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Teaching plant physiology to prospective biology teachers: How do we deal with Lesson Study-Problem based Learning (LS-PBL) to enhance scientific argumentation skill?

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Abstract

Argumentation has been widely discussed in science education for many years. Argumentation is a part of science, to make a statement and claim, justifying the claim, and supporting it with the data. Science education need to be integrated with scientific argumentation empowerment. LS-PBL can be one way to empower argumentation skills. The aims of this study is to determing prospective biology teachers' science argumentation skill through Lesson Study-Problem based Learning (LS-PBL). This research was conducted on 30 prospective biology teachers at Biology Department Universitas Negeri Malang. Research participants are prospective biology teachers who are taking Plant Physiology course during their 3rd semester. The learning implementation was carried out in a blended learning. Lesson study activities carried out consist of three activities, namely, plan, do, and see. The instruments used are essay tests of scientific argumentation skills, chapter design, lesson design, lesson plans, and worksheets. Data analysis used quantitative descriptive analysis. The results showed the average value of the argumentation obtained in the first week was 45.33 (moderate), the second week was 50.00 (moderate), and the third week was 56.00 (moderate). The percentage of the frequency of each level of scientific argumentation decreased with each test at levels 1 and 2, while levels 3 and 4 increased. However, there is no level 5 argumentation found in tests 1, 2, and 3. An increase in argumentation skills can occur due to the application of PBL which is integrated with LS. The PBL learning model accommodates prospective biology teachers to construct their arguments, while lesson study is useful for improving the learning process so that learning activities increase from week to week and what is lacking can be improved. LS-PBL can be used as a professional tool to improve the learning process and empower argumentation skills.

Keywords: Lesson Study, Problem-based Learning, Plant Physiology, Scientific Argumentation.

Introduction

Today's science education focuses on preparing future citizens to be critical consumers of scientific knowledge rather than merely recipients of scientific facts (Mkimbili, 2019). Teaching biology concept i.e plant physiology to the prospective biology teacher not only make them understand the concepts of plant physiology itself, but also provide examples of how to teach the material well. The learning approach focuses not only on "what concepts did you learn" but also "what examples did you get in the learning process today". Learning that is integrated with the empowerment of 21st century skills also provided the opportunity for prospective teacher students to understand and master 21st century skills, which will then be taught to their students. Thus, the learning process carried out provides two benefits at the same time, i.e teaching concepts and training student teacher candidates to teach 21st century skills. Science/biology education has been regulated in the education curriculum in Indonesia, including higher education, secondary education, and elementary education. Science/biology emphasizes process skills (Maison et al., 2020), meaningful learning (Martínez et al., 2017; Mkimbili, 2019), contextual (Haryanto & Arty, 2019; Situmorang et al., 2019; Suryawati & Osman, 2018), and constructivist (Cakir, 2008; Josi & Patankar, 2016; Tuerah, 2019). The learning activities carried out are expected to be able to build new concepts. The new concept can be the new

one or replacing the old concepts. Furthermore, teaching and learning in 21st century should be engage and promote students' 21st century skill such as science argumentation (Clark et al., 2010; Kundariati et al., 2021; Noviyanti et al., 2019).

Argumentation as a reasoning process has been defined by Toulmin, Rieke, & Janik (1984) (Toulmin et al., 1984) commonly known as Toulmins' Argument Pattern (TAP). TAP illustrates the nature of an argument in terms of claims, data, warrants, backings, and rebuttals (Erduran et al., 2004). The Toulmin present study consists of six elements of argumentation. Argumentation centers on a claim, a position being taken, and evidence or grounds that support the claim. Toulmin refers to the link between the evidence and the claim as a warrant. The type and quality of the reasoning involved in the chain of reasoning are referred to as backing. An argument consists of a rebuttal that identifies exceptions to the claim or presents counter-arguments (Frey et al., 2015). Argumentation skill has 5 levels, which have their categories and tiers at each level. Level 5 is the higher level of argumentation and level 1 is the lowest level of argumentation (Cetin et al., 2014). Student's argumentation skills are still low and need to be developed (Maghfiroh et al., 2019; Purwati et al., 2019; Putri & Rusdiana, 2017).

One of the learning models which can promote argumentation skill is Problem-based Learning (PBL). This learning model has the ability to train students in finding their own concepts based on real problems from life with inquiry skills (Nur et al., 2016). PBL encourages students to know how to learn and work together in groups to find solutions to real-world problems (Akçay, 2009). The advantage of PBL is that it can improve students' ability to think of various strategies in learning new topics and finding solutions to problems at hand, so that these processes are able to create a meaningful learning environment (EL-Shaer & Gaber, 2014). Problem-based Learning (PBL) should be explicitly introduced to students through the school curriculum with the aim of empowering other 21st century skills and innovations in the field of education. In addition, improving the quality of the learning process and output can be pursued by applying lesson study.

Together with PBL, Lesson Study can be alternative way to fix the learning problem and enhance learning quality. The LS concept is a model for fostering the teaching profession through collaborative and sustainable learning assessments based on collegial principles and mutual learning to build a learning community to improve teacher professionalism (Savitri et al., 2019). There are three stages in the LS, namely plan (planning), do (implementation), and see (reflection) (Susilo, 2013). Lesson study provides an opportunity for teachers to reflect on their long-held beliefs and begin to form new types of beliefs related to creating a meaningful learning atmosphere (Inprasitha & Changsri, 2014). Lesson study is an area where teachers and supervisors can learn through collaborative work. Supervisors can share their knowledge from the theories in the career field while teachers gain knowledge from participating in their activities throughout the lesson study process. When the two work together, they can share knowledge and experiences. Research findings support the way supervisors and interns can work collaboratively. The structure and collaborative work according to the lesson study process can create a system in transferring all experiences to develop the quality of new teachers and supervisors in the project (Inprasitha & Changsri, 2014). Lesson study should be used wisely, as part of a whole-school approach to improving classroom practice. Lesson study has the potential to promote focused improvement in teaching and learning and consequent improvement in student outcomes (Ngang & Sam, 2015).

Method

Setting and Participants

Our study was conducted with participating prospective biology teachers in Biology Department, Universitas Negeri Malang. Thirty prospective biology teachers were agree to be participant in this study. The participants in this study were prospective biology teacher offering C students, who had taken Plant Physiology course during their third semester in the 2021/2022 academic year. The research was conducted for 3 weeks to study the material of cellular respiration, photoassimilates translocation, and phytohormones. The learning process is carried out in a blended learning manner, with some prospective biology teacher students participating online and others offline.

Data Sources and Analysis

A set of essay test of argumentation skills related to the topics of cellular respiration, photoassimilates translocation, and phytohormones. Argumentation assessment was follow Toulmin Argumentation Pattern (Toulmin, 1958) and it's level was determined using argumentation levels' rubric developed by Erduran et al. (2004). The quality of students' argumentation was measured using a rubric developed by (Robertshaw & Campbell, 2013) (Table 1). Meanwhile, the instruments used in Lesson Study-PBL to enhance argumentation skills including chapter design, lesson design, lesson plan, and student worksheet. The validity

of instruments were determined by conducting expert appraisal consisted of the instructional and technical review.

Table 1. Mastery Level Determination of Argumentation

Mean Score (%)	Mastery Level
80.00–100.00	Excellent
60.00–79.99	Good
40.00–59.99	Moderate
20.00–39.99	Weak
0.00–19.99	Very weak

Results and Discussion

The results of this study are in the form of record during the plan, do, and see activities in lesson study and a summary of argumentation skills improvement.

Lesson Study-Problem based Learning as A Professional Development Program

We conducted the professional development program over six weeks and within one week there are two meetings. Argumentation instruction was explicitly implemented during the professional development program via the direct teaching of various aspects of argumentation including instruction pertaining to the various definitions, structure, function, and application of arguments, and the criteria used to assess the validity of arguments. Agenda membelajarkan argumentasi ilmiah pada prospective biology teacher dijabarkan pada Tabel 2.

Table 2. Science Argumentation Lesson on Plant Physiology

Session Title	Summary
Pre-intervention Argument lesson	Introduced participants to what an argumentation-based lesson might look like.
Week 1 Constructing argument into oral and written lesson ***(do)***	Constructing argumentation through answering questions and fulfilling the worksheet. The worksheet asks prospective biology teachers to answer following science argumentation pattern which consist of claim, ground, warrant, backing, and rebuttal.
Week 2 Evaluating science argument	Ask questions about the topic of photoasimilates translocation. *"Does it right if, root (tuber) Beta vulgaris subsp. maritime is a sink and also a source"*
Week 3 Constructing argument into oral and written lesson ***(do)***	Constructing argumentation through answering questions and fulfilling the worksheet. The worksheet asks prospective biology teachers to answer following science argumentation pattern which consist of claim, ground, warrant, backing, and rebuttal
Week 4 Evaluating science argument	Ask questions about the topic of cellular respiration. *"Why sitting under a tree at night can interfere with breathing".*
Week 5 Constructing argument into oral and written lesson ***(do)***	Constructing argumentation through answering questions and fulfilling the worksheet. The worksheet asks prospective biology teachers to answer following science argumentation pattern which consist of claim, ground, warrant, backing, and rebuttal.
Week 6 Evaluating science argument	Asking questions about the topic of cellular respiration. "*A child tries to ripen a mango fruit by squeezing it together with ripe bananas in one place. A few days later the mangoes ripen perfectly. The child tried again by squeezing the strawberries with ripe bananas, but the strawberries did not ripen*".

Plan was carried out before learning implementation. In this step, lecturer discussing the learning model, strategies, and methods which will be implemented for the next week, with the lesson study team

who consists of 4 people. This step require lecture to determine the essential and nonessential materials to developing the chapter design, lesson designs, and preparing implementation of learning (Kundariati et al., 2019). The do step was carried out by learning activity in the classroom. The learning process was guided by lesson design and lesson plan which had been designed. Student activities are observed by observer which helps during the process learning. This step includes two activities, namely the implementation of learning and observation activities or observations made by members lesson study (Almujab et al., 2018). And the last phase, see (evaluation), aims to review or evaluate activities learning carried out by lecturers. The see process is expected to be input and improvement for activities further learning. The evaluation was done by discussing the entire lesson study team guided by moderator (Almujab et al., 2018). This phase begins with explanation of self-reflection from the lecturer and continued reflection by observers. Solution of the problem during the learning process later considered in the activity plan next (Kundariati et al., 2019). Learning activities are carried out by applying a problem-based learning model. Prospective biology teacher is given real problems related to plant physiology concepts. Lesson Study which integrated with the Problem-based Learning (LS-PBL) pattern can be illustrated in Figure 1.

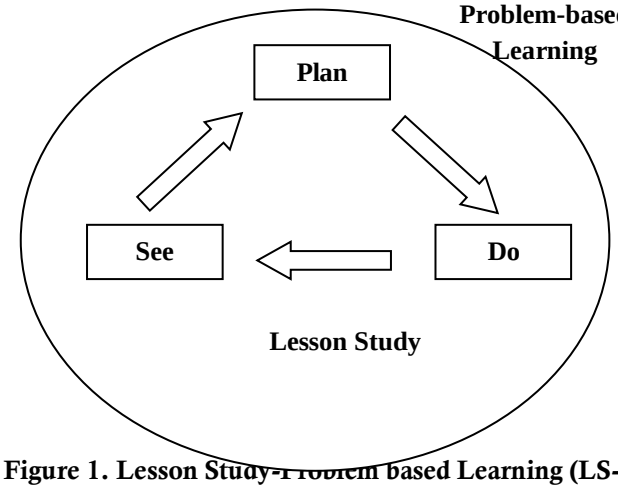


Figure 1. Lesson Study-Problem based Learning (LS-PBL)

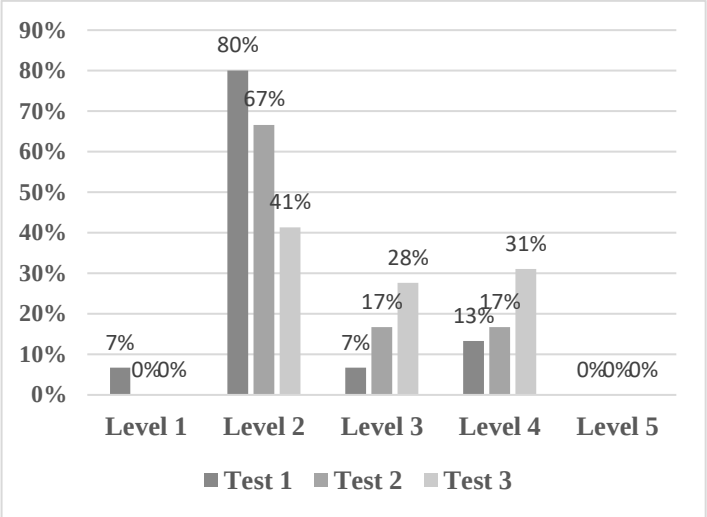
Views of Scientific Argumentation

Step see in the first week found that students still raise a lot of questions instead of problem formulation, so that in the following week the lecturer provides alternative problem formulations for students to solve. This alternative is then continued for the following week. The results of observations of empowered 21st century skills, namely scientific argumentation, showed that students were still compiling level 2 arguments in, so that evaluations were carried out continuously and emphasized how to cunstruct arguments involving the rebuttal component. Evaluation and empowerment of argumentation skills is carried out throughout the lesson. Argumentation skills are empowered through students' worksheets and verbal arguments through open-ended-questions. Another see steps' result is to pay more attention to the phenomena that are used as learning orientations so that there are no wrong concepts. The results of this view are then used as improvements for further learning. Furthremore, the mean score of argumentation skills in each cycle is presented in Table 3.

Table 3. Student Argumentation Skill Score

	Cycle 1	Cycle 2	Cycle 3
Score	45.33	50.00	56.00
Description	Moderate	Moderate	Moderate

A summary of the achievement of the argumentation skills of prospective biology teacher students is presented in Figure 2.



The average value of argumentation obtained in the first week was 45.33 (moderate), the second week was 50.00 (moderate), and the third week was 56.00 (moderate). This result indicates that problem-based learning that is applied using lesson study can improve the argumentation skills of prospective biology teachers. A percentage of 7% was obtained on test 1 and in the next test there was no level 1 argument. The level 1 argument contained a sentence in the form of a simple claim. Level 2 arguments in test 1 obtained a percentage of 80%, decreased to 67% in test 2, and decreased to 41% in test 3. The arguments consist of claims that are supported by ground/data and support/warrant but have no rebuttal/rebuttal. Level 3 argumentation on test one is 7%, increased by 17% on test 2, and increased by 28% on test 3. Arguments consist of several claims with data, warrants and backing with weak rebuttals. Level 4 argumentation on test 1 is 13%, increased by 17% on test 2, and increased by 31% on test 3. Arguments consist of several claims with data, several warrants and backing, with strong rebuttals. However, level 5 arguments have not been found. Level 5 arguments are long sentences consisting of several claims, ground, warrant, backing, and rebuttal. Students are only able to give one form of rebuttal with rebuttal support. Meanwhile, to arrange a lot of student rebuttal is still difficult. This rebuttal component is the most difficult component to empower, because everyone generally uses a claim-justification pattern or asks questions and provides support and evidence for the statement, without having to refute the statement given. An example is the claim regarding "Fruits ripen because it is induced by ethylene gas (claim). Ethylene is an unsaturated hydrocarbon compound which is a gas at room temperature, produced by fruits and vegetables during the ripening process and can accelerate the ripening process (ground). Ethylene regulates fruit development and ripening by influencing the color, texture, nutritional quality, and aroma of the fruit (warrant). Ethylene gas reduces chlorophyll, but increases levels of carotenoids, anthocyanins, sugars and backing organic compounds. Based on the example argument, it can be seen that the focus of the sentence is to support the claim that the fruit ripens because it is induced by ethylene gas.

Rebuttal or rebuttal, namely the argument against a claim, reason, and warrant. A disclaimer is also called a counter-claim or a refutation of a claim (Alindra & Ana, 2018). The arguments that arise are still on one, two, three, and four. Level 3 and 4 arguments are still very rare, which means that students have not been able to bring up a strong rebuttal. This is in line with the findings (Chang & Chiu, 2008; Foong & Daniel, 2013; Lin & Mintzes, 2010; Ryu & Sandoval, 2012; Simonneaux & Simonneaux, 2009; Topcu et al., 2010) which state that the component of refutation in the argument is the component the most difficult to empower despite intervention.

Scientific argumentation skills are improved by applying problem-based learning. Problem-based learning is a pedagogical approach that allows students to learn while being actively involved with problems (Yew & Goh, 2016). Problem-based learning requires students to be more active in the learning process because students do not only rely on educators as a source of information but also take advantage of other learning resources. Learning with the PBL model begins with a problem, students identify, learn, apply and generate problems from learning (Woods, 1994). Several studies have shown that problem-based learning can effectively facilitate students' argumentation skills (Brown et al., 2016; Pratiwi et al., 2019). Argumentation skills can be empowered through the provision of problems that are used as triggers in the Problem Based Learning syntax (Fang et al., 2018; Pritasari et al., 2015; Tawfik, 2017). PBL has a positive

effect on empowering argumentation skills because of its strength. Some of the advantages of PBL include learning based on problem solving processes in real situations, students build their knowledge through learning activities, focus on problems, scientific activities occur through group work, using knowledge sources, both from the library, internet, interviews, and so on. observation can assess their learning progress, can carry out scientific communication in discussion activities or presentation of their work, students' individual learning difficulties can be overcome through group work in the form of peer teaching (Shoimin, 2016).

PBL syntax learning steps that can empower students' argumentation skills include student orientation activities on problems. This activity supports the construction of claims. This is in line with the statement Pritasari et al. (2015), which states that claims are statements that arise at the stage of meeting problems and analyzing problems and learning problems. In the problem meeting phase, claims emerged to start the learning process. The next learning step that supports the empowerment of argumentation skills is group investigation. Learning activities at this stage focus students on investigating the problems they posed in the previous step. Investigation activities support the construction of ground, warrant, backing, and qualifier. Arguments contain three aspects which include claims, evidence, and reasoning (Lockl & Schneider, 2007). A claim is an intended statement. Evidence is scientific data to support a statement. Reasoning is a reason or justification for connecting a statement with evidence. So that the data obtained at the investigation stage can be used to support claims in the form of evidence and reasoning.

In addition, group activities provide opportunities for students to discuss so that they can develop better arguments. This is in line with research conducted by Heng et al. (2014), which states that the argumentation of students in groups shows a higher level than individuals. Heng further said that an emphasis on group learning is needed to improve students' mastery of scientific argumentation, which also improves students' reasoning abilities and scientific knowledge. The difference in the level of argumentation of students who study with groups and individuals shows that group activities foster students' scientific arguments and improve performance. Students involved in group arguments share ideas, detect and correct others' mistakes, explain ideas and listen to other people's explanations. This process results in a deeper understanding of the concepts being studied and further improves argumentation skills. Furthermore, invitations and rebuttals in groups allow students to be aware of their weaknesses and their arguments (Foong & Daniel, 2013). Another study which states that argumentation in groups is higher than that of individuals has also been carried out by Erduran et al. (2005); McNeill & Martin (2011); Schwarz et al., (2003).

Conclusion

Science argument value obtained in the first test was 45.33 (moderate), the second test was 50.00 (moderate), and the third test was 56.00 (moderate). This result indicates that problem-based learning that is applied using lesson study can improve the argumentation skills of prospective biology teachers. There was a percentage of 7% on test 1 and on the next test there was no level 1 argument. Argument level 2 on test 1 obtained a percentage of 80%, decreased to 67% on test 2, and decreased to 41% on test 3. Argument level 3 on test one by 7%, an increase of 17% on test 2, and an increase of 28% on test 3. Argument level 4 on test 1 by 13%, an increase of 17% on test 2, and an increase of 31% on test 3 However, level 5 arguments have not been found. Level 5 arguments are long sentences consisting of several claims, ground, warrant, backing, and rebuttal. The increase in argumentation skills can occur because of the application of PBL which is integrated with the LS. The PBL learning model accommodates prospective biology teachers to construct their arguments, while lesson study is useful for improving the learning process so that learning activities increase from week to week and what is lacking can be improved. LS-PBL can be used as a professional tool to improve the learning process and empower argumentation skills. The suggestion for further research is to apply LS-PBL in science/biology learning to empower other 21st century skills.

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