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The Analysis of PLOICE Model Application to Develop Science Process Skills: On the Coffee Learning Process

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The STEM approach is a learning approach that is in line with learning needs to face the challenges of the 21st century. Then, the use of the STEM approach is highly recommended. It is needed an innovation to facilitate the application of the STEM approach such as integrating the STEM approach with the learning model. So, an integration of the PBL model and the STEM approach is created and then arranged which is known as the PLOICE learning model. The PLOICE learning model is a learning model that has the following syntax: Problematize, Learn, Organize, Investigate, Create, and Evaluate. In this research, students will be involved in scientific investigations on the management of shade-grown coffee to increase coffee production. Student participation in determining the management of shade-grown coffee can help develop students' science process skills. The research implemented a quasi-experiment where two classes received different treatments, namely the experimental and control classes. The experimental class received treatment using PLOICE and control using conventional treatment. In the results that the application of the PLOICE model had a significant effect on the development of students' science process skills. In implementing the PLOICE model, students are more active in discussions and questions and answers.

Keywords: PLOICE, STEM, PBL, science process skills, coffee learning process

INTRODUCTION

The STEM approach is an approach that integrates science, technology, engineering, and mathematics. The STEM approach is one approach that is currently widely used in classroom learning (Duc et al, 2019). The STEM approach is a learning approach that is in line with the learning needs to face the challenges of the 21st century (Mukaromah et al., 2022). The STEM approach equips students to solve the complex problems that are

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real in everyday life. Students solve problems innovatively and independently without assistance from the lecturer so that each student or group gets evidence of solving problems in various ways (Huber, 2020). The STEM approach is focused on training students how integrate the skills and abilities in complementary fields of science, technology, engineering, and mathematics. So, the students not only understand the principles but can practice and create products that can ease people's everyday lives (Bao, et al., 2019).

Currently, the STEM approach is the recommended approach for use in learning in various countries, one of which is Indonesia (Wahono et al., 2020). After conducting observations in the form of questionnaires on the use of the STEM approach at several universities in central Indonesia, the use of the STEM approach was still relatively low, namely 25% with a success rate of 58%, those percentage is obtained from the completeness of student learning outcomes. Lecturers tend to use a scientific and contextual approach to classroom learning. Several lecturers revealed that they had not used the STEM approach because they did not understand the procedures, requirements, and how this approach was used (Khotimah et al., 2022). Based on the observations above, innovation needs to be carried out to facilitate the application of the STEM approach to learning activities. The innovation can be done by integrating the STEM approach with the learning model. Therefore, implementing this learning model in the classroom, means you are simultaneously implementing the STEM approach.

The learning model that will be integrated with the STEM approach must be able to apply all aspects of science, technology, engineering, and mathematics. These four aspects can be applied if integrated with a learning model that starts from problems, one of which is the problem-based learning model (PBL). PBL confronts students with a problem that must be solved, so the PBL learning model encourages students to solve problems and compile their knowledge through learning activities, carrying out scientific activities, and communicating (Serevina et al., 2018). The application of PBL can significantly grow students' abilities in integrating and clarifying relevant information by proposing more solutions than students in conventional classes (Duda, 2019). PBL makes students not only read and memorize but PBL is designed to train students to think and work to solve the problems (Uliyandari et al, 2021).

Akcanca (2020) revealed that the benefits of PBL can encourage students to learn and build their thinking framework and knowledge through the problem-solving demands given. However, in reality, students learn to use original ideas and methods according to their thinking in solving the problems given. As a result, the problem-solving process is mostly less systematic following scientific principles. Khoiriyah & Husamah (2018) states that PBL is active learning based on the use of unstructured problems as a stimulus for learning and only focuses on the interrelationship of scientific disciplines, collaboration, and getting results. Based on the shortcomings of PBL, it requires integration with an approach that has a design that directs learning to a scientific stage process, so that it can improve the quality of student education. The approach needed is a STEM approach.

Based on empirical evidence, there is a need for integration between the PBL model and the STEM approach which allows students to maximize their understanding, knowledge, and experience of science process skills. The integration of the PBL model and the STEM approach is then structured in a way known as the PLOICE learning model. The PLOICE learning model is a learning model that has the following syntax: Problematize, Learn, Organize, Investigate, Create, and Evaluate. The PLOICE learning model is a learning model that requires students to actively learn, students are faced with problems and they are required to look for solutions to those problems. The problem-solving process must fulfill scientific stages that are carried out independently so that students will find many ways to find solutions to the problems given to produce prototypes.

The syntax of the PLOICE learning model is divided into five stages. The first stage is Problematize, this stage directs students to a problem. The second stage is Learn, in this stage the students search and read references related to the problem, so they can find a way to find a solution. The third stage is organize, in this stage the students prepare the observation steps and take a hypothesis. The fourth stage is Investigate, in this stage, the students make observations according to the steps that have been prepared. The fifth stage is Create, in this stage, the students conduct discussions by analyse data and creating products in the form of prototypes. The sixth stage is Evaluate, in this stage, the students make presentations and ask questions.

The PLOICE learning model will be applied to material on managing coffee shade plants to increase coffee production. Students will be actively involved in learning activities to solve shade-grown coffee management problems, students will look for relevant references, make observations and measurements, and the students will analyse the results to produce a prototype. The implementation of learning to manage shade-grown coffee involves several aspects of science, technology, engineering, and mathematics (STEM). Scientific aspects include types, characteristics, and abiotic and biotic factors of coffee plants and their shade. Technology in the form of the use of applications that support the creation of shade-grown coffee management simulations. Engineering in the form of using tools to measure abiotic factors. Mathematics consists of determining the distance between coffee plants and shade and the area of shade plants.

These student learning stages enable students to develop their science process skills to the maximum. Science process skills are the skills to solve problems and build new concepts and new understandings about science which include identifying, controlling variables, determining hypotheses, interpreting data, experimenting, and finding results from the problems (Mulyeni et al., 2019). Science process skills are very important and will always be related to everyday life. Science process skills can train students to construct scientific concepts during the learning process (Kasuga et al., 2022).

In Harahap et al. (2019) research, material that in the learning process involves students in the activities of investigating, observing, interpreting problems, making hypotheses, and getting results is material that can develop students' science process skills. Another study by Firmayanto et al., (2021) states that learning materials that involve students directly in scientific investigations can develop students' science process skills. Scientific inquiry includes observation, classification, measurement, prediction, communication, and inference. Therefore, material on managing coffee shade plants to increase coffee production is relevant to the need to develop science process skills in students. Based on the description above, this research aims to determine the effect of implementing the PLOICE learning model on students' science process skills in the material of managing shade-grown coffee.

Literature Review

STEM Approach

STEM education is a learning innovation choice combining several coherent scientific disciplines into a completely new approach. So, it can create competent and quality students who are competent in mastering the material and its application in everyday life (Bhakti et al., 2020; Suratno et al., 2019). The combination of elements of the STEM approach to the teaching and learning process can be applied at all levels of education, from elementary school to college. The application of the STEM approach is very flexible and does not depend on age because aspects of STEM implementation include intelligence, skills, creativity, and design abilities (Riyadi et al., 2020). In Huber's (2020) research, STEM treatment classes trigger students to be more active, and collaborative, and result in more conducive discussion. The STEM approach channels positive influences on student learning. The STEM approach channels positive influences on student learning. In Sari et al. (2020) research, the STEM approach develops science process skills effectively. Students can solve real-life problems with systematic thinking and their creativity following the scientific process. The STEM approach is an approach to educational elaboration, especially in science.

Problem-Based Learning

PBL is a learning model for presenting material themes implemented by posing problems, posing questions, and facilitating observations and discussions (Nurhayati et al., 2021). PBL is believed to be effective compared to traditional learning in involving students in learning (Wu et al., 2020). PBL trains students to work together and plan how to gain knowledge by asking questions, exploring references, and finding solutions to problems. Implementing PBL has proven to improve student skills, including science process skills (Kasuga et al., 2022). The stages of the PBL model include involving students in problems, analysis, learning organization, researching, making conclusions, and presenting results. Lecturers facilitate students in seeking references from various sources at the problem analysis stage (Sari et al., 2021; Sari et al., 2018).

PLOICE Learning Model: Integration of PBL with STEM Approach

PLOICE is a learning model formed from the integration of the PBL model with the STEM approach. There is a need to apply a STEM approach to classroom learning and there are shortcomings in the PBL model. The weakness of the PBL model is the problem-solving process tends to be less systematic following scientific principles. It needs to integrate with the STEM approach which has a structured approach including science, technology, engineering, and mathematics. PLOICE is a learning model that focuses on independent learning by students. Learning begins with giving a problem, with the final result of a product being a prototype, real media, and images according to the problem given. When the problem has been given, the students independently carry out the problem-solving process after everything is handed over to the students. The lecturer only gives instructions on the PLOICE learning syntax. The rest of the process involves students using their creativity in groups to solve problems. Synthetics of the PLOICE learning model are Problematize, Learn, Organize, Investigate, Create, and Evaluate. Problematize, giving students a complex problem. Learn, as a group, that students understand the problem by looking for references according to the problem given. Organize: after understanding the problem, the group creates a problem formulation hypothesis and arranges an experimental stage. Investigate, the group carries out experiments according to the stages that have been prepared. Create, the group analysis the results and creates a product. Evaluating the group explains the product and carries out a joint evaluation.

Science Process Skills

Science process skills allow students to practice solving problems according to scientific provisions to develop students' abilities in conducting investigations, analysis, problem-solving, and concluding (Andriyani et al., 2019). Science process skills can make students have the character of scientific behaviour in learning and everyday life (Zulaekah et al., 2023). Science process skills are divided into two, namely basic science process skills and integrated science process skills. Students at lower educational levels study basic science process skills. Integrated science skills are studied by students with a higher level of education, one of which is at the tertiary level (Kasuga et al., 2022). Integrated science process skills have several stages: observing problems, making temporary guesses, preparing experiments, setting variables, interpreting data, making temporary conclusions, conducting research, and delivering it (Saat, 2004). Science process skills can provide direct experience for students, such as observation, classification, and measurement (Juhji & Nuangchalerm, 2020). Science process skills enable students to process information, solve problems, carry out scientific processes, and conclude (Tan et al., 2020). Science process skills require students to understand scientific concepts through scientific investigations (Kurniawan et al., 2020).

METHOD

Research Design

The research implemented a quasi-experiment where two classes received different treatments, namely the experimental and control classes. Quasi-experiment applies a pre-test/post-test non-equivalent group design. The pre-test/post-test non-equivalent group means an application that places the students being evaluated in the students' natural environment so that no special treatment is controlled. This research aims to discover how applying the PLOICE learning model affects the development of science process skills in coffee learning process. Researchers chose research subjects for the experimental and control classes according to the material used: shade-grown coffee management. Experimental and control class subjects were students in the odd semester of the 2021/2022 academic year at several universities in Jember, Indonesia. After the experimental and control classes have been determined, a pre-test is carried out with the same questions. Then, after different treatments were carried out, the students in the experimental (PLOICE) and control (Conventional) classes were given a Post-test with the same questions (Braddock, 2019). The following Figure 1 explains the design of experimental and control groups.

P1	O1	PLOICE	O2
P2	O1	Conventional	O2

Figure 1
The Experimental and control group design
Notes. P1: Experimental Class; P2: Control Class; O1: Pre-test: O2: Post-test

Sample

The sample for this research was 75 students from two classes taking ecophysiology courses. The researcher determined the number of research samples using the Slovin formula. The formula needed to find the population sample size is unclear. Slovin's formula is $n=N/1+Ne^2$ description n: number of samples, N: number of population, *e*: allowed error 0.1 (Tejada & Punzalan, 2012). The research sample in the experimental class was 33 students, and the control class was 37 students. The sample was selected from the university that taught the ecophysiology course material. The experimental class received treatment using PLOICE and control using conventional.

Data Collection Method

The data collection method is divided into several stages. The first stage is collecting model validation data and learning tools that will be used by expert validators. The second stage of data collection is an essay test containing questions according to indicators of science process skills. The essay test is carried out before learning (pretest) and after learning (posttest). The learning process lasts for 2*60 minutes on material for managing shade-grown coffee. The third stage of data collection is in the form of observation sheets observing student activities during the learning process. The observation sheet will be filled in by the observer. After obtaining the data, proceed with the analysis of the data that has been collected.

Research Procedures and Instruments

Experimental class research implements the PLOICE learning model with syntax: 1) Problematize, directing students to problems, 2) Learn (analysing problems to solve problems in groups. 3) Organize, create hypotheses, and compile observations. 4) Investigate, and make observations. 5) Create, analysis results, and create products 6) Evaluate and conclude. The control class uses a conventional learning model: the lecture method, assignment, discussion, and presentation. The research instrument for implementing the PLOICE model is equipped with instruments: PLOICE model guide, syllabus, RPS, RPP, LKM, and assessment of science process skills. The PLOICE model instrument and learning tools in this study underwent validation testing. Validation was assessed by three expert validators from Jember University Professor and Doctor of Biology Education lecturers and one practitioner validator from a Lecturer of Master's degree at Jember State Polytechnic. Those three expert validators are experts in learning models, tools, and materials. Validation assessment uses four levels: 80.26% – 99% (highly valid), 62.6% - 80.25% (valid), 43.76% – 62.5% (less valid), 25%-43.75% (invalid). Therefore, the validation test got an overall final score of

90.9%, which is very valid. The results of the validation of the science process skills assessment sheet used two assessments, namely the first assessment in the form of an essay test consisting of three questions which included indicators of science process skills. The second assessment is in the form of an observation sheet of student activities during the lesson. The use of these two assessments is to strengthen the results of implementing the PLOICE learning model in developing students' science process skills.

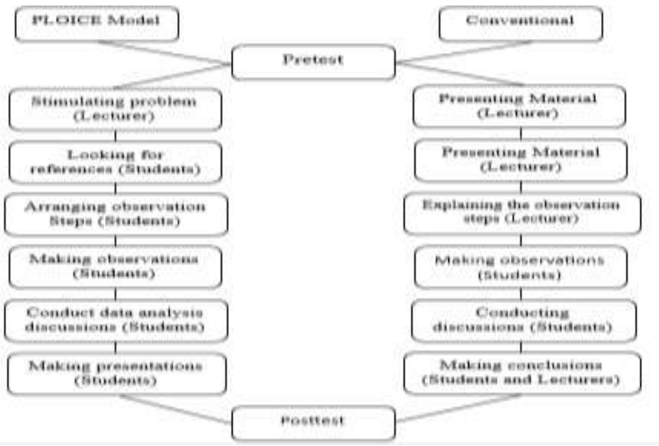

Figure 2
Comparison of PLOICE and conventional learning stages

Data Analysis

The assessment of science process skills used essay test sheets for pre-test and post-test. Besides, the assessment of science process skills uses an observation sheet, which the observer fills in during the lesson. Assessment of integrated science process skills with indicators: 1) Problem observation. 2) Hypothesis design. 3) Variable control. 4) Data interpretation. 5) Forecasting or temporary conclusions. 6) Experiment. 7) Communication (Elfeky et al., 2019). The criteria for assessing science process skills are 100-86 (very good), 85-71 (good), 70-56 (enough), and ≤55 (Not good). Besides observation results, if the data is normally distributed, use the t-test. If it is not normally distributed, then use the Mann-Whitney test. Analysis of science process skills uses pre-test and post-test scores, and if the data is normally distributed and homogeneity, the ANACOVA test is calculated. It is also necessary to know the pattern of relationships between variables using regression analysis. Last, the data analysis is using IBM SPSS Statistics 29.0.

Student Assignments

Developing science process skills in solving shade-grown coffee management problems to increase coffee production assigns students to take tests in the form of essay questions at the beginning before learning activities and at the end after learning activities. Three essay questions include indicators of science process skills. Questions for problem observation indicators, hypothesis design, and data control: "How can shade-grown plants affect coffee production?". Questions for indicators data presentation and temporary conclusions "What are the abiotic and biotic factors that are triggered by the presence of Shade-grown plants that influence coffee production? Explain how they influence." Questions for experimental and communication indicators "What is good management of Shade-grown plants to increase coffee production? Explain the experimental steps taken!"

FINDINGS

The results of research on the application of the PLOICE learning model to develop students' science process skills on the problem of managing shade-grown coffee to increase coffee production are in the form of observer assessment sheets according to indicators of science process skills and test results in the form of filled-in questions as pre-test and post-test.

The Analysis of Data Results on the Science Process Skills Activity Assessment

Average results for each science process skill indicator are obtained from the observer assessment sheet results. Observers conduct observations and assessments of the activities of implementing science process skills carried out by each student. Observations and assessments are filled in according to the observation sheet.

Table 1
Average results for each indicator of science process skills

Indicator	Experimental Class			Category	Control Class			Category
	Mean		Std. Deviation		Mean		Std. Deviation	
	Statistics	Std. Error			Statistics	Std. Error		
Problem observation	88.64	2.20	12.64	Very good	74.32	2.46	15.01	Good
Hypothesis design	90.15	2.15	12.41	Very good	71.62	2.59	15.77	Good
Variable control	87.88	2.21	12.68	Very good	75.00	2.37	14.43	Good
Data interpretation	87.88	2.21	12.68	Very good	73.65	1.92	11.71	Good
Forecasting	90.15	2.15	12.41	Very good	77.70	1.88	11.46	Good
Experiment	87.88	2.21	12.68	Very good	72.97	1.78	10.83	Good
Communication	92.42	2.03	11.66	Very good	70.95	2.74	15.03	Good

Based on the average results, each indicator of science process skills from the experimental and control classes has a different average value. The experimental class got a higher score in the very good category from all indicators, while the control class got a score in the good category from all indicators. The experimental class had the highest score on the communication indicator of 92.42 with a standard deviation of 11.66 in the very good category, while in the control class, the highest score on the problem observation indicator was 74.32 with a standard deviation of 15.01 in the good category.

An independent t-test will recalculate the students' science process skill scores from the observation sheet. This test determines the effect of applying the PLOICE learning model to develop science process skills in coffee learning process. Independent-test t-test can be carried out with the condition that the data must be normally distributed and homogeneous. So, the normality and homogeneity tests are carried out first for experimental class and control class data.

Table 2
Normality test of science process skills data

Class	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistics	Df	Sig.	Statistics	Df	Sig.
Experiment	.131	33	.162	.958	33	.233
Control	.153	37	.029	.921	37	.012

Based on the normality test above, the value data of science process skill from the experimental class received significance values of 0.162 and 0.233 (sig. > 0.05), and the control class received significance values of 0.29 and 0.12 (sig. > 0.05). These results indicate that the data is normally distributed. Then, each indicator's homogeneity test results of the value data of science process skill are shown below.

Table 3
Homogeneity test of science process skill scores

Levene Statistics	df1	df2	Sig.
17.175	1	68	.001

Based on the homogeneity test above, the value data of science process skill obtained a significance of 0.001 < 0.05 (sig. < 0.05). These results show that the data is not homogeneous. If the data is normally distributed but not homogeneous, then the independent t-test cannot be carried out. However, the test will continue using non-parametric tests like the Mann-Whitney test.

Table 4
Mann Whitney test of science process skills data

Mann-Whitney U	Wilcoxon W	Z	Asyimp. Sig. (2-tailed)
64.500	767.500	-6.444	.001

Based on the Mann-Whitney test above, the science process skills data gets Asyimp. Sig. (2-tailed) is 0.001, which means it is smaller than the probability value of 0.05 (Asyimp. Sig. (2-tailed) < 0.05). These results show that there is a significant difference in the science process skill scores of the experimental class and the control class. Due to these differences in values, it can be concluded that there is an influence of the application of the PLOICE learning model using the coffee learning process on the development of students' science process skills.

The Analysis of Pre-test and Post-test Score Data Results for Science Process Skills

The following are the average results of the Pre-test and Post-test scores for the science process skills of experimental and control class students.

Table 5
Results of Pre-test and Post-test scores

Class		N	Minimum	Maximum	Mean	Std. Deviation
Experiment	Pre-test	33	20	65	37.27	12.51
	Post-test	33	70	95	82.42	6.97
Control	Pre-test	37	20	55	34.05	9.26
	Post-test	37	60	85	69.05	8.96

Based on Table 5 above, the average Pre-test and post-test for the experimental class are 37.27 and 82.42, with standard deviations of 12.51 and 6.97. Meanwhile, the control class Pre-test and Post-test averages were 34.05 and 69.05, with standard deviations of 9.26 and 8.66. The minimum scores for the Pre-test and Post-test in the experimental class were 20 and 70, while the minimum scores for the Pre-test and Post-test in the control class were 20 and 60. The maximum scores for the Pre-test and Post-test in the experimental class were 65 and 95, while the maximum scores for the Pre-test and Post-test in the control class were 55 and 85. If we look at the mean and std. deviation, experimental class students who used the PLOICE learning model got a higher science process skills Post-test score mean 82.42 and std. deviation 6.97 compared to control class students who used the conventional learning model who got a Post-test score mean 69.05 and std. deviation 8.96. Analysis of the PLOICE learning model application to science process skills was continued with the Paired Sample t-test with the condition that the data results were tested for normality. Data is categorized as normal if the significance ($p < 0.05$).

Table 6
Pre-test and Post-test normality test

Class	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistics	Df	Sig.	Statistics	Df	Sig.
Experiment	.144	33	.081	.938	33	.061
	.151	33	.054	.939	33	.065
Control	.135	37	.086	.944	37	.061
	.134	37	.092	.943	37	.059

The normality test results of the experimental and control class Pre-test and Post-test data each obtained significance results greater than 0.05 (sig. > 0.05). If the data is homogeneous then continue with the ANACOVA test to determine whether there is a difference between the scores before and after implementing the PLOCE learning model.

Table 7
Post-test homogeneity test

Levene Statistics	df1	df2	Sig.
2.720	1	68	.104

The homogeneity test results of post-test scores on science process skills obtained a significant value of $p = 0.104 > 0.05$. It indicates that the post-test scores for the experimental and control classes were homogeneous. If the data is homogeneous, it can be continued with the independent sample t-test.

Tabel 8
Pretest and posttest ANACOVA test

Dependent Variable: Nilai *Post test*						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3479.902	2	1739.951	45.359	0.001	0.575
Intercept	24988.442	1	24988.442	651,425	0,001	0,907
Treatment	3256,597	1	3256,597	84,896	0,001	0,559
Error	2570,098	67	38,360			
Total	399800,0	70				
Corrected Total	6050,0	69				

The results of the ANACOVA test showed that the significance for the treatment was 0.001 (Sig<0.05), indicating that at the 95% confidence level, it could be said that there was a very significant influence between the values before and after administering the PLOICE model. Furthermore, the significance of the corrected model was 0.001 (Sig<0.05), indicating that at a 95% confidence level, the PLOICE model had a stimulant effect on science process skills. It means that the application of the PLOICE model has a significant influence on scientific process skills in the management of coffee shade plants to increase coffee production.

There are several characteristics of students' answers to the Pre-test and Post-test questions with varying scores from the experimental class to the control class. The diversity of scores can be grouped into levels of science process skill categories, namely very good, good, enough, and not good. So, it can be seen how the scores differ for each student from the experimental and control classes.

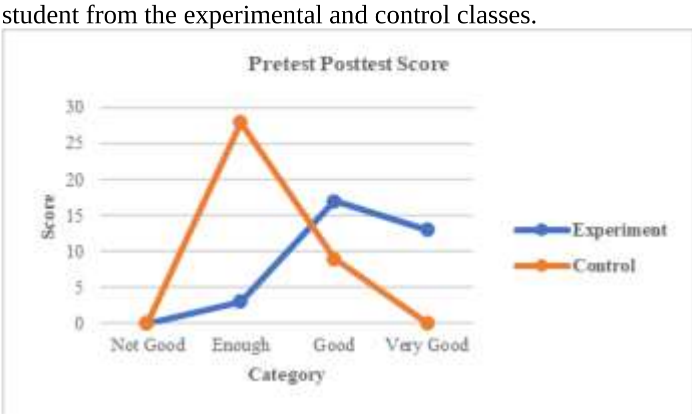

Figure 3
Post-test scores for experimental and control classes

Figure 3 shows that the post-test score in the experimental class is better than the control class's. In the experimental class, the average student scores in the good and very good categories. Seventeen students got scores in the good category, 13 in the very good category, and only three in the enough category. Meanwhile, in the control class, the number of students who got scores in the enough category was 28, and students who got scores in the good category were 9. In the control class, no students got scores in the very good category.

Furthermore, examples of student answers are in the very good and enough categories. The first question is, "How can shade-grown plants affect coffee production?". The second question "What are the abiotic and biotic factors caused by the presence of shade-grown plants that affect coffee production? Explain how they influence." The third question is, "How can shade-grown plants be managed properly to increase coffee production? Explain the experimental steps taken!" The results of the essay test answers aim to determine the success of the PLOICE learning model for developing science process skills on coffee learning process in the form of shade-grown coffee management to increase coffee production. The results of the essay test answers are included in the very good category if the answers can be explained in detail and correctly according to the themes studied.

1) Shade-grown plants can influence the production of coffee plants because of many factors, including the presence of Shade-grown plants, which will manage the intensity of light that illuminates the coffee plants. Suppose the intensity of light that reaches the coffee follows the maximum growth standards for coffee. In that case, it will improve photosynthesis, growth, and development of the coffee and impact coffee production in the future. Shade-grown plants also maintain air temperature and humidity. Shade-grown plants will also produce leaf litter. This litter will indirectly maintain soil moisture and add good microorganisms for coffee plants.
2) The abiotic factor that influences this is light intensity. Shade-grown plants can be arranged according to standard shade requirements for coffee plants. Air temperature and humidity: Shade-grown plants will maintain air temperature and humidity even in extreme weather. Soil moisture, Shade-grown plants will produce soil litter, which can help maintain soil moisture and the production of soil microorganisms. The influencing biotic factor is that the distance between coffee plants and shade must follow the coffee plant's needs and the characteristics of the Shade-grown plants. If the plant distance is not appropriate, obtaining a standard shade area for the coffee plant will be difficult. The area of shade also has an effect. If the shaded area is not appropriate, then the intensity of light that illuminates the coffee plant will not be appropriate. Extreme temperatures unsuitable for growing coffee will also affect coffee plants. If coffee plants are continuously illuminated to high temperatures, the coffee plant will dry out and die.
3) One good management method for coffee plants is using Shade-grown plants that align with the conditions for growing coffee and adjusting the coffee plants' shade area. The shaded area must be adjusted so that only 50% of the light intensity can illuminate the coffee plants. The incoming light intensity is 50%, the standard light intensity for coffee plants. Then, adjust the standard pH for coffee plants to 6.5 – 7.2. Then, adjust the soil litter requirements to maintain soil moisture and increase soil microorganisms. The standard litter for coffee plants is 3-2 cm. Suppose you are calculating a coffee plantation where the distance and area have not been calculated. In that case, the first thing to do is identify the problem and look for references regarding shade-grown coffee management. Then, prepare research, formulate problems, create hypotheses, and make observations and measurements on coffee plantations. Then, analyze the results, arrange the product, and create a product related to the observations. Last, the students and one class conclude the results of the product.

The results of the essay test answers are categorized as the good enough category if the answers can be explained in detail and correctly according to the themes studied.

1) Shade-grown plants can have an effect because there is an area of shade that can be used to shade coffee plants so that they are not illuminated by direct sunlight.
2) Biotic factors: distance between coffee plants and shade, area of shade, height of coffee and shade.

3) By adapting Shade-grown plants to growing coffee plants. One is by using Shade-grown plants that follow the conditions for coffee and keeping direct sunlight on the coffee plants. The steps are to formulate the problem, observe coffee plantations, and produce results.

DISCUSSION

The research results show that applying the PLOICE learning model can significantly develop science process skills on coffee learning process. The advantage of the PLOICE learning model for developing science process skills is that this learning has syntax, which will refer to systematic learning activities following the scientific learning process. Using PLOICE learning can indirectly train students' knowledge in practicing their science process skills. The PLOICE learning model is a learning model built from the integration of the PBL model with a STEM approach. There has been much research on the PBL model itself, proving that the application of the PBL model can improve science process skills. Like Fahmi et al. (2021) research, applying the PBL model improves students' science process skills. Positive students respond by asking questions, giving opinions, understanding problems, conducting experiments, tabulating data, and solving problems that have been done independently. This attitude can affect improving students' science process skills. Argaw et al. (2017) research shows that PBL can increase student activity during the learning process, develop knowledge, and train students' science process skills. Zainuddin et al. (2020) research, shows that learning that begins with problems will be able to develop scientific concepts regarding students' understanding and creativity to carry out active experiments so that they can improve students' science process skills.

Integrating PBL and STEM approaches aims to complement the shortcomings of the existing PBL model. Students learn to use original ideas and methods according to their thinking in solving problems, so the problem-solving process is mostly less systematic following scientific principles (Akcanca, 2020). These deficiencies are then integrated with a STEM approach, adding science, technology, engineering, and mathematics elements to learning. Besides, integrating STEM approaches in the learning model eases the application of the STEM approach to learning. It is caused by the use of the STEM approach in higher education, which is still very low. The existence of the PLOICE learning model, namely the addition of PBL integration and a STEM approach, can increase the development of science process skills. The STEM approach to learning can attract students' attention to learn and encourage student creativity. Students can achieve better conceptual knowledge about project design activities that utilize technology (Fan & Yu, 2015).

After conducting research and analyzing data from observer sheet tests and pre-test and post-test essay tests, it can be concluded that applying the PLOICE learning model can improve science process skills. Science process skills can be developed through learning applied to direct scientific activities. When viewed from the syntax of the PLOICE learning model, namely, Problematize, Learn, Organize, Investigate, Create, and Evaluate in the first stage of Problematize, the stage of directing students to a problem. At this stage, scientific activities have begun, namely observing a problem from a scientific perspective to find the point of the problem. Learning that triggers students into a problem will enable students to transfer deep thinking strategies and trigger more effective learning (Saqr et al., 2023). Learning begins with effective problems to make students more focused on learning to find solutions to these problems. Students better understand the concepts taught (Choo et al., 2022).

The second stage is Learning. In this stage, students are directed to search for and read references related to the problem. So they can find a solution. This stage trains students to observe problems with their opinions and must be based on trusted references such as journals or books. Learning that involves extracting relevant literacy from journals and relating to the problems faced will help clarify concepts that were not initially understood (Bond et al., 2020). A literacy foundation for understanding issues can train students to make the right decisions for the next steps following a literacy foundation that refers to relevant references for the problem (Carless, 2020).

The third stage is organizing. In this stage, students prepare the observation steps to be carried out and create a hypothesis. Observation steps are arranged according to systematic and scientific efforts. Students are also trained to formulate problems and hypotheses according to scientific activities. This activity can train students' science process skills. Students are introduced to choosing appropriate steps for a particular problem. Students must solve problems according to the steps that have been prepared and cannot be changed. At the end of the lesson, there will be an evaluation to see whether the chosen steps were successful. It can help students increase their problem-solving understanding (Goulet-Lyle et al., 2019).

The fourth stage is an investigation. At this stage, students make observations according to the steps that have been prepared. Observations are made to look for data to get answers whether they are following the hypothesis that has been made or not. Learning will be more effective if assisted by an environment outside the classroom and authentic assignments. Improving the quality of student learning and the ability to work together can be developed through direct experimental activities (Almulla, 2020). The fifth stage is Create. In this stage, students analyze data and create a product to simulate shade-grown coffee management. At this stage, students are required to utilize technology to create simulations in the form of software. Then, it involves science, engineering, and mathematics to create a simulation suitable for managing shade-grown coffee. The sixth stage is evaluation, and the core stage is that students make a presentation about the product that has been made and carry out an evaluation if there are errors in the product.

Based on the six syntaxes of the PLOICE learning model, each stage can train students' science process skills. Apart from that, shade-grown coffee management is supported by the theme. Students will conduct design activities to observe and measure abiotic and biotic factors on coffee plantations. Observations were made to see whether the plantation had suitable Shade-grown plants for coffee plants. If the management of Shade-grown plants is still not appropriate, then students design a simulation to manage Shade-grown plants on the plantation. It can ensure the appropriate standard for the growing requirements of coffee plants. Using themes that are appropriate to the PLOICE learning model also has a significant effect on developing students' science process skills.

CONCLUSION

Applying the PLOICE learning model can develop students' science process skills on the problem of managing shade-grown coffee to increase coffee production. It was proven in the results of the observer assessment sheet that the experimental class got a higher score in the very good category from all indicators. In contrast, the control class scored in the good category from all indicators. In the non-parametric test, science process skills get Asyimp. Sig. (2-tailed) of 0.001. It indicates that there is a significant difference in the science process skill scores of the experimental class and the control class. In the test results in the form of fill-in-the-blank questions, the ANACOVA test results showed that the post-test and pre-test scores were significant, $p = 0.001 > 0.05$. It indicates that the application of the PLOICE model had a significant effect on the development of students' science process skills. In implementing the PLOICE model, students are more active in discussions and questions and answers. Students look interested and enthusiastic about solving the problems they face. This research was only carried out on a limited basis at the University so there is a need for further research applying the PLOICE model at other levels of education.

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