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Integrating Amorphophalus Of Bukit Barisan Selatan National Park Into Problem-Based Learning to Foster Higher-Order Tinkhing Skills and Responsibility

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Abstract

This study was conducted to determine the effect of integrating Amorphophallus diversity from Bukit Barisan Selatan National Park (BBSNP) within a problem-based learning (PBL) framework focused on biodiversity on the higher-order thinking skills and sense of responsibility of male and female students. A non-equivalent control group pretest-posttest design was employed. The sample was selected from a population of seven classes; Class X.1 was designated as the experimental group and Class X.2 as the control group, following an ANOVA consistency check. Research instruments included a higher-order thinking skills test and a Likert-scale questionnaire on responsibility. Data analysis revealed a significance value of 0.000 for the model, which is less than 0.05; this indicates that the implementation of PBL integrating TNBBS Amorphophallus diversity significantly influenced students' higher-order thinking skills. Meanwhile, the significance value for gender was 0.964 (> 0.05), indicating no difference in learning outcomes between male and female students. Consistent with the findings on higher-order thinking skills, there was no significant difference in the sense of responsibility between male and female students in the sample classes; both groups demonstrated development within the "good" category. These findings demonstrate that integrating local biodiversity into biology instruction significantly impacts specific learning outcomes.

Keywords: amorphophallus, biodiversity, PBL, HOTs, responsibility.

Integrasi Amorphophalus TNBBS Pada Materi Keanekaragaman Hayati Dalam *Problem-Based Learning* Terhadap Sikap Tanggung Jawab dan Hots Siswa Laki-Laki dan Perempuan

Penelitian ini dilakukan untuk mengetahui pengaruh integrasi keanekaragaman amorphophallus di Taman Nasional Bukit Barisan Selatan (TNBBS) pada materi keanekaragaman hayati dalam *problem-based learning* terhadap keterampilan berpikir tingkat tinggi dan tanggung jawab siswa laki-laki dan perempuan. Desain penelitian menggunakan pretest-posttest kelompok kontrol non-ekuivalen. Sampel penelitian ditentukan dengan menerapkan uji konsistensi ANOVA dan dipilih kelas X.1 (eksperimental) dan kelas X.2 (kontrol) dari populasi 7 kelas. Instrumen penelitian berupa tes keterampilan berpikir tingkat tinggi dan kuesioner tanggung jawab dengan skala Likert. Hasil analisis data menunjukkan nilai signifikansi (sig. value) untuk model sebesar 0,000 yang lebih kecil dari 0,05. Ini berarti

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bahwa penerapan PBL-integrasi keanekaragaman amorphophallus TNBBS memiliki pengaruh signifikan terhadap keterampilan berpikir tingkat tinggi siswa. Sementara itu, nilai signifikansi untuk jenis kelamin menunjukkan angka 0,964 > 0,05 yang berarti tidak ada perbedaan hasil belajar antara siswa laki-laki dan perempuan. Selaras dengan data keterampilan berpikir tingkat tinggi, sikap tanggung jawab siswa laki-laki dan perempuan di kelas sampel juga menunjukkan tidak adanya perbedaan yang signifikan. Artinya baik laki-laki dan perempuan mengalami perkembangan dalam katagori baik. Temuan ini menunjukkan bahwa integrasi keanekaragaman hayati lokal dalam pembelajaran biologi memiliki pengaruh signifikan terhadap peningkatan hasil belajar spesifik.

Kata kunci: amorphophallus, keanekaragaman hayati, PBL, HOTs, tanggung jawab

INTRODUCTION

Amorphophallus is a genus of plants that has the characteristic of flowers with cobs shaped like imperfect male genitalia (amorphous, damaged shape; phallus, male genitalia). In addition, the presence of tubers and a foul aroma when the flowers bloom are also common characteristics of this group of plants (Sundari et al., 2022). Due to the difference in ripening time between male and female flowers, this plant is difficult to reproduce naturally and its status is rare and protected. There are around 25 species that live in Indonesia and one of them, *Amorphophallus titanum* is endemic to Sumatra, precisely in the Bukit Barisan Selatan National Park (BBSNP) area (Sulistyawati et al., 2018). In addition, other species from the Amorphophallus Genus were also found, namely *Amorphophallus gigas, Amorphophallus paeoniifolius, Amorphophallus asper, Amorphophallus beccari* and *Amorphophallus muelleri* (Malik et al., 2020). Amorphophallus plants have great potential to be used as food and medicine, but not infrequently due to limited knowledge some people consider them as weeds (Claudel et al., 2023). As a herbaceous plant, amorphophallus plants also ecologically function as water retainers on the forest floor so that it does not evaporate easily. The high diversity and potential benefits, Amorphophallus plants are worthy of being integrated into learning on the topic of biodiversity.

Biodiversity is a term that refers to the diversity of life on earth which includes genetic variation, species and ecosystems. Some biodiversity issues that are currently in the world spotlight include the loss of natural habitats, excessive exploitation of natural

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resources and climate change which have an impact on the level of biodiversity, ecosystem balance and human welfare (Echeverria et al., 2021). Indonesia as a country that was once determined to have the second highest level of biodiversity after Brazil, in fact has the longest list of endangered species in the world. Therefore, serious collaborative efforts are needed to prevent and mitigate biodiversity threats. Bringing biodiversity issues into classroom learning is thought to be able to foster students' sensitivity to current problems. Integration with the local context, namely the diversity of amorphophallus in BBSNP and its problems, is thought to be able to add meaning to the learning experience and influence student learning outcomes. The results of the study showed that plant diversity in BBSNP has great potential in supporting the achievement of the objectives of implementing the curriculum in Indonesia (Wiono & Meriza, 2021).

The challenges facing Indonesian education in the 21st century extend beyond the development of students' cognitive competencies to encompass their responsibility toward environmental sustainability and biodiversity conservation. International assessment results indicate that Indonesian students struggle to analyze scientific phenomena, evaluate evidence, and apply scientific concepts to solve real-world problems (Reski et al., 2024). These competencies are closely linked to higher-order thinking skills, which biology education is expected to foster. This conclusion aligns with domestic research findings showing that Indonesian students' higher-order thinking skills fall within the low-to-moderate range. One study found that students demonstrated relatively poor performance when answering biology questions requiring analysis, evaluation, and creation (Fauzi & Wicaksono, 2021). Similarly, studies on biological literacy regarding biodiversity reveal that students have not yet fully developed the ability to connect scientific concepts with environmental and conservation issues (Reski et al., 2024). These findings suggest that biology instruction has not yet fully facilitated the development of the higher-order thinking skills necessary to generate solutions for contemporary environmental problems.

Specifically in Lampung, several studies indicate that higher-order thinking skills have not been optimally developed through school-based instruction. Research shows that the implementation of HOTS-oriented assessment in classrooms remains limited; consequently, students do not consistently engage in analytical and evaluative tasks

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(Herlisya, 2025; Wiono & Meriza, 2022). Furthermore, regarding the attitude of responsibility, a high level of conceptual understanding of biodiversity does not automatically translate into proactive environmental responsibility or conservation behavior (Surbakti, 2017). Contextual learning approaches that integrate local biodiversity and conservation issues remain underutilized. Given that Lampung is home to significant conservation areas—such as BBSNP—integrating local biodiversity issues into the curriculum is essential to foster a sense of responsibility and higher-order thinking skills among high school students. Such contextual learning is expected to bridge the gap between scientific knowledge and active student participation in biodiversity conservation.

Several studies have demonstrated that problem-based learning effectively enhances critical thinking skills (Nurhayati et al., 2021), scientific literacy (Wiono et al., 2025), collaboration (Dewi & Mercuriani, 2024), and problem-solving abilities (Vidergor, 2018). Other research has integrated topics regarding biodiversity and local resources into biology instruction to improve students' scientific literacy and science process skills (Hidayat et al., 2024; Nadia et al., 2024). However, previous studies have largely focused on cognitive outcomes, rarely simultaneously addressing the affective dimension of responsibility toward biodiversity conservation. Responsible behavior in this study refers to the definition of actions based on the motivation to prevent damage or improve the environment (Oktaviana et al., 2022). Furthermore, research integrating local biodiversity conservation issues into problem-based learning remains limited, particularly regarding rare and endemic plant species found in conservation areas. To date, no study has specifically integrated Amorphophallus species from BBSNP into problem-based learning to foster student responsibility and higher-order thinking skills. Because in fact, responsible behavior will lead a person to develop important skills that are closely related to environmental conservation (Luong & Van, 2021). Existing biodiversity learning materials are generally presented as conceptual content, lacking authentic conservation problems that would enable students to analyze ecological issues, propose solutions, and develop a personal sense of responsibility for biodiversity preservation.

There are several structural differences in the brain between males and females that influence their ability to process, respond to, and store information. The

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hippocampus—a brain region involved in long-term information storage—is larger in females than in males. Differences are also found in the cerebral cortex, potentially leading to variations in thought control, decision-making, and intellectual functioning between the sexes (Sasser, 2010). Given these structural and neurobiological differences, analyzing learning outcomes from a gender perspective is crucial. Gender-based differences influence not only cognitive processes and high-level reasoning but also play a significant role in shaping attitudes toward the environment, affective responses, and pro-environmental responsibility. Empirical studies indicate that female students often demonstrate higher levels of environmental concern, affective responsibility, and consistency in sustainable behavior, whereas male students tend to exhibit greater confidence in practical problem-solving and in mastering conceptual and technical material. Some research shows no significant difference in learning outcomes between male and female students (Hasnunidah & Wiono, 2019; Wiono, 2023; Wiono et al., 2025). Conversely, other studies suggest that female students excel in demonstrating thinking skills, while male students tend to engage more in practical activities (Wiono & Dewi, 2023). This indicates the existence of distinct learning behaviors for males and females, consistent with their brain structure differences. Within the framework of Problem-Based Learning (PBL)—where real-world environmental issues, such as Amorphophallus conservation in BBSNP, demand both deep analytical skills and a strong sense of ethical responsibility—there remains a significant research gap regarding how male and female students differently process and respond to the local biodiversity crisis. Examining Higher-Order Thinking Skills (HOTS) and environmental responsibility through a gender lens provides a more comprehensive and nuanced foundation, enabling educators to design inclusive and gender-responsive PBL strategies that optimize cognitive reasoning and bridge the gap between awareness and tangible conservation action for both male and female students.

Based on the background above, this article highlights the characteristics of male and female students' learning behavior in developing high-level thinking skills and attitudes of responsibility through problem-based learning. The novelty of this study lies in the use of local issues, namely amorphophallus plants in BBSNP in biodiversity materials during the biology learning process. It is hoped that learning can take place more meaningfully and the solutions created by students are more effective in

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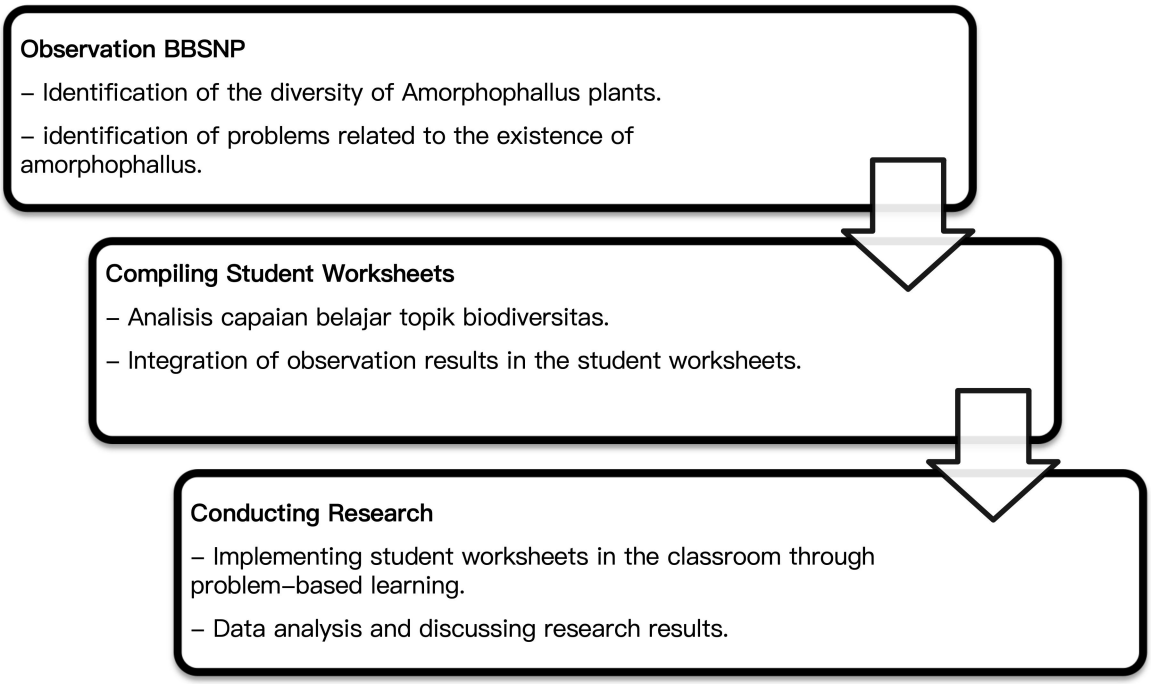
accordance with the problems of amorphophallus plant biodiversity in BBSNP.

RESEARCH METHODS

This research began by identifying the diversity of amorphophallus plants in BBSNP. The next step is to integrate the findings of field observations with biodiversity content in the form of Student Worksheets adjusting the syntax of problem-based learning. The series of research activities are described in the following flowchart.



Figur 1. Research Flow

This study was conducted by applying a quasi-experimental method in a pretest-posttest non-equivalent control group design. As an independent variable, namely the problem-based learning model, while the independent variables are high-level thinking skills and responsible attitudes. While gender acts as a moderating variable. The design of the research plan is presented in Table 1.

Table 1. Factorial Research Design

Gender	Learning model (M)	
	PBL (M_1)	GI (M_2)
Boys (G_1)	M_1G_1	M_2G_2
Girls (G_2)	M_1G_2	M_2G_2

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The research location is at SMAN 1 Semaka, Lampung Province considering the proximity to the TNBBS forest area. The research sample was determined by applying the ANOVA consistency test and selected class X.1 (experimental) and class X.2 (control) from a population of 7 classes. The research instruments used were multiple choice high-level thinking skills tests and responsibility attitude questionnaires. The high-level thinking skills test was developed by referring to (Krathwohl, 2008) with indicators of analyzing, evaluating and creating is presented in Table 2. Meanwhile, the responsibility attitude questionnaire was compiled by referring to Hegel's theory with indicators of obeying, caring and acting as presented in Table 3.

Table 2. High-Order Thinking Skills Indicators

No.	Level of thinking	Descriptions
1.	Analyze	Breaking down information, ideas, or concepts to understand its parts and the relationships between them.
2.	Evaluate	Assess the advantages and disadvantages of an idea, solution, or product based on certain criteria.
3.	Create	Combining ideas or information to create something new and original.

Before being used, all questions were confirmed for their validity and reliability using standardized tests, namely sequentially product-moment correlation and Cronbach's alpha. Data analysis was assisted by the Windows SPSS version 25 data processing application. The collected high-level student skills data were then tested for normality and homogeneity by applying the Kolmogorov-Smirnov one sample test formula and the Levene test of equality of variances error with a significance level of 5% each. Hypothesis testing was carried out by applying the independent sample t-test assisted by the SPSS version 25 application. Test criteria, If p-value <0.05 then H_0 is rejected and if p-value ≥ 0.05 then H_0 is accepted.

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Table 3. Responsible Attitude Indicators

No.	Dimensions	Descriptions
1.	Comply	Demonstrate awareness of the importance of the existence of amorphophallus plants in BBSNP.
2.	Care	Mentioning conservation measures for amorphophallus plants in BBSNP. Mentioning current issues related to amorphophallus in BBSNP.
3.	Action	Use materials that cause pollution wisely.

The questionnaire contains 30 closed statements with answer choices using a Likert scale with five answer criteria, namely Strongly Disagree; Disagree; Cannot Determine; Agree; and Strongly Agree. The scale value is determined by the distribution of agree or disagree responses from a group of respondents acting as a trial group (pilot study). Furthermore, the attitude score of each student will be categorized based on the attitude criteria of the Bertram scale. After that, a two-way ANOVA test calculation is carried out, so that from the data the researcher can determine which dimensions are most mastered by the students.

RESULTS AND DISCUSSION

Field observations in the Sukaraja Atas resort area of BBSNP found six species of amorphophallus plants, namely *Amorphophallus titanum, Amorphophallus gigas, Amorphophallus paeoniifolius, Amorphophallus asper, Amorphophallus beccari* and *Amorphophallus muelleri*. Furthermore, this information is integrated into biodiversity material through student worksheets with reference to learning outcomes and PBL syntax. At the end of phase E, students are required to have the ability to respond to global issues and play an active role in solving problems (Kemdikbud, 2022). This achievement will be achieved by students by recognizing, analyzing and building effective solutions to the problem of decreasing levels of amorphophallus diversity in BBSNP. Meanwhile, student worksheets developed based on the PBL concept have been shown to influence the development of students' high-level thinking skills (Herman et al., 2022). The function of student worksheets in this study is to direct

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students' learning activities and high-level thinking exercises such as analyzing problems, evaluating learning products and creating effective solutions.

Amorphophallus titanum

Amorphophallus gigas

Amorphophallus paeoniifolius

Amorphophallus asper

Amorphophallus beccari

Amorphophallus muelleri

Figure 2. Amorphophallus species in the Sukaraja Atas Resort of BBSNP (resource: private document)

Figure 2 reveals the presence of six species identified during field research at the Sukaraja Atas resort BBSNP. Each Amorphophallus species exhibits unique morphological characteristics: *A. titanum* is distinguished by the world's largest compound inflorescence, featuring a towering spadix and a blackish-purple spathe; *A. gigas* stands out due to an exceptionally long inflorescence stalk (peduncle) that exceeds human height; *A. paeoniifolius* features a short, broad inflorescence cup and a large, edible corm (suweg); *A. asper* is characterized by a rough petiole surface with dark speckles; *A. beccarii* is notable for its curved spathe and a spadix that appears slender and delicate; and *A. muelleri* (porang) is recognized by the presence of bulbils at the leaf vein branch points, serving as specialized vegetative organs. Despite their specific differences, all six are grouped within the Amorphophallus genus due to shared

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taxonomic traits characteristic of the Araceae family: an underground corm system; a single, palmately compound leaf divided into three sections (trisect); distinct vegetative and generative phases (monophagic/heterophagic); and a characteristic inflorescence consisting of a spadix enclosed by a spathe that emits a scent of decay to attract pollinating insects. These diverse species thrive in BBSNP thanks to favorable conditions: a wet tropical climate, high humidity, a forest canopy providing shade, and humus-rich, well-drained volcanic soil—an ideal environment that sustains the dormancy and corm growth cycles of Amorphophallus in the wild (Claudel et al., 2023).

Table 4. Results of the Test of the Influence of Learning Models, Gender, and Their Interactions on Higher Order Thinking Skills.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2625.039[a]	3	875.013	15.122	.000
Intercept	377725.784	1	377725.784	6.528E3	.000
Model	1594.945	1	1594.945	27.564	.000
Gender	.116	1	.116	.002	.964
Model * Gender	373.013	1	373.013	6.446	.013
Error	3819.033	66	57.864		
Total	417633.000	70			
Corrected Total	6444.071	69			

a. R Squared = ,407 (Adjusted R Squared = ,380)

Table 4 show the results of the statistical analysis that there are differences in learning outcomes based on the learning model applied in the control class and the experimental class. It can be seen in Table 4. that the sig. value for the model is 0.000 which is smaller than 0.05. Meanwhile, Table 4. Also shows that there is no difference in student learning outcomes based on gender because the sig number is 0.964 > 0.05. While the interaction between the learning model and gender obtained a result of 0.013 < 0.05 which means it has an effect on student learning outcomes. The results of this statistical analysis conclude that the application of integrated PBL-amorphophallus BBSNP diversity has a significant effect on students' high-level thinking skills.

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Meanwhile, no significant difference was found between the achievements of male and female students.

Students in the experimental class appeared mentally active in formulating problems and finding solutions to the decreasing diversity of amorphophallus in BBSNP. They collaboratively identified and analyzed the main problems that were caused by both natural and human actions. Scientific debates also occurred when they validated the information that would be used to build solutions. When presenting the results of group work, student representatives appeared confident when conveying solutions and the underlying reasons. All of these activities confirmed that integrated problem-based learning of amorphophallus biodiversity in BBSNP had a significant effect on students' high-level thinking skills. Selecting the right problems was also proven to be able to train thinking skills and solve problems in the real world. The learning outcomes of students in the experimental class are illustrated in Table 5, which shows a higher corrected average value than the control class.

The findings of this study are in line with the conclusions of (Annisya & Suyanti, 2024) that PBL has a significant influence on HOTS of grade XI students on acid-base material. In the field of biology learning, it was also found that PBL has a significant effect on students' HOTS on the material of the muscular and skeletal systems (Nomleni & Nubatonis, 2021). Meanwhile, at the university level, lectures implementing PBL also have a significant effect on high-level thinking skills of physics education students on the topic of optics (Nurhayati et al., 2021). The results of these studies have shown that the application of PBL at the junior high, high school and university levels has a significant effect on HOTS in natural science clusters such as chemistry, physics and biology content. This is very coherent with the characteristics of PBL which in its application is able to train students to formulate problems clearly, identify problems correctly, explore information to build solutions, and convey solutions firmly to the audience.

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Table 5. Comparison of Corrected Mean Values of Higher Order Thinking Skills in the two models

Models	Mean value				Notation
	Initial	Final	Difference	Corrected	
PBL	62,74	82,31	19,57	81,68	a
GI	59,86	70,97	11,11	71,72	b

*. The mean difference is significant at the 0,05 level.

Table 5 shows that the average higher-order thinking skill scores of students in the experimental class were higher than those in the control group. In the control class, the topic of biodiversity was introduced by examining the biodiversity levels of the Bali starling, a species endemic to the island of Bali. The issues integrated into the lesson were real-world in nature yet unfamiliar to the research sample in Lampung. Instruction was conducted using the steps of the guided inquiry model. Structurally, this model did not provide students with the opportunity to present their learning outcomes or evaluate the problem-solving process. Yet, the learning objectives for this topic required students to demonstrate their role in addressing the decline in biodiversity and its impact on life. Consequently, student learning outcomes—specifically their proposed action plans—required more comprehensive feedback, which could be facilitated by the structure of a problem-based learning approach. Similar findings have been reported in other studies regarding the application of the guided inquiry model, noting its lack of a stage for evaluating student learning outcomes (Fatimah et al., 2020; Nuzuliya, 2024). Furthermore, the integration of local potential into guided inquiry did not have a significant effect on learning outcomes (Hidayatussani et al., 2020).

Table 6. Average Results of High-Order Thinking Skills

No.	Level of thinking	Pretest	Postest	Difference	n-gain	Category
1.	Analyze	23,13	77,92	54,79	0,70	High
2.	Evaluate	22,29	78,75	56,46	0,72	High
3.	Create	19,58	76,87	57,29	0,70	High

Table 6 presents the results of implementing problem-based learning and its impact on higher-order thinking skills, as evidenced by the progress of specific indicators: analyzing, evaluating, and creating. Overall, the N-gain scores fell into the

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high category. This outcome is attributed to the stages of problem-based learning, which encourage students to actively engage in classroom problem-solving activities. This student-centered approach is designed to guide students in constructing knowledge through interactions with learning resources, peers, and the teacher (Atmojo et al., 2022). If this series of activities is developed sustainably, it will transform the behavior of individuals or groups, fostering an understanding of and concern for the decline in Amorphophallus biodiversity within BBSNP. Consequently, the knowledge gained serves as a foundational skill, enabling students to comprehend how events unfold and the significance they hold.

Analytical skills develop as students are trained to read and understand the discourse presented by the teacher using problem-oriented syntax. Students are trained in groups to identify important issues within the discourse on the decline of amorphophallus biodiversity in BBSNP. Students who successfully identify problems then discuss and confirm them as a group. Meanwhile, evaluation skills are developed through the final syntax, namely evaluating the problem-solving process. In this session, students and teachers jointly review the solutions (learning outcomes) created by specific groups. Reduction, refinement, and confirmation are activities that are guaranteed to occur to ensure the quality of the learning product. In addition, the activities of each group member during the learning process are also evaluated together. This is done to enhance positive and constructive activities in subsequent learning. Creative skills in PBL are specifically trained in the syntax of developing and presenting results. After analyzing, confirming problems, and investigating, students are then trained in groups to create solutions. To ensure the solutions are understood and followed by the audience, they must also choose persuasive and educative words.

Several studies also show results consistent with these findings, such as those by (Nomleni & Nubatonis, 2021; Nurhayati et al., 2021; Nadila et al., 2024; Annisya & Suyanti, 2024). The overall results of the above studies conclude that each indicator of higher-order thinking skills—analyzing, evaluating, and creating—increased after the implementation of problem-based learning. This indicates that the syntax in PBL is able to stimulate students' analytical, evaluative, and creative abilities. The activity of finding collaborative solutions to the problems presented is able to build and consolidate knowledge constructively.

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Table 7. Comparison of Corrected Mean Scores of Higher Order Thinking Skills in Both Genders

Gender	Mean value				Notation
	Initial	Final	Difference	Corrected	
Boys	59,85	79,23	19,38	76,67	a
Girls	64,45	84,14	19.69	76,74	a

*. The mean difference is significant at the 0,05 level.

Table 7 shows that the development of higher-order thinking skills among students in the sample group did not exhibit significant differences. This demonstrates that both male and female students developed higher-order skills to a similar extent. These results align with findings from various studies regarding the influence of gender on learning outcomes related to scientific literacy, critical thinking, metacognitive awareness, and argumentation skills (Wiono & Rakhmawati, 2025; Wiono & Meriza, 2023; Wiono & Dewi, 2023; Hasnunidah & Wiono, 2019). However, during the learning process, female students appeared more active in asking pertinent and substantive questions compared to their male counterparts. Furthermore, the female students demonstrated greater precision and acuity when analyzing problems. This greatly facilitated group efforts to identify and confirm genuine issues within the source material and to formulate solutions. Another strength of the female students was evident during the presentation of findings, where only one of the five groups was represented by a male presenter. Conversely, the male students excelled in operating computers to create presentation visuals. These observations reinforce the conclusion drawn by brain researchers that the language-related areas of the brain function more actively in women than in men (Anwar et al., 2019).

Empirical research shows that males and females have the same potential to develop higher-order thinking skills through problem-based learning. However, when developing these skills, male and female students have different approaches (Firmanti, 2017; Wiono & Dewi, 2023). Most female students feel more comfortable when learning involves discussions, reading, writing, role-playing, and communication activities. Meanwhile, male students enjoy learning more through activities such as assembling, designing, creating simulations, and activities that stimulate hands-on practice. These differences stem from the brain structures of males and females, specifically the hippocampus, inferior parietal lobe, hypothalamus, and corpus callosum

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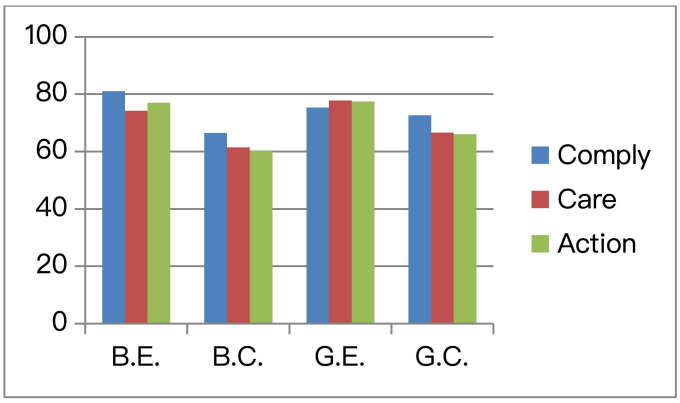
(Brizendine, 2006; Amin, 2018). Each of these areas is different in size in males and females, resulting in different outcomes (hormones and learning behaviors) in the two sexes. These findings also provide useful information for teachers when communicating with male and female students. While female students can be reprimanded simply by displaying displeasure, such as a look or a shake of the head, male students understand more quickly when stimulated by touch and sound.



Descriptions:
BE = Boys in Experiment Group
BC = Boys in Control Group
GE = Girls in Experiment Group
GC = Girls in Control Group

Figur 3. Results of the Responsibility Attitude Questionnaire

Figur 3. shows that the average score of students' responsibility attitudes in the experimental class is higher than the control class. However, based on the category, students in both classes have a responsible attitude in the same range, namely good (61 - 80). The average that reaches the very good category is seen in the obedient dimension (81) of male students in the experimental class. This means that both materials that integrate amorphophallus plants or Bali starlings in biodiversity learning develop students' responsibility attitudes in the good category. Likewise, both models applied in the experimental and control classes develop the dimensions of obedience, care and student action in the good category.

The absence of differences in categories in both sample classes indicates that current and real information about the biodiversity of amorphophallus and Bali starlings both provide insights related to the environment. In line with this, the sample's domicile located around the BBSNP area makes them familiar with forest flora and fauna. As the conclusion of a study also shows that students who often interact with nature show higher responsibility scores than groups who rarely come into contact with the environment (Suryanda et al., 2020). More specifically, it can be seen from the results of Wisnu's study (2023) which concluded that videos of ecosystem conditions in the

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People's Forest Park were able to influence students' attitudes of responsibility. A broader conclusion is also shown from the results of other studies which conclude that learning materials in science are able to strengthen attitudes of responsibility (Jeramat et al., 2019).

Further analysis of the questionnaire items showed that students in the experimental class appeared more aware of the importance of amorphophallus in BBSNP for the surrounding community, were aware of current issues and how to act appropriately according to their capacity, and were wise in using objects that could potentially reduce the population or species of amorphophallus in BBSNP. This understanding will lead to strengthening students' conservation literacy, enabling them to act wisely when interacting with the BBSNP forest. In line with the aforementioned findings, a study also concluded that learning materials sourced from local natural resources have been proven to strongly shape responsible behavior among the Dayak Kenyah Umo' Longh community in utilizing the forest to meet their needs (Utari et al., 2021). They consciously limit themselves in processing and extracting forest resources.

More broadly, these findings indicate that biodiversity content plays a role in fostering students' sense of responsibility toward the environment. A comprehensive understanding that biodiversity is a source of life and human well-being will lead students to be aware, concerned, and responsible for its preservation (Suryanda et al., 2020). However, schools, as institutions that shape students' character, need to create policies that support the development of a strong sense of responsibility. All teachers are also strongly encouraged to model responsible behavior within the school environment.

CONCLUSION

Observations at BBSNP found six species of amorphophallus, namely *Amorphophallus titanum, Amorphophallus gigas, Amorphophallus paeoniifolius, Amorphophallus asper, Amorphophallus beccari* and *Amorphophallus muelleri.* Integrated problem-based learning of amorphophallus plants at BBSNP had a significant effect on students' responsibility and high-level thinking skills in biodiversity material. All levels of thinking such as analyzing, evaluating and creating were in the high category. Likewise, responsibility, each dimension such as obedience, care and action

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were in the good category. Male and female students did not show different learning outcomes in either high-level thinking skills or responsibility. However, learning observations showed that female students tended to be more thorough in analyzing problems. While male students preferred the activity of designing presentations of group work results via computer.

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