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The use of fern herbarium as a project and learning material in project-based learning to improve learning outcome

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Abstract

Herbarium is a plant specimen used by experts to identify plants; however, it can also be used as teaching concept. Skill and knowledge are needed in making herbarium to produce standard herbarium giving good description and easy for identification. Unfortunetely, herbarium project is rarely used to improve skill and plant identifications knowledge for students. This study aimed to determine the skills of students in making herbarium and training students to identify plants through the PjBL model. In addition, this study aimed to compare the learning outcomes of students making herbarium taught with the PjBL model (experimental class) with the Direct Instructions model (control class). The method was quasi experiment with Nonequivalent Control Group Design. Instruments were test questions and learning tools such as teaching modules, student worksheet, herbarium, and assessment sheets for the evaluation students' attitudes and skills that have been validated by 2 validators using the Guttman scale. Identification of herbarium made by experimental class students referred to standard herbarium of research results in *Hutan Lindung Gunung Raya*, as learning material, while the control class used literature such as internet. Implementation of learning was in accordance to the stages PJBL or DI. Herbarium made by experimental class students was more accurate in identification and description compared to those of control class herbarium. PjBL also improved student cognitive, psychomotor, and affective significantly. This indicates that the use of other environment-based projects can be developed in PjBL and provides more opportunities for students to explore ways out of a problem.

Abstrak. *Herbarium adalah spesimen tumbuhan yang digunakan oleh para ahli untuk mengidentifikasi tumbuhan; tetapi juga dapat digunakan sebagai konsep pembelajaran. Keterampilan dan pengetahuan dibutuhkan dalam pembuatan herbarium untuk menghasilkan herbarium standar yang memberikan deskripsi yang baik dan mudah diidentifikasi. Syangnya, proyek herbarium jarang digunakan untuk meningkatkan keterampilan dan pengetahuan identifikasi bagi peserta didik. Studi ini bertujuan untuk mengetahui keterampilan peserta didik dalam membuat herbarium dan melatih peserta didik untuk mengidentifikasi tumbuhan melalui model PjBL. Selain itu, studi ini bertujuan membandingkan hasil belajar peserta didik diajar dengan model PjBL (kelas eksperimen) dengan model Direct Instructions (kelas kontrol). Metode yang digunakan adalah kuasi eksperimen dengan Nonequivalent Control Group Design. Instrumen adalah soal tes dan perangkat pembelajaran seperti modul ajar, lembar kerja peserta didik, herbarium, dan lembar penilaian untuk evaluasi sikap dan keterampilan peserta didik yang sudah divalidasi oleh 2 orang validator menggunakan skala Guttman. Identifikasi herbarium yang dibuat oleh peserta didik kelas eksperimen mengacu herbarium standar hasil dari penelitian di Hutan Lindung Gunung Raya, sebagai bahan ajar, sementara pada kelas kontrol peserta didik mengacu literatur seperti internet. Implementasi pembelajaran dilakukan sesuai dengan sintaks PJBL atau DI. Herbarium yang dibuat oleh peserta didik pada kelas eksperimen lebih akurat dalam identifikasi dan deskripsi dibandingkan dengan herbarium dari kelas kontrol. PjBL juga meningkatkan pengetahuan, keterampilan, dan sikap peserta didik secara signifikan. Ini mengindikasikan bahwa penggunaan proyek lain berbasis lingkungan dapat dikembangkan dalam PJBL dan memberikan kesempatan lebih banyak kepada peserta didik menggali jalan keluar dari sebuah masalah.*

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A. Introduction

Herbarium is a collection of specimens of living things that have been dried or preserved with the aim of helping the plant identification process (Handayani et al., 2020). Herbarium can also be used as an alternative to protect the existence of plants so that they can continue to be sustainable (Syamsiah et al., 2020). Herbarium can also be used as a support for learning and research (Mertha et al., 2018). It can also be used in the field of education as a basic concept for studying plant species because there were labels containing the information needed as evidence that the plant specimens obtained once existed in the location of the plant in question. In addition, herbarium can be one of the solutions in science learning for students to identify and classify plants.

Ferns are one of the biodiversity groups that play important role in the continuity of the ecosystem (Yassir et al., 2020). Ferns also have benefits for humans, such as food, ornamental plants, medicinal concepts, and craft materials (Astuti et al., 2017). The surrounding community does not utilize ferns for their daily needs, so fern existence is still maintained. However, ferns in the *Hutan Lindung Gunung Raya* have not been widely studied both in terms of type and function. The presence and function of ferns are very important in forests as understory plants that can reduce erosion. Studies in *Hutan Lindung Gunung Raya*, West Kalimantan showed that only 14 fern species were found at each elevation of the site (Natasya et al., 2024) out of 1300 species of ferns in Indonesia (Akbar et al., 2018). Therefore, there are still many more ferns growing as wild plants that are not known by the community (Ridianingsih et al., 2017). The lost of ferns can happen due to forest conversion. This can reduce the diversity of fern species over time. Ferns need to be preserved considering their important role for ecosystems, such as formation of humus, protecting soil from erosion, maintaining soil moisture, and as medicine plants (Yassir et al., 2020). One of the ways that can be done is by introducing these types of plants that can be implemented in students learning activities. Introducing activities to learn and to concept about fern diversity can be alternative activities in learning project such as in PjBL.

Project-based Learning (PjBL) is a learning model that involves students to produce a project and develop problem solving skills in working on the project (Apriany et al., 2020). PjBL is one of the innovative learning that is centered on students and teachers as motivators and facilitators (Lion et al., 2022). This model is also designed to guide students through projects that integrate various learning resources, providing opportunities to explore content using various ways that are meaningful to students, and collaborate on experiments. The PjBL can integrate student to design, communicate and participate (Dewi, 2022), making it easier to complete the specified project (Hamidah & Citra, 2021). This process emerges from the results of the stages in the PjBL model. The syntax in the PjBL model, namely: (1) determining fundamental questions, (2) making project plans, (3) preparing project schedules, (4) monitoring project progress, (5) assessing results, (6) evaluating experiences (Yulianto et al., 2017). In biology, project-based learning can be done by raising problems in the surrounding environment. Herbarium that contains plant samples and descriptions can be a teaching material for students. In addition, herbarium can also be used as a tool to train students in identifying plants. The herbarium of ferns obtained from research in the *Hutan Lindung Gunung Raya* can be used as learning material, so that it becomes a reference for project-based learning activities.

The results of interviews with one of the 7th grade science teachers at SMP Negeri 3 Paloh, Sambas Regency, the teachers usually more often use direct learning model (Direct Instructions). The activity of teaching is still teacher-centered. Teachers have also never done project-based learning activities such as PjBL. Based on information from science teachers, students have never been introduced to and learned to use herbarium.

In science learning especially in the field of biology, there is topic on the classification of living things. In this topic, there is a subconcept “Grouping of Living Things”. This concept focusses on the example of the types of ferns that exist around the students' environment. PjBL is carried out on the basis of examples that were easily found around the students' environment to stimulate students to be more interested in learning about it, such as identifying, and classifying plants that found in fields.

The learning process of PjBL is still not widely practiced by teachers in schools (Mufidah et al., 2020). The low implementation of PjBL models is caused by teachers not understanding the process carried out in the learning model (Wardhan, et al. 2023). According to Yusriani et al. (2020), teachers' difficulties in implementing the PjBL model include teachers still unfamiliar with the syntax of the PjBL model. In addition, teachers are less capable to direct students to create projects in accordance with the PjBL model.

Herbarium is a plant specimen containing vegetative and generative organs that have been dried (Rezeqi & Handayani, 2018) so that it can be used to help the identification process. Herbarium is also an important thing that students need to recognize to train students' skills in recognizing and identifying plants (Bria et al., 2023). Herbarium requaieres minimum standard to be used for plant identification. Biology teachers understand how to make herbarium so that its step of herbarium making can be done in accordance to PjBL syntax. The purposes of this study were to know the difference in student’s learning outcome to compare learning outcome using PjBL and direct Instructions in making herbarium. The study

also aimed to achieve students' skills in making herbarium and train students to identify plants that were made in the form of herbarium.

B. Material and method

This research used a quantitative experimental method, namely by comparing learning outcomes between experimental and control class students. The experimental method was quasi-experiment with nonequivalent control group design which referred to Sugiyono (2019) with a design in Table 1.

Table 1 Research design

Treatment	Learning outcomes	
	Pretest	Post-test
X_E	O_1	O_2
X_C	O_3	O_4

Descriptions:
O_1 = Pretest of experimental class
O_2 = Post-test of experimental class
O_3 = Pretest of control class
O_4 = Post-test of control class
X_E = Treatment of experimental classes taught with the PjBL model of making fern herbarium
X_C = Treatment of control classes taught with Direct Instructions model

The population in this study were 7th grade students of SMPN 3 Paloh Sambas regency. The samples in the study were VIIA class 18 students as the experimental class and VIIB 16 students as the control class. The material taught in this study is "Classification of Living Things" based on the Learning Achievement: "at the end of phase D, students are able to classify living things and objects based on observed characteristics". Learning activities were conducted in three meetings over two weeks.

The instruments used in this study were test instruments in the form of pretests and post-tests. The type of instrument was multiple choice. The grids of pretest/post-test questions were provided in Table 2.

The learning tools used in this study were teaching modules, student worksheet, attitude (affective) and skill (psychomotor) assessment sheets, and herbarium of ferns from research in *Hutan Lindung Gunung Raya*. Herbarium making started from collecting complete fern organ specimens in *Hutan Lindung Gunung Raya*. The specimens were then cleaned and arranged on newspaper for drying and sprayed using 70% alcohol and pressed in a bamboo sasag. After air-dried for 2-3 weeks, the specimens were mounted on a white background thickpaper and identified using book identification (van Steenis 2006; Holtum 1967). The complete identity of the specimen was listed on collector sheet that placed on the bottom right of the paper. The herbarium size was 30x40 cm. The herbariums were then validated by two experts in plant science using Guttman scale. The test instruments in the form of pretest/post-test questions and learning devices have been tested and revised by two validators who were experts before use.

Pretest was conducted to determine the initial ability of students before being given treatment. The pretest data was statistically tested to determine the difference between the experimental class and the control class before treatment. Statistical tests carried out were normality and homogeneity tests. The normality test used the Liliefors test and the homogeneity test used the F test with the Microsoft Excel application. If both data were normally distributed and homogeneous, then the data analysis continued with the t test. However, if one or both data were not normal or homogeneous, then the data analysis continued with the U-Mann Whitney test to determine the difference between the experimental class and the control class. The experimental class learning activities used the syntax of the PjBL model provided in Table 3.

Table 2 Pretest/post-test question grids

No.	Concept	Number of questions	Question number
1.	Definition, purpose and stages of classification, and identification	5	1,2,3,4,5
2.	The concept of categorizing living things	3	13,8,9
3.	Techniques for classifying living things	10	10,11,12,14,15,16,17,18,19,20
4.	Binomial nomenclature	2	6,7

Table 3 Learning activities using syntax of the PjBL model

Syntax	Student	Teacher	Meeting
1	Obtaining solution	Asking questions	1
2	Planning project with its material method	Guiding students to discuss project planning	1
3	Making the schedule for the project	Guiding student to discuss project shedule	1
4	Communicating project progress	Monitoring project progress	2
5	Identifying species refer to fern herbarium from teacher	Assessing the projects made by students	3
6	Conveying the experience during the creation of the project	Asking about students' experiences while making the project	3

Table 4 Learning activities using syntax of the DI model

Syntax	Student	Teacher	Meeting
1	Listening	Conveying learning objectives	1
2	Listening	Explaining the concept of classification according to text book	1
3	Discussing and works on student worksheet	Directing students to do the activities on the student worksheet	1
	Discussing and works on student worksheet	Re-directing students to continue working on the activities on the student worksheet	2
4	Answering the questions	Checking students' understanding	1
	Answering the questions	Inviting students to recall the material that has been presented	2
5	Working on assignment	Providing further tasks with applications to more complex situations in daily life	1
	Bringing assignments that have been done at home	Assessing the tasks that students have done	3

Table 5 Student assessment criteria

Score	Criteria
81≤100	Excellent
61<81	Good
41<61	Enough
21<41	Bad
0<21	Worst

Learning activities in the control class used the syntax of the Direct Instructions model provided in Table 4. Assessments of attitude (affective) and skills (psychomotor) were carried out during learning activities in both classes. Attitude assessment included aspects of religion, social, cooperation, and self-confidence. Skills assessment included creative, critical reasoning, process and results of herbarium making.

The data were collected in the form of knowledge, attitude and skill assessment data of students in both classes. Knowledge (cognitive) assessment was obtained from pretest and post-test results. Attitude and skill assessments were observed and valued base on affective and psychomotor assessment sheets. Student worksheet assessment was carried out to each group using the student worksheet assessment rubric that has been made. Herbarium assessment was carried out using a herbarium assessment sheet consisting of four aspects, namely organ completeness, description and classification, size and layout, and herbarium size. Herbarium assessment refers to the assessment rubric that has been made before, while the attitude and skills assessment sheet was carried out at each meeting with a maximum score of 4 on each aspect. The assessment scores obtained was calculated to obtain a score, using the Formula 1.

$$\text{Score} = \frac{total\ score\ obtained}{maximum\ score} \text{ x } 100 \text{ ……..Formula 1}$$

Learning outcomes were a combination of knowledge, attitude and skills assessment results. The data on learning outcomes obtained can be seen according to criteria by Ridwan (2015) which listed in Table 5. Learning outcome data were then tested for normality and homogeneity. If the learning outcome data was normally distributed and homogeneous, then proceed with the t-test to compare the experimental class and control class after being given the treatment. The t-test used independent sample t-test with the help of Microsoft Excel application. If the data on the learning outcomes of the experimental and control classes showed a significant difference, then proceed with the effect size test. Effect size testing was carried out to determine the magnitude of the effect of the treatment given to the experimental class, namely PjBL learning activities to make fern herbarium.

C. Results and discussion

PjBL learning activities (experimental class)

Project-based learning activities (PjBL) in the experimental class were carried out by providing examples that were easily found around the students' environment. Herbarium from the results of fern inventory research in *Hutan Lindung Gunung Raya* was used as a new learning material for students to learn to identify and classify plants found around their environment. This modification has an impact on the PjBL process as shown in Figure 1.

Figure 1 shows the process of implementing project-based learning (PjBL) to make fern herbarium implemented in the experimental class. The first stage, the teacher asked basic questions about solutions to the diversity of fern species and their roles that were not widely known so that it causesed a reduction in the number of these plant species, because their existence was ignored. The teacher then introduced the herbarium of ferns from the inventory in *Hutan Lindung Gunung Raya*, starting from the function and how to make it. The making and use of herbarium in learning activities by students has never been done before in SMPN 3 Paloh. Students then answered the

problem by recognizing the types of ferns through identification using the herbarium of ferns that have been made by the teacher. The questions given by the teacher indirectly made students gaining knowledge through investigation using the questions that had been given. Surya et al. (2018) stated that the application of the PjBL model allowed students to master concepts, solve a problem through project completion, and develop ideas or ideas to solve problems together. Students gained a deeper understanding of the material when they actively constructed their understanding by working together and using ideas (Kokotsaki et al., 2016).

In the second stage, students in groups made project planning. The planning that students do was to determine the tools and concepts and how to make a herbarium which was then written in the student worksheet. Making projects carried out by students will provide new experiences, because this has never been done by students before. Insyasiska et al. (2015) stated that project-based learning provided opportunities for students to imitate what scientists do which will provide interesting and enjoyable experiences for students. In addition, project-based learning can increase interaction among students and peers to produce products and gain meaningful learning experiences (Taupik & Fitria, 2021).

In the third stage, students compiled a schedule for making the project. Students were making plans during the herbarium making process, starting from taking plant samples, drying to pasting. Students were able to plan, carry out their designs, and present the projects that had been made so as to create long-term memory of the results they had learned (Palupi et al., 2024).

In the fourth stage, students begin to create the herbarium project. The teacher monitored the progress of the students' projects. As also found by Palupi et al. (2024), this indirectly creates communication from various directions, both between teachers and students, and between students.

In the fifth stage, students have made herbarium and further identifyed the specimen of ferns using herbarium made by the teacher (Figure 2). The introduction of herbarium made from *Hutan Lindung Gunung Raya* can be utilized as a learning material for students that can make it easier to identify certain specimens (Syamsiah et al., 2020). Herbarium from previous research can help students identify ferns found around their environment by looking at the similarities in morphological characteristics (Rezeqi & Handayani, 2018). At this stage, the teacher also assessed the herbarium that has been made by students. Product presentations were not carried out due to limited lesson time. In the sixth stage, experience evaluation was conducted. Students conveyed their feelings and experiences while completing the project (Apriany et al., 2020).

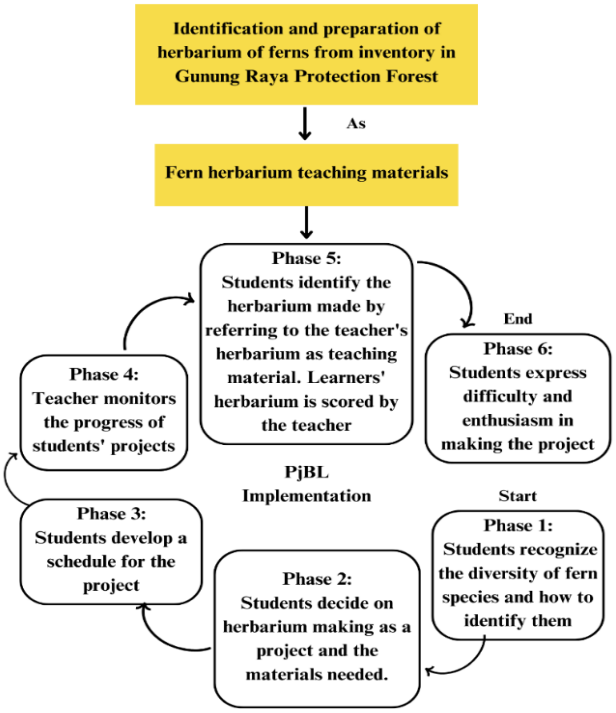

Figure 1
Implementation process of project-based learning using herbarium as teaching concept and project

Figure 2
Identification activities using herbarium from the results in *Hutan Lindung Gunung Raya* reseach

Learning activities DI (control class)

Learning activities using the Direct Instructions (DI) model in the control class were carried out by delivering concept directly to students and providing further assignments in the form of making herbariums (Table 4). Unlike the experimental class, students in control class worked on the project without monitoring along finishing the project. In addition, the identification process used literature such as identification websites https://www.plantamor.com/ on the internet (Plantamor, n.d.).

In the first stage, the teacher conveyed the learning objectives to be achieved. Then, at the stage of

demonstrating knowledge and skills, the teacher introduced the herbarium of ferns from the results of research in the *Hutan Lindung Gunung Raya* as an initial introduction. At this stage the teacher also delivered the material in accordance with the content in the textbook without providing opportunities for students to explore further, so that learning was teacher centered. In the DI model, teachers convey materials directly to students, so there is only one-way communication in learning activities (Sidik & Winata, 2016). This made students less active and unable to be independent without a teacher (Diani et al., 2021).

In the guiding stage of training, there was communication among students, because students worked together in doing the activities contained in the student woksheet in groups. Sholihah & Amaliah (2022) stated that group discussions carried out by students can create interactions between group members in order to complete the tasks that have been given by the teacher together, to involve the activeness of students in collaboration.

In the next stage, the teacher provided feedback to students regarding the concept that has been taught in the previous stage. Giving feedback aimed to see if students have done the tasks given correctly and see the extent of students' understanding of the concept provided (Arianti et al., 2016). At the time of providing feedback, students only memorized the concepts given by the teacher without understanding the meaning of the learning material. This allowed students to only be able to master concepts at the lowest cognitive level and depend on the teacher's mastery.

Furthermore, the teacher gave the task of making a fern herbarium as a form of implementation of the last stage in the DI model, providing opportunities for application. Arianti et al. (2016) stated by this time student can be trained to more complex situations in everyday life for example classifying the types of ferns around the environment and making them in the form of herbarium.

Students were given two weeks to complete the creation of a herbarium. The project development in the control class was not conducted with structured planning as in the experimental class, thus only focusing on the final result of the project. Suryadi (2022) states that learning in the DI model is centered on the teacher delivering the content of the material in a structured manner, thus focusing on learning achievement results. The herbarium created by the students was brought to the final meeting for identification.

During the identification activity, students in the control class only used a website plantamor in laptop program to identify the fern herbarium they found by comparing it to images on the laptop screen (Figure 3). Control class students used identification websites such as plantamor to identify the ferns they found. This was noticeably different from the experimental class, which used actual herbarium samples (Figure 2) for identification, allowing students to clearly observe the herbarium used as an identification tool.

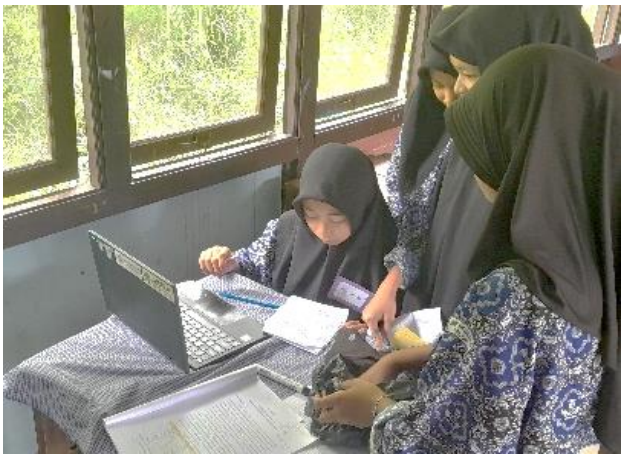

Figure 3 Identification activity using online sources

Student learning outcomes

The pretest data of experimental and control class students were then analysed using the U-Mann Whitney test because there was one data that was not normally distributed. The U-Mann Whitney test was conducted to see if there was a difference between the two classes before treatment. The results of the U-Mann Whitney test showed that there were no significant differences between the experimental and control classes before treatment, so they were considered to have the same initial ability (0.454<0.05).

The learning outcomes, including assessments of knowledge, attitudes, and skills, from the experimental class were compared with those of the control class to observe any differences between the two. The data on the learning outcomes of the experimental and control classes after treatment shown in Table 6.

Table 6 Student learning outcomes in the experimental and control classes after treatment

	Knowledge	Attitude	Skills	Average
Experimental	75.3	82.3	76.8	78.13
Control	67.8	78.5	69.2	71.83

The average learning outcome score of the experimental class (78.13) was higher significantly than that of the control class (71.83) based on t-test alpha 0.05. These results were in line with Insyasiska et al. (2015), which showed differences in cognitive learning outcomes and creativity between experimental and control classes. The experimental class, taught using PjBL, had higher average learning

outcomes compared to the control class, which was taught using a conventional model. This showed that the PjBL model, through making a fern herbarium, has an impact on student learning outcomes.

In the attitude assessment, the experimental class achieved an average score of 82.2 (very good), while the control class achieved an average score of 78.5 (good). The average attitude scores in both classes were relatively close; nevertheless, each fell into different criteria namely very good and good criteria, subsequently. This was due to the control class students becoming more active during group discussions while working on activities in the student worksheets. During these discussions, communication occurred among group members, which helped developing social skills, teamwork, and confidence in the students. Sholihah & Amaliyah (2022) stated that group discussions can make students interacted with each other to solve the problems given.

In the experimental class, interactions during learning activities were more frequently. Discussions were not only occurred among group members but also with the teacher, such as when the teacher monitored the students' project progress. Additionally, the experimental class students were more disciplined in completing the project due to the schedule created during the project planning phase. Students were able to complete the project according to a predetermined schedule, thus increasing cooperation among group members. Surya et al. (2018) stated that the PjBL learning model can develop students' attitudes in expressing opinions, respecting others' opinions, deliberating in groups, and cooperating to complete assigned projects.

The skills assessment results showed that the experimental class achieved an average score of 76.8 (good), while the control class obtained an average score of 69.1 (good). These results indicated that both classes obtained scores classified as good, but with different scores where the experimental class scored higher than the control class. This was because in the PjBL model, students had the freedom to learn, which motivated them to explore themselves through the projects they undertook, without the rigid rules typically found in conventional learning (Dewi, 2022).

In project-based learning, students were trained to determine alternatives or solutions to problems through projects, stimulating critical thinking skills (Rafik et al., 2022). In the experimental class, students were presented with problems related to types of ferns that were not well known to the public and whose existence was often overlooked. However, ferns play an important role in the ecosystem and were beneficial to humans. In this case, students determined solutions to the problems presented, leading to critical thinking to address these issues. Additionally, Sari & Anggreini (2018) stated that project-based learning enhanced skills, especially creative thinking, when working on a project.

Statistical analysis was conducted to assess the significance of the differences between the experimental and control classes using t-test. Before performing the t-test to examine the differences in learning outcomes between the two classes, normality and homogeneity tests were conducted first. The results of the normality test were listed in Table 7. The results of the normality test indicated that the learning outcome data for both the experimental and control classes were normally distributed because the $L_{count}<L_{table}$. The analysis was then continued with the homogeneity test used the F-test. The results of the homogeneity test were listed in Table 8. Then, the results of the homogeneity test showed that the data were homogeneous because the $F_{count}<F_{table}$. The data analysis was continued with t-test to see the difference in learning outcomes between the two classes, because both data were normally distributed and homogeneous. The results were listed in Table 9.

Table 7 Results of the normality test for the experimental and control classes after treatment

Class	L_{count}	L_{table}	Results	Descriptions
Experimental	0.105	0.200	$L_{count} < L_{table}$	Normally distributed
Control	0.108	0.213	$L_{count} < L_{table}$	Normally distributed

Table 8 Results of the homogeneity test for the experimental and control classes

Class	Variance	F_{count}	F_{table}	Result	Description
Experimental	26.13	1.55	2.31	$F_{count} < F_{table}$	Homogeneous Data
control	40.63				

Table 9 Results of the t-test for learning outcomes of the experimental and control classes

Class	Variance	S	t_{count}	t_{table}	Result	Description
Experimental	26.13	5.63	3.31	1.69	$t_{count}t > t_{table}$	Significant Difference
Control	40.63					

Description: S = Combined variance

The statistical analysis of student learning outcomes indicated a significant difference between the experimental and control classes after the treatment, as evidenced by the $t_{count}>t_{table}$, specifically 3.31>1.69. These results were supported by Harizah et al. (2021), which showed a significant difference between the learning outcomes of students taught using the PjBL model and students taught using the conventional model. This indicated that in PjBL learning, students can conduct real experiments within their groups. The series of learning activities in PjBL can actively encouraged students to independently build their knowledge and skill. The differences between the two classes were also evident in the processes involved in the creation of the herbarium and the identification activities, as shown in Figure 4. The differences in the herbarium created by students in the experimental and control classes were reflected in the scores obtained for each assessment aspect of the herbarium (see Table 10).

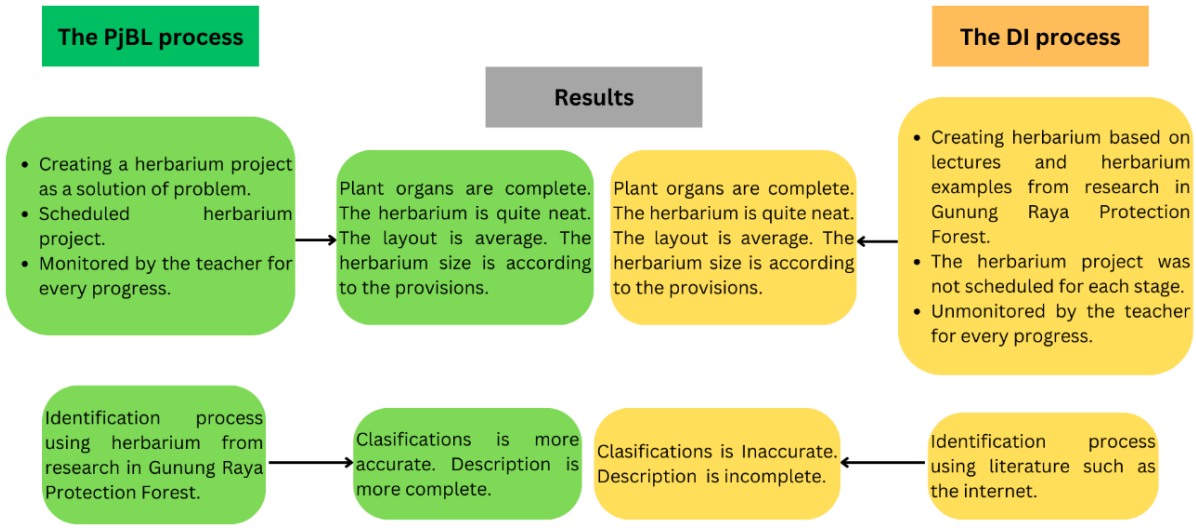

Figure 4 Differences in herbarium creation and identification between PjBL and DI model

Table 10 Herbarium scores for students on each aspect

Class	Completeness of organs	Description and classification	Neatness and layout	Herbarium size
Experimental	80	80	75	95
Control	80	65	70	95

Based on the four aspects assessed on herbarium assessment between experimental and control classes, two aspects, namely organ completeness and herbarium size, had the same scores between experimental and control class students. However, in the classification and description aspect, students in the experimental class had a higher score (85) compared to students in the control class (65). The results of identification and description in the experimental class were more accurate, with the naming of fern species and the descriptions being more comprehensive. This result was because students carried out identification using herbarium from the result in *Hutan Lindung Gunung Raya*, which made the observed objects more clear and real, making it easier for them to identify the ferns they encountered. The herbarium specimens made by the experimental class students were the same as the specimens obtained from the research conducted in *Hutan Lindung Gunung Raya* so that the herbarium results from this study could be a reference to help identify herbarium samples from students.

Bria et al. (2023) stated that direct observation of objects or through the preservation and preparation of organisms as learning material will better support the achievement of competencies and optimal learning objectives, as students were more engaged and focused in their learning. However, to anticipate different scenarios, if the plant specimens found by students did not match the provided herbarium specimens, alternative literature sources can be used to assist in identifying the species obtained. In the control class, the writing of identification results and descriptions was still lacking in completeness. This was because students in the control class relied on literature such as websites on the internet, where they had to search for images that most closely matched the ferns they discovered.

Additionally, in the aspect of neatness and layout, the experimental class achieved a slightly higher average score (75) compared to that of control class (70). This was because in the process of creating their herbarium, the experimental class had a scheduled plan for each stage that was monitored by

the teacher. In contrast, the control class students created their herbarium merely to fulfill an assignment without a planned schedule for each stage, and their work was not monitored by the teacher. The herbarium samples from the students and the herbarium specimens obtained from research in the *Hutan Lindung Gunung Raya* shown in Figure 5. The higher learning outcomes in the experimental class compared to the control class indicated the influence of the PjBL learning activities conducted. This was evident in the results of the effect size analysis of student learning outcomes, as shown in Table 11.

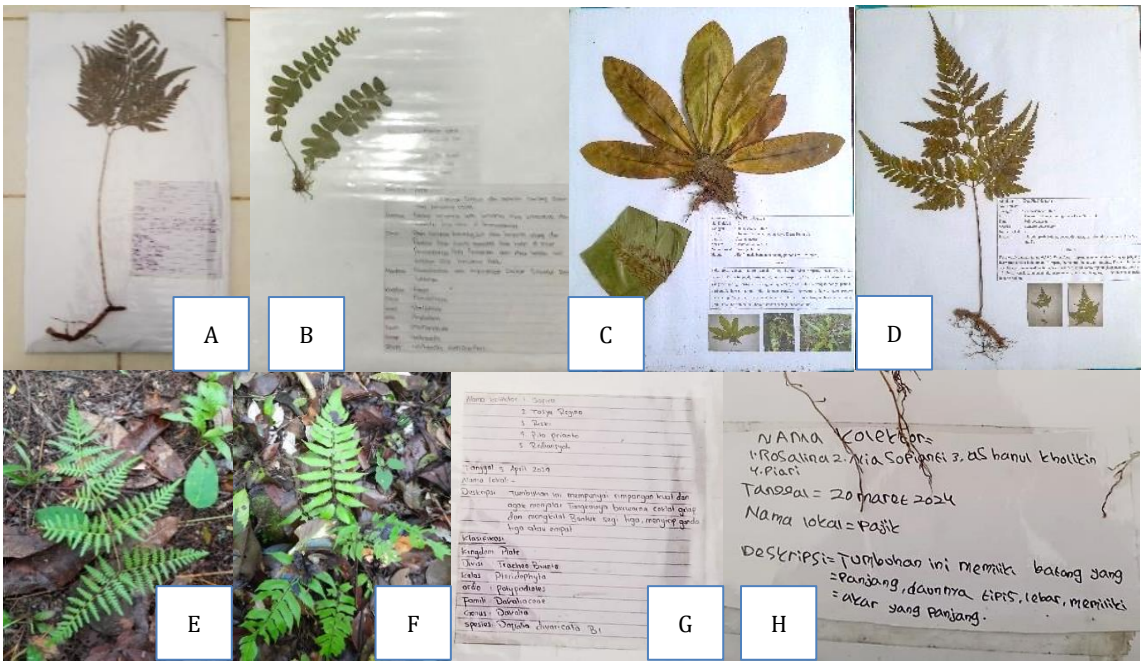

Figure 5
Student and teacher herbarium samples: (A) Herbarium from the experimental class, (B) herbarium from the control class, (C) and (D) herbarium samples from research in the *Hutan Lindung Gunung Raya*, (E) and (F) fresh sample example, (G) identification result from experimental class, and (H) identification results control class (text in Indonesian)

Table 11 Results of the effect size test

Class	M	S_d	d	Category
Experimental	78.13	5.11	2.3	High
Control	71.83	6.37		

Descriptions:
M = Average
S_d = Standard deviation
d = effect size value

The effect size test results for student learning outcomes showed a value of 2.3, when converted according to the effect size calculation categories outlined by Handayani et al. (2018), fall into the high category. This finding showed that the implementation of the PjBL model through making fern herbarium impacted on improving the learning outcomes of 7th grade students at SMPN 3 Paloh. This was supported by Mayuni et al. (2019) that the PjBL model has a high influence on student learning outcomes. The high effect size value was attributed to the improvement in learning outcomes observed in the experimental class after the implementation of the PjBL learning model using fern herbariums. The PjBL learning model can improve student learning outcomes because there was a lot of interaction during the learning process (Palupi et al., 2024). This finding of using herbarium as a project in PjBL indicates that other environmental projects can be used to improve students' knowledge, skills and attitudes, as well as improve problem-solving abilities so as to support the achievement of learning competencies and objectives (Bria et al., 2023).

D. Conclusion

The learning outcomes of students taught with the PjBL model were significantly higher different from the learning outcomes of students taught with the DI model of making fern herbarium. On the results of herbarium assessment, the experimental class had higher scores in the description and classification aspects compared to the control class. Learning

outcomes included assessment of knowledge, skills and attitudes show the experimental class taught with the PjBL model making herbarium of ferns significantly higher from the control class taught with the DI model. This indicates that the use of environment-based projects can be developed in PjBL rather than DI and provides more opportunities for students to explore ways out of a problem. So that they can understand learning material more comprehensive. Biology learning is recommended to optimize environment-based PjBL, technology integration, and competency-based assessment to improve students' understanding and skills. The curriculum should also support ecological literacy and conservation awareness.

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