Comment and suggestion from observer act as other reflection that builds a new idea to be taken account to improve the next lesson. Direct experience, explore the impact of teachers' teaching on students' outcome, focusing the relationship between students and teachers in lesson study make teachers have a better plan for their teaching (Brown & Crippen, 2017).

CONCLUSION

The study revealed that there was the development of teachers'TPACK in several indicators in both types of lesson study, school-based lesson study, and biology teacher association based lesson study. The suggestion from the observer in school-based lesson study is more to the aspect of pedagogy that gives effect to the development pedagogical perspective of the teacher. Meanwhile, the opinions and comments from observers in biology teacher association based lesson study were to the aspects of pedagogy, content, and technology. The development of teachers' TPACK was influenced by a discussion with the facilitator from the university (the expert), self-reflection, and other reflection. Biology teacher association based lesson study give more impact on teachers' TPACK development as the model teacher received a varied suggestion from a knowledgeable teacher.

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