ISSN: 2311-1550

Journal of Learning for Development – JL4D

2021, Vol. 8, No. 3, pp. 532-540

Implementation of Problem Based Learning to Increase Scientific Explanation Skill in Biology Learning about the Environment

Monika Lintang Laksmi[1], Dewi Puspita Sari[1], Yudi Rinanto[1] and Raden Rara Sapartini[2]

[1]*Sebelas Maret University, Indonesia*

[2]*One Senior High School, Surakarta, Indonesia*

Abstract: This research aimed to describe and find out whether implementation of Problem-Based Learning can improve scientific explanation skills in biology learning about the environment. The research method was Classroom Action Research through the implementation of Problem-Based Learning. This classroom action research consisted of two cycles, which were concluded by planning, acting, observing and reflecting. The research subject was a natural science class consisting of 34 students. Data were collected by essay test, observation method, interviews and documentation. Data were validated by the triangulation technique consisting of three components: data reduction, data presentation and conclusion. The research results showed improvement in the scientific explanation skills of students on the implementation of Problem Based Learning. The percentage improvement of students' scientific explanation was 61% in claim, 53% in evidence, and 51% in reasoning.

Keywords: Problem Based Learning, scientific explanation, Classroom Action Research, biology education.

Introduction

Education is everyone's learning experience for survival. Education in the school environment occurs because of interactions between the commissions in the school consisting of students, teachers, school officials, and parents or guardians (Astuti, 2017). Interactions in the classroom occur between teachers and students. Interaction activities between teachers and students that occur reciprocally for educational purposes can also be called the learning process. The learning process that students go through involves cognitive, affective, and psychomotor abilities (Putri & Hamid, 2016).

An initial observation that has been done by researchers in One Senior High School in Surakarta during the learning process showed that 52.9% of students chatted with their friends, 20.6% of students played on cellphones, 47% of students responded to teacher questions with simple answers, 17.6% of students responded to questions demanding a lengthy explanation of the process or reason for the phenomenon and 35.4% of the students did not respond to teacher questions, thus, many students do not respond to the ongoing learning process. Minimal student response in the learning process results in low student understanding (Fauziah, 2010), and, therefore, influences students' answers about explanations of a phenomenon (Rohwer & Rice, 2015). Explanation of the reason or cause of a phenomenon is an activity in preparing a scientific explanation (Berland & Reiser, 2008), and the ability of students to provide scientific explanations is less than ideal in most contexts.

An explanation by students is often called a scientific explanation in the learning process (Nasir & Nur, 2018). A scientific explanation has three components: claim, evidence and reasoning (Osborne & Patterson, 2011). Scientific explanation describes the product of science in the form of a scientific explanation of the process, cause and reason for the occurrence of a phenomenon (McNeill & Krajcik, 2009). The link between claim, evidence and reasoning is used to assess students' understanding, so an assessment in the form of rubrics is required to evaluate students' scientific explanation skills.

Based on the results of initial observations that have been made by researchers about students' scientific explanation skills of students at One Senior High School Surakarta in a conventional learning model, 65.4% of students were not able to make claims, 80.1% of students did not have evidence, and 83.09% of students were not able to connect claims and evidence into reasoning. The follow-up observation concluded that the scientific explanation ability of students was less than optimal. Scientific explanation skills are acquired within a learning process that actively engages students. Student activity is demonstrated through collaborative activities and analysis through scientific investigation (Hmelo-Silver, 2004). Therefore, scientific investigations produce answers in the form of scientific explanations. The scientific explanation requires unstructured problems to get many solutions to the same problem (Noer, 2011). Learning models that accommodate unstructured problem solving use Problem-Based Learning approaches (Chin & Chia, 2006). A Problem-Based Learning model typically has five stages, namely: (1) meeting the problem, (2) problem analysis and learning issues, (3) discovery and reporting, (4) solution presentation and reflection and (5) overview, integration and evaluation (Tan, 2003).

The stages of a Problem-Based Learning model, therefore, accommodate the development of students' scientific explanation skills. The ‘meeting the problem’ stage allows students to understand the existing problem so that various questions can arise at this stage. The problems stimulate students to make preliminary explanations as the initial stage in developing scientific reasoning. The ‘problem analysis and learning issues’ stage is a phase for students doing problem analysis. This stage provokes students to come up with a claim in the form of a solution to answer questions at the meeting of the problem stage (Kumala et al, 2017). The third stage is ‘discovery and reporting’, and students are tasked with collecting data to prepare a solution. This stage enables students to find evidence in scientific explanation skills (Faizah et al, 2018). Another scientific explanation component that is accommodated through the discovery and reporting stage is the reasoning component. Group discussions at the discovery and reporting stage train students to develop reasoning appropriately by linking claims and evidence (Alozie et al, 2010). The next stage of solution ‘presentation and reflection’ is presenting solutions that have been prepared and reflected upon. Problem solutions provided need to address the data that has been collected. This stage enables students to reflect on the solutions that have been made to connect claims and evidence to the best reasoning (Drăghicescu et al, 2014).

Based on the results of the background description, researchers formulated the following problem: "Can problem-based learning improve scientific explanation skills in environmental materials for One Surakarta High School students?" Following the problem formulation, the study explored whether there was improvement of students' scientific explanation skills after using Problem-Based Learning.

Methods

Research Methodology

The research adopted Class Action Research methodology.

Population and Sample

The research was conducted at One Senior High School Surakarta, located at Monginsidi Street No. 40 Surakarta. The subjects in this study were in a natural-science-class, which comprised 34 students. The class selection was based on students' lack of ability to convey scientific explanations judging by the observation results.

Data Collection and Analysis

The data collected during the study represented the achievement of students' scientific explanation skills, observations, interviews with teachers and students and documentation of activities. Data collection was done using test and non-test techniques. Data validity tests were conducted using triangulation techniques. The data obtained was rated using a Likert scale for each scientific explanation indicator. Data analysis was completed in three stages: data reduction, data presentation and conclusion drawing. Indicators of success in the study are characterised by changes in the improved scientific explanation of students.

Result and Discussion

Result

Students' scientific explanation skills were analysed in each cycle. The analysis of students' scientific explanation ability was assessed from each component of the scientific explanation. The results of the analysis showed changes, improvement, and decreases at each stage of the action cycle. The achievement of the students' scientific explanations score at the pre-cycle stage shows that students, in drafting scientific explanations, had relatively low skills which need to be improved. Actions can be taken to accommodate the ability to develop student scientific explanation by applying a learning model that involves students actively participating in the learning process. Experts believe that scientific explanations can be developed through learning involving active student participation (Aguiar, 2016). Problem-Based Learning involves students directly investigating the veracity of an unstructured problem to provide some resolution, and it is aligned to support training to develop students' scientific explanation skills (Berland & Reiser, 2008). Scientific explanation skills consist of three components: claim, evidence and reasoning. The discussion of the results of the study will discuss one by one the three components.

Claim

A claim is an idea, opinion or hypothesis about an event (Kaya, Erduran & Cetin, 2012). A claim must describe what happened or identify the causative factors of an event (Novak, Mcneill &Krajcik, 2009). A claim is the easiest component to disclose. Claims are made to be the basis of other components (Amielia, Suciati & Maridi, 2017). The results of the increase in claim components in this study can be seen in Figure 1, as follows.

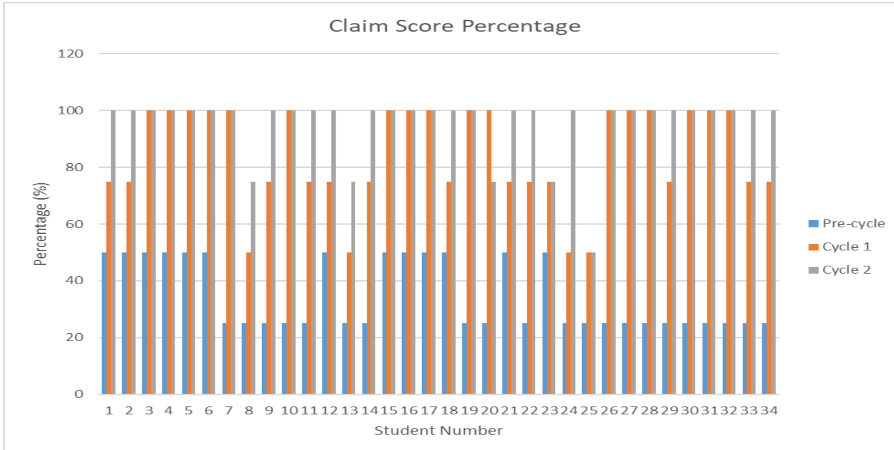

Figure 1: Claim score percentage

Figure 1 indicates the percentage of students' scores in the claim component from the pre-cycle to cycle 2. The highest claim component score increased from pre-cycle action to cycle 1 action by 75%. The increase in the percentage of claim scores indicated in Figure 1 also occurs in cycles 1 to 2. Most students obtained the highest increase of 50% from cycle 1 to cycle 2.

The average percentage of claim component scores in the pre-cycle stage to cycle 1 increased by 50%, while cycle 1 to cycle 2 increased by 11%. The percentage of the claim component score of each student mostly increased across the cycles. But a decrease in the percentage of claim scores was observed in one student from cycle 1 to cycle 2. One student who experienced a decrease in claim scores was the student number 20. The decrease in student claim scores was due to the lack of understanding concepts about environmental change materials, and student number 20 entered the class 40 minutes late, hence, did not follow the learning stage of meeting the problem and problem analysis of the learning issues. Meeting the problem and problem analysis stages both play a role in forming a scientific understanding of students in order to compose the initial claim.

Evidence

The next stage of Problem-Based Learning is discovery and reporting, where students act as researchers who are tasked to collect data and information in developing solutions. Students collect data used as evidence relating to the causes and impacts of environmental damage in a particular area in cycle 1 and environmental conservation efforts through recycling of contaminants in cycle 2. The evidence obtained by students comes from tracing information through learning resources and conducting direct investigations in the field.

The evidence obtained during the investigation process was written in a worksheet. Data collection activities or evidence in the form of facts about an event enable students to compile evidence components on scientific explanation capabilities (Faizah et al, 2018). The results of the increase in evidence components in this study can be seen in Figure 2, as follows.

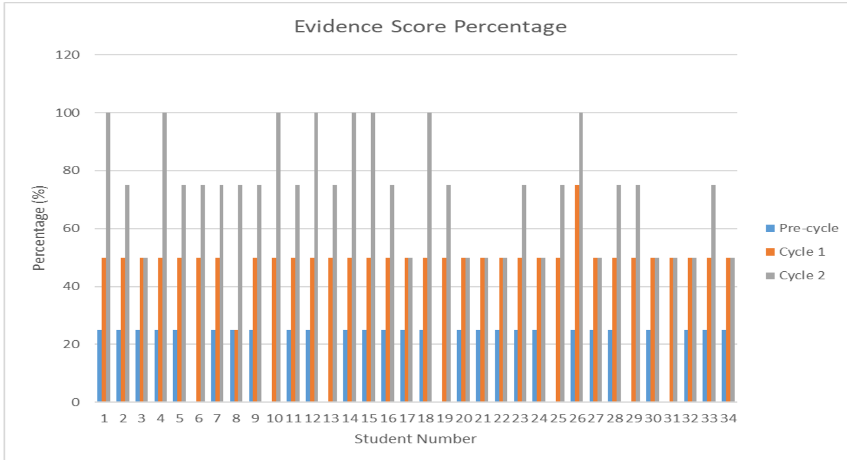

Figure 2: Evidence score percentage

Figure 2. indicates the percentage gain of the students' scores on the evidence component of the pre-cycle stage, the first cycle, and the second cycle. The highest evidence score increase from the pre-cycle to cycle 1 was obtained by student number 26, with 50%. Some students did not experience an increase, with a fixed score percentage of 25% obtained by student number 8. The increase in score was also experienced from cycle 1 to cycle 2, the most significant increase being 50%.

In the pre-cycle stage, seven students (6, 10, 13, 19, 25, 29 and 31) received a percentage of evidence score of 0%. These students are judged incapable of disclosing evidence according to reading. The evidence mentioned by students at the pre-cycle stage was not present in the reading and did not corroborate the statements that had been made before.

The average percentage of evidence component scores in the pre-cycle to cycle 1 stage increased by 30%, while cycle 1 to cycle 2 increased by 23%. The percentage of the score of the evidence component of each student increased across the cycles. The evidence component had a lower score percentage than the claim component, implying that most students had difficulties determining the evidence that corresponds to an event. The low percentage of evidence scores compared to claims was due to students' weak mastery of the concept. Incorrect data or information can be acquired by students who are weak in the mastery of concepts. Low understanding of concepts confused students in the data collection process of searching for evidence (McNeill & Krajcik, 2009).

The increase in grades from cycle 1 to cycle 2 was due to teachers' guidance at the discovery and reporting stage. Teachers ask students to look for evidence from valid, accountable sources. If possible, the teacher asks students to see the evidence they have previously obtained from various sources. Some groups got evidence from the students' direct observations. Students who are used to finding and compiling evidence from valid sources can improve their concept understanding skills. High student concept understanding skills facilitates students' gathering evidence (McNeill & Krajcik, 2009). The percentage of evidence scores in cycle 2 was shown to increase compared to cycle 1, which indicates that guidance by teachers can actively build students' skills in solving problems and assist students in improving reasoning activities and understanding of scientific concepts (Smyrnaiou et al, 2012). Thus, students find it easier to compile evidence that can support their claims.

Reasoning

In addition to accommodating students to find evidence, the discovery and reporting phase can accommodate students to develop sound reasoning. Group discussions at the discovery and reporting stage train students to develop reasoning appropriately by linking claims and evidence (Alozie et al, 2010).

The solution presentation and reflection stage is the stage for students to make presentations about their solutions and reflect. Problem solutions provided by each group need to address the facts and information that have been collected. Students discuss to develop reasoning that can relate each piece of evidence to the student's statement. At this stage, students play a role in connecting the information data obtained into a solution according to each group's idea (Drăghicescu et al, 2014).

The solution presentation and reflection learning phase can accommodate students to bring up the reasoning component in compiling scientific explanations. The solution to the student's problem that is finally found can change from the formulation of the solution or the initial statement that the student made as a hypothesis, therefore, at this stage, the students must re-correct the initial claim that they have made. The results of the increase in reasoning components in this study can be seen in Figure 3, as follows.

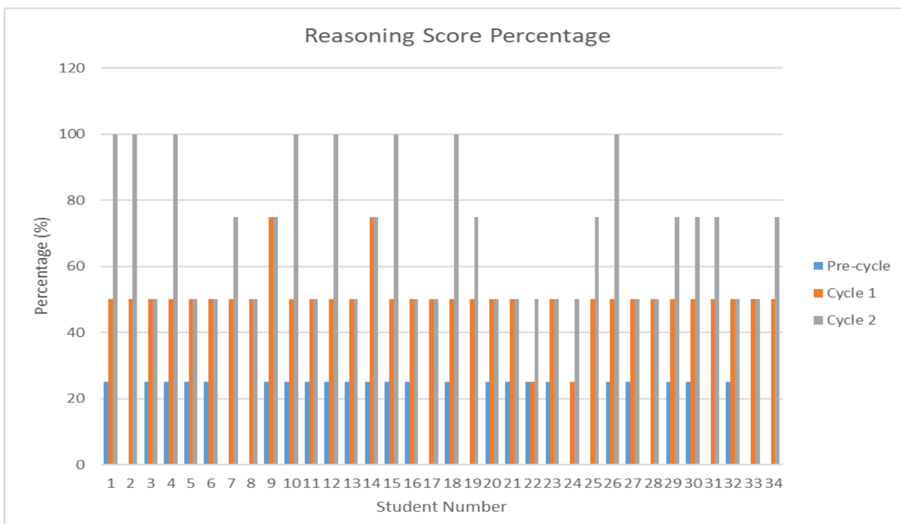

Figure 3: Reasoning score percentage

Figure 3 indicates the percentage gain of the reasoning component score of each cycle from the pre-cycle to the 2nd cycle stage. The highest increase in reasoning scores (50%) increases in the pre-cycle to cycle 1. Some students did not experience an increase in the pre-cycle stage to cycle stage 1, namely, student number 22, with a score percentage of 25%.

At the pre-cycle stage, 11 students (2, 7, 8, 17, 19, 24, 25, 28, 31, 33 and 34) could not write down reasons to corroborate the statements and evidence that they had made. Eleven students had a reasoning component score percentage of 0%. This is because the learning model used at the pre-cycle stage did not enable students to make excuses to corroborate their statements.

The average percentage of reasoning component scores in the pre-cycle stage to cycle 1 increased by 33%, while in cycle 1 to cycle 2 it increased by 18%. Each student's reasoning component score percentage improved across the cycles. Some students obtain a constant percentage of reasoning scores from the pre-cycle stage to cycle 1. The constant increase in the percentage of reasoning scores obtained by student number 2 increased by 50% in each cycle, and students numbered 24, 29 and 30 increased by 25%. The percentage of reasoning scores that did not improve was due to students having difficulties linking supporting evidence to statements that were made before. The process of linking supporting evidence with claims requires understanding the concept. Low understanding of concepts by students leads to supporting evidence with claims not following scientific principles (Hsu et al, 2015).

The corrective action for cycle 2 is that teachers should assist students in actively helping them improve reasoning activities and understanding of scientific concepts. Teachers should guide students to listen and pay attention when other groups give presentations on how to solve a problem. Teachers should provide students with several opportunities to ask questions and argue and give feedback when students finish presenting results, asking questions or making remarks. Corrective action in cycle 2 can increase the percentage of evidence scores from cycle 1 to cycle 2. Thus, the improvement provided by the teacher can improve the student's understanding of the concept so that students can connect supporting evidence with claims following scientific principles.

The increase in the percentage of evidence scores in cycle 2 is directly proportional to the increase in reasoning scores in cycle 2. The improvement of the two components of scientific explanation is directly proportional to the statement that the completeness of the evidence owned by students influences the preparation of reasoning to reinforce the statements that have previously been made (Supeno et al, 2017).

Discussion

The student's scientific explanation skill score increases from each cycle because students compose claims, evidence and reasoning during the learning process. The written evaluation test given at the end of the cycle directs students to compile scientific explanations. Improved scientific explanation skills can occur when students must explain claims, evidence and reasoning in writing (McNeill, 2010). The high percentage of scientific explanation component scores shows that students have compiled claims, submitted appropriate evidence and supported claims, and could develop reasons for the relationship between claim and evidence in explaining a phenomenon (Yao et al, 2016).

The percentage score of the scientific explanation claim component had a higher average than the evidence and reasoning components. The low percentage of scientific explanation component scores indicates that students had difficulty in compiling scientific explanations. Students' problems in compiling scientific explanations was due to basic knowledge and understanding of concepts (Yao et al, 2016). Students' difficulty in compiling scientific explanations occurred when students were required to provide evidence that matched the initial statement. Inappropriate evidence resulted in errors in the preparation of reasons. Reasoning prepared by students should connect claims and evidence so that the student's explanation can be accepted. Scientific principles and correct concepts are needed for students to develop scientific explanations to connect supporting evidence and statements that give rise to the reason for an event (Hsu et al, 2015).

The stages of the Problem-Based Learning model can enable students to develop claims, source evidence and demonstrate reasoning. The problem meeting stage enables students to provide preliminary ideas as the initial stage of compiling scientific explanation. The problem analysis and learning issues stage enables students to bring up claims. The third stage is discovery and reporting to acclimate students to find evidence and discuss reasoning. The solution presentation and reflection stage enables students to reflect on the reasoning that has been made.

Conclusion

Based on the research results, Problem-Based Learning can improve students' scientific explanation skills in biological materials about the environment. The syntax of Problem-Based Learning accommodates improved scientific explanation skills used gradually in three cycles (pre-cycle, cycle 1, and cycle 2). The percentage of scores of the three scientific explanation components increased from the pre-cycle stage to cycle stage 2, the increase in the score of the claim component was 61%, the evidence component 53% and the reasoning component 51%.

References

Aguiar, O. G. (2016). Explanation, argumentation and dialogic interactions in science classrooms. *Cultural Studies of Science Education*, *11*(4), 869-878. https://doi.org/10.1007/s11422-015-9694-4

Alozie, N. M., Moje, E. B., & Krajcik, J. S. (2010). An analysis of the supports and constraints for scientific discussion in high school project-based science. *Science Education*, *94*(3), 395-427. https://doi.org/10.1002/sce.20365

Astuti, C. C. (2017). Original research article analisis korelasi untuk mengetahui keeratan hubungan antara keaktifan mahasiswa dengan hasil belajar akhir. *Journal of Information and Computer Technology Education*, *1*(April), 1-7. https://doi.org/https://doi.org/10.21070/jicte.v1i1.1185

Berland, L. K., & Reiser, B. J. (2008). Making sense of argumentation and explanation. *Science Education*, *93*(1), 26–55. https://doi.org/10.1002/sce.20286

Chin, C., & Chia, L. G. (2006). Problem-Based Learning: Using ill-structured problems in biology project work. *Science Education*, *90*(1), 44-67. https://doi.org/10.1002/sce.20097

Drăghicescu, L. M., Petrescu, A.-M., Cristea, G. C., Gorghiu, L. M., & Gorghiu, G. (2014). Application of Problem-Based Learning strategy in science lessons – Examples of good practice. *Procedia - Social and Behavioral Sciences*, *149*, 297-301. https://doi.org/10.1016/j.sbspro.2014.08.245

Faizah, L., Probosari, R. M., & Karyanto, P. (2018). Penerapan Problem Based Learning untuk meningkatkan keterampilan argumentasi lisan siswa kelas xi pada pembelajaran biologi. *Jurnal Biotek*, *6*(2), 1-12. https://doi.org/10.24252/jb.v6i2.6395

Fauziah, A. (2010). Peningkatan kemampuan pemahaman dan pemecahan masalah matematika siswa SMP melalui strategi REACT. *Forum Kependidikan*, *30*(1), 1-13.

Hmelo-silver, C. E. (2004). Problem-Based Learning: What and how do students learn? *Educational Psychology Review*, *16*(3), 235-267.

Hsu, C. C., Chiu, C. H., Lin, C. H., & Wang, T. I. (2015). Enhancing skill in constructing scientific explanations using a structured argumentation scaffold in scientific inquiry. *Computers and Education*, *91*, 46-59. https://doi.org/10.1016/j.compedu.2015.09.009

Kumala, G. S. R., Nurlaelah, I., & Setiawati, I. (2017). Bernalar dan Argumentasi melalui Problem Based Learning. *Quagga*, *9*(2). https://doi.org/https://doi.org/10.25134/quagga.v9i02.748

McNeill, K. L. (2010). *Explanations, arguments and evidence in science, science class and the everyday lives of fifth grade students*. McNeill NARST.

McNeill, K. L., & Krajcik, J. (2009). Synergy between teacher practices and curricular scaffolds to support students in using domain-specific and domain-general knowledge in writing arguments to explain phenomena. *Journal of the Learning Sciences*, *18*(3), 416-460. https://doi.org/10.1080/10508400903013488

Nasir, M., & Nur, M. (2018). Training inquiry model ditinjau dari kemampuan scientific explanation mahasiswa. *Bioedukasi Jurnal Pendidikan Biologi*, *9*(1), 51-56. https://doi.org/10.24127/bioedukasi.v9i1.1383

Noer, S. H. (2011). Pembelajaran matematika berbasis open-ended. *Jurnal Pendidikan Matematika*, *5*(1), 104-111.

Osborne, J. F., & Patterson, A. (2011). Scientific argument and explanation: A necessary distinction? *Science Education*, *95*(4), 627-638. https://doi.org/10.1002/sce.20438

Putri, A., & Hamid, A. (2016). Persepsi guru terhadap kualitas buku ajar fisika kelas X SMA negeri se-kota banda aceh. *Jurnal Ilmiah Mahasiswa*, *1*(4), 208-211.

Rohwer, Y., & Rice, C. (2015). How are models and explanations related? *Erkenntnis*, *81*(5), 1127-1148. https://doi.org/10.1007/s10670-015-9788-0

Smyrnaiou, Z., Foteini, M., & Kynigos, C. (2012). Students' constructionist game modelling activities as part of inquiry learning processes. *Electronic Journal of E-Learning*, *10*(2), 235-248.

Supeno, Kurnianingrum, A. M., & Cahyani, M. U. (2017). Kemampuan penalaran berbasis bukti dalam pembelajaran fisika. *Jurnal Pembelajaran Dan Pendidikan Sains*, *2*(1), 64-78.

Tan, O. S. (2003). *Problem-based learning innovation: Using problems to power learning in the 21st century*. Cengage Learning.

Yao, J.-X., Guo, Y.-Y., & Neumann, K. (2016). Towards a hypothetical learning progression of scientific explanation. *Asia-Pacific Science Education*, *2*(4), 1-17. https://doi.org/10.1186/s41029-016-0011-7

Authors:

Monika Lintang Laksmi is a Master's student in biology education at Sebelas Maret University, Indonesia and a biology tutor at Primagama, Surakarta, Indonesia. Email: monikalintang@student.uns.ac.id

Dewi Puspita Sari is a lecturer at Sebelas Maret University, Indonesia. Her research interests include biology education, especially animal development structure and ornithology. Email: dewipuspita@staff.uns.ac.id

Yudi Rinanto is a lecturer at Sebelas Maret University, Indonesia. His research interests include biology education, especially medicinal plants and metabolism. Email: yudirinanto@staff.uns.ac.id

Raden Rara Sapartini is a teacher at One Senior High School, Surakarta, Indonesia. Her research interests include biology education in high school/class action research. Email: rsabio8@gmail.com

Cite this paper as: Laksmi, M. L., Sari, D. P., Rinanto, Y., & Sapartini, R. R. (2021). Implementation of problem-based learning to increase scientific explanation skill in biology learning about the environment. *Journal of Learning for Development*, *8*(3), 532-540.