JPPIPA 9(6) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

PjBL Model with the Context of Making Liquid Organic Fertilizer (LOF) from Bamboo Shoots to Build Students' Critical Thinking Skills

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Received: April 14, 2023
Revised: April 21, 2023
Accepted: June 25, 2023
Published: June 30, 2023

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DOI: 10.29303/jppipa.v9i6.4285

Abstract: This study aims to obtain information about students' critical thinking skills (CTS) through the application of the project based learning (PjBL) model on reaction rate material in the context of making liquid organic fertilizer (LOF) from bamboo shoots. The method used is an experimental method with a one-group pretest-posttest design. This study uses one class with a total of 27 students. The instruments used were observation sheets on the implementation of learning and tests of critical thinking skills which consisted of 15 multiple-choice questions. Test result data were processed using the N-gain test and paired sample t-test. The results showed that the application of the PjBL model in the context of making LOF from bamboo shoots obtained a learning implementation percentage of 85.4 and was included in the very good category. In addition, the CTS of students as a whole experienced an increase of 0.69 in the moderate category. The results of the paired sample t-test show that the significance value obtained is 0.000 <0.05 so it can be concluded that there is an increase in the CTS of students through learning.

Keywords: Bamboo shoots, Critical thinking skills, Liquid organic fertilizer (LOF), Project based learning, Rate reaction

Introduction

In this era of rapid development, critical thinking skills (CTS) are very important for students facing various life problems and global competition challenges. Critical thinking is a high-level skill that is important for solving complex and sharp problems that require in-depth analysis (Wardani et al., 2017). According to Cottrell (2005), critical thinking is the ability to accurately draw conclusions from a situation and assess and carefully consider the decisions taken. Ennis (1996) places a strong emphasis on the use of rational and reflective thinking in critical thinking. Reflective means consciously looking for the best solution, while reason means based on facts to make the best decision.

In chemistry learning, besides students having to understand chemistry concepts properly and being skilled in conducting experiments, students' CTS also really needs to be developed. Besides that, learning chemistry also has other goals and functions, namely to foster a scientific attitude that includes a critical attitude towards scientific claims, namely not easily believing without the support of observations, understanding chemical concepts, and applying this knowledge to solve problems in everyday life (Fernanda et al., 2019).

Many studies on critical thinking have been carried out. The results of research by Suardana et al (2018) showed that the average CTS score of high school students was at a high level (59.0%), medium (43.1%), and low (34.7%). Another study conducted by Khoirunnisa & Sabekti (2020), shows that the average CTS of students in chemical bonding material are still relatively low, especially in the aspect of building basic skills. The low quality of CTS students can be caused by several factors. One of them is the selection of a learning model that has not led to an increase in the CTS of students.

How to Cite:
Sumarna, O., & Rushiana, R. A. (2023). PjBL Model with the Context of Making Liquid Organic Fertilizer (LOF) from Bamboo Shoots to Build Students' Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4501–4507. https://doi.org/10.29303/jppipa.v9i6.4285

Through a literature review, several solutions to improve students' CTS have been offered, namely through a scientific approach (Agustin et al., 2016); guided inquiry model (Auliya & Yonata, 2020; Ishma & Novita, 2021; Mukmainah & Yonata, 2020); the POE model (Sagala et al., 2021) However, some of these solutions in the learning process do not use contexts that students usually encounter in everyday life. The use of context in learning can help students to build CTS, inviting students to be able to associate material that has been received at school with the context in everyday life (Mahanani et al., 2019; Rushiana et al., 2023).

According to Sumarna et al (2022), one of the contexts that can be used in learning chemistry is making LOF. LOF is a solution obtained from the decomposition of organic materials that contain nutrients (Tanti et al., 2019). Previous research by Husna et al (2022) has examined the LOF of stale moles in chemistry lessons. Likewise, Sumarna et al (2022) have prepared a worksheet with the context of making LOF made from bamboo shoots. Bamboo shoots can be used for the manufacture of LOF because they contain ingredients such as calcium, phosphorus, potassium and have growth hormones such as gibberellin, auxin, and cytokinins. In addition, bamboo shoots also contain microorganisms such as Azotobacter and Azospirilium which can produce plant growth hormones and act as fixers for N_2 from the air (Kasi et al., 2018; Walida et al., 2019). Thus, LOF from bamboo shoots is very potential to support plant growth.

Several studies regarding the use of LOF bamboo shoots as a plant fertilizer have shown good results on the number of fruits and can reduce the number of seeds in cayenne pepper plants (Buksalwembun & Andriani, 2020). In addition, the results of research by Angraeni et al (2018) showed that the administration of LOF bamboo shoots affected plant height, number of leaves, and leaf color of kale plants. Likewise, research conducted by Walida et al (2019) showed that the application of LOF bamboo shoots to red chili plants gave a good response to plant height, stem diameter, number of leaves, flowering age, and initial production weight.

Making LOF is a natural process that involves bacteria through fermentation (Buksalwembun & Andriani, 2020). This fermentation process produces carbon dioxide gas whose volume can be measured at any time. Changes in the volume of gas produced per unit of time can be studied using the concept of reaction rate (Permana, 2021). Thus, the context of making LOF from bamboo shoots can be used in learning the material on the rate of reaction, especially in the sub-material on the factors that affect the rate of reaction.

Learning using the context of making LOF from bamboo shoots can be applied using a project-based learning (PjBL) model. The PjBL model refers to an inquiry-based learning method that engages students in knowledge construction by asking students to complete meaningful projects and develop real-world products (Krajcik & Shin, 2014). Completion of projects in PjBL can be used as a learning tool to achieve competency attitudes, knowledge, and skills (Fathurrohman, 2016). Besides being able to help students to construct their knowledge through real experiences, the application of the PjBL model can also develop students' CTS through contextual problem-solving activities. In PjBL students cooperate cooperatively and make projects carried out by real students (Effendi, 2017; Iskandar & Mulyati, 2019). Thus, the application of the PjBL model can assist students in developing their critical thinking skills.

This is in line with the results of research by Matahari et al (2023); Sumardiana et al (2019), which stated that PjBL is suitable for increasing students' CTS. Likewise, Sastrika et al (2013), stated that PjBL has the potential to train students' thinking processes that lead to students' CTS because CTS are developed at each stage of the PjBL model. Another study by Zahroh (2020), stated that the PjBL model had a 44.89% effect on CTS students in electrochemical material.

Based on the description above, the CTS of students in chemistry learning still need to be developed. For this reason, researchers have implemented project-based learning in the context of making LOF from bamboo shoots. The PjBL model with the context of making LOF from bamboo shoots is an innovation in building CTS students in chemistry learning.

Method

This study used an experimental method with a one-group pretest-posttest design. In this design, the researcher measured the increase in students' CTS by giving the pretest to the group that was given the treatment. Then apply the PjBL model with the context of making LOF from bamboo shoots and finally by giving a posttest.

The implementation of PjBL in this study follows the PjBL stages of The George Lucas Educational Foundation (2005) which consists of 6 steps. The six stages include determining fundamental questions, designing project plans, compiling schedules, monitoring project activities, testing results, and evaluating experiences.

The population in this study were students of class XI at a high school in Cimahi, West Java. The sample in this study consisted of 27 students in senior high schools. The sampling technique used was purposive sampling. The instruments used were implementation observation sheets and 15 multiple-choice questions to measure students' CTS. The two instruments have been validated.

Observational data were analyzed by calculating the percentage of implementation of the PjBL Model. The percentage results obtained are then interpreted based on the criteria presented in Table 1.

Table 1. Category Percentage of Learning Implementation

Percentage (%)	Category
0 − 20	Very less
21 – 40	Less
41 – 60	Enough
61 – 80	Good
81 − 100	Very good

The data obtained from the students' pretest-posttest results are used to find the N-gain value. The N-gain value serves to determine the increase in the CTS of students after the application of the PjBL Model in the context of making LOF from bamboo shoots. The N-gain values obtained are then interpreted according to the categories in Table 2. In addition, the data from the pretest-posttest results were also tested for normality and homogeneity as well as statistical tests using IBM SPSS Statistics 25 software.

Table 2. N-gain Criteria

N-Gain	Criteria
$g \geq 0.7$	High
$0.7 > g \geq 0.3$	Medium
$g < 0.3$	Low

Result and Discussion

Implementation of Project Based Learning Models

In the implementation of the PjBL model in the context of making LOF from bamboo shoots, three observers observed the implementation of the learning. Observation of the implementation of learning is carried out by referring to the implementation observation sheet. Table 3 shows the results of observations at each PjBL stage.

Table 3. PjBL Model Implementation Percentage

PjBL Syntax	% Compliance	
	Every Stage	Each Session
Start with the essential question	86.1 (Very good)	
Design a plan for the project	80.6 (Good)	84.4 (Very good)
Create a schedule	83.3 (Very good)	
Monitoring	87.5 (Very good)	
Assess the outcome	83.3 (Very good)	87.5 (Very good)
Evaluate the experience	91.7 (Very good)	
Average	85.4 (Very good)	

The first stage of the PjBL model is to determine the basic questions. At this stage, students formulate questions related to the discourse contained in student worksheets that have been understood before. Many questions were asked by students, but they still did not lead to learning material. Then the teacher guides students to connect the questions to be asked with the material to be studied, so that 3 basic questions are obtained such as: 1) what sub-material is the reaction rate appropriate for making LOF through fermentation from bamboo shoots?, 2) what factors influence the rate of LOF production by fermentation of bamboo shoots?, (3) what will be observed in studying the rate of production of LOF by fermentation of bamboo shoots? Activities in this first stage can train students to focus on questions. The percentage of learning implementation at this stage reached 86.1% and was included in the good category.

The second stage is designing the project plan. Students understand the work steps contained in the worksheet. Furthermore, the students discussed determining the tools and materials to be used in the project, described the set of experimental tools, and determined what observations would be made in the project for making LOF from bamboo shoots. At this stage, the teacher guides students to understand what observations are made, so that students can describe the set of experimental tools after knowing what will be observed. Activities at this stage train students to determine an action to answer basic questions, and are trained to interact with other people. The implementation of learning at this stage was 80.6% and included in the good category.

After knowing what to do in the project. Students discuss in groups to arrange project work schedules and divide the tasks of each group member. The division of tasks aims to make the project work as well as possible through the cooperation of members. This stage trains students to determine actions and interact with others in order to arrange schedules so that projects are carried out well. In this third stage, the implementation of learning was obtained at 83.3% and included in the very good category.

In the fourth stage, it has an implementation percentage of 87.5%. Activities at this stage are students in groups doing project work at home. Teachers at this stage are monitoring project activities via the WhatsApp group or personal chat. The teacher ask about the progress of the project and the obstacles encountered in carrying out the project. If there are problems in carrying out the project, the teacher's role is to assist students. To ensure that the work of each group is carried out properly, the teacher instructs each group to send documentation of project work. Students at this stage are trained to observe and consider the results of observations, evaluate, give arguments, and interact with others.

In the results testing phase, students in groups present project results through presentations, and students from other groups provide feedback. The drawback of this activity is the unavailability of a projector so presentation activities only use laptops and each group distributes presentation slides in the WhatsApp group. In this presentation activity, all groups can present their results well.

The activity after the presentation is a discussion. Each member of the other groups is allowed to submit questions and responses to the presenting group. This discussion activity aims to allow students to exchange ideas and build knowledge together. Several students actively asked and answered in this discussion activity. Activities at this stage train students to ask and answer questions, provide arguments, define terms, and consider definitions. Implementation at this stage reached 83.3% and was included in the very good category.

The final stage of the PjBL model is the evaluation of the experience. This activity is carried out by explaining the suitability of project results with the concept of factors that affect the rate of reaction. In addition, there are discussion activities related to learning experiences and project work. Students take turns expressing their experiences during the project work that has been carried out. This last stage trains students to make and determine value judgments, and argue. Implementation at this stage reached 91.7% and was included in the very good category.

Based on Table 3, the implementation of learning with the PjBL model as a whole reached 85.4% in the very good category. In the first session, the implementation of learning reached 84.4%. This is because students are still preparing and adapting to the PjBL model of learning in the context of making LOF from bamboo shoots. Therefore, students need to be accustomed to learning with various learning models. In the second session, the implementation of learning was better than in the previous session, reaching 87.5%.

Critical Thinking Skills

CTS of students is measured by giving a pretest and posttest which consists of 15 questions. Based on the results of the research that has been done, the following data is obtained.

Table 4. Average pretest, posttest, and N-Gain results

Average pretest	Average posttest	Average N-gain	Category
35.56	79.01	0.69	Medium

Based on Table 4, the average pretest score was 35.56 and the posttest average score was 79.01. The results of the pretest and posttest of all students were then analyzed with the N-gain test to determine the increase in CTS of students after implementing PjBL in the context of making LOF from bamboo shoots.

Based on the calculation results, the overall N-gain value is 0.69. These results indicate that the overall increase in the CTS of students is in the medium category, the N-gain value for each can be grouped as shown in Table 5.

Table 5. Number of Students and Category N-gain

Number of Students	Category N-gain
15	High
17	Medium

To see the significance of the increase in CTS, a normality test was carried out first. Based on Table 5, the results of the normality test using a significance level of 5% obtained sig (2-tailed) = 0.200 > 0.05. This shows that the data is normally distributed. After that, homogeneity was carried out with a significance level of 5% and obtained sig 0.107 > 0.05. These results show that the two data are homogeneous.

Table 4. Normality, Homogeneity, and Paired Sample T-Test Results

Normality	Homogeneity	Paired Sample T-Test
0.200 > 0.05	sig 0.200 > 0.05	sig 0.000 < 0.05

Then do a statistical test. The test used is the paired sample t-test because the data used comes from the same sample. Based on calculations using a significance level of 5%, sig (2-tailed) = 0.000 < 0.05. These results indicate that there are differences in the CTS of students before and after the implementation of PjBL in the context of making LOF from bamboo shoots.

The results of this study are reinforced by previous research conducted by Desiana et al (2022) that the implementation of PjBL can improve students' CTS. PjBL can improve students' CTS because learning with this model focuses on the concepts and principles of the material being taught, involves students in solving problems and completing meaningful tasks, giving students opportunities to work independently in building their knowledge through real experiences, and produce valuable and realistic products (Effendi, 2017; Hikmah et al., 2016; Iskandar & Mulyati, 2019). In addition, each stage of the PjBL model has enormous potential to train students' thinking processes that lead to CTS (Panjaitan et al., 2020).

The use of the context of making LOF from bamboo shoots allows contextual learning. Contextual learning is an effort to improve students' CTS (Pratiwi et al, 2016;

Rushiana et al., 2023). The use of context in learning chemistry can help connect with the subject matter so that it can increase learning motivation and train critical thinking skills in solving problems (Sagita et al., 2021; Yunita et al., 2018).

Conclusion

Based on the results of the research conducted, it can be seen that the application of the PjBL model in the context of making LOF from bamboo shoots obtained a learning implementation percentage of 85.4 and was included in the very good category. In addition, overall, the CTS of students experienced an increase of 0.69 and was included in the moderate category. The results of testing the hypothesis obtained a sig (2-tailed) value of 0.000 <0.05 so it was concluded that there was a CTS of students through the implementation of PjBL in the context of making LOF from bamboo shoots.

Acknowledgments

The researcher thanks the lecturers, teachers, and students who have participated in carrying out this research.

Author Contributions

The first author, Omay Sumarna, contributed to the conceptualization of research, validation of research instruments, guiding data analysis, and writing research articles. The second author, Ruci Aditya Rushiana contributed to designing research, compiling research instruments, conducting research, analyzing data, and writing research articles. All authors have read and agree to the published version of the manuscript.

Funding

The author would like to thank the Institute for Research and Community Service (LPPM) of the Indonesian University of Education for funding this research.

Conflicts of Interest

The authors declare no conflict of interest.

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