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Identification and alternative solutions to plant blindness in high school students

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ABSTRACT

This study was conducted to determine the level of plant blindness in three schools in West Java. This study was also conducted with the aim of looking at the differences in the level of plant blindness as well as the relationship between the tests and questionnaires given to students. As a follow-up, this study discusses alternative solutions to the problems that arise in the three schools. The population of this study was three schools in West Java, namely one school in Bandung City, West Bandung Regency, and Indramayu Regency. From the population, one class was taken using Convenience sampling technique. The research method used was descriptive cross-sectional method. The data that has been obtained is then processed using descriptive and inferential statistics to see the differences and relationships. The results showed a significant difference between the three schools. The results also showed a positive relationship between the test results and the plant awareness questionnaire. This shows that students who have high plant awareness have high knowledge as well. The alternative solution proposed in this study is the use of eDNA Metabarcoding research as a practicum to study biodiversity, considering that eDNA can identify plant species specifically and accurately.

INTRODUCTION

Plant blindness is one of the problems that occur worldwide (Amprazis et al., 2021; Dünser et al., 2024; Pany et al., 2022a; Putriani et al., 2023). The cause of this problem is the biological factors that occur in this part of the world. These factors include the relatively slower movement of plants compared to animals causing human visual organs to capture the focus on animals. In addition, plant blindness can also be exacerbated by plant growth itself, where a species often lives near the same species, leading to the phenomenon of plant as backdrop (Thomas et al., 2022). In addition, plants are also often perceived as elements that do not harm humans, so people often ignore their existence.

The impact of various biological factors that occur is the severity of plant blindness among students. One of them is students in Greece, who show their preference for fauna compared to flora (Amprazis et al., 2021). In addition, students in Austria also stated that plant observation is not a favorite thing among students, this is due to the assumption that plant observation is an embarrassing activity and requires more time (Dünser et al., 2024). In addition, another study states that students in Austria classify plants as creatures that are no more alive than animals, indicating a gap between plants and animals (Pany et al., 2022a). Other results stated that students experience a decrease in plant awareness as they age (Amprazis & Papadopoulou, 2024b).

Despite being a problem that occurs globally, research on plant blindness in Indonesia is still limited. Based on the review, there are only a few studies on plant blindness, one of which is by Putriani et al. (2023). In the study, it was found that high school students in one of the schools in Hulu Gurung, Kalimantan, had 15% plant identification skills, while junior high school students only had 4%. After further research, it was found that students did not pay attention to the plants around them even though these plants were often used by students in their daily lives. This shows that students in Hulu Gurung high school and junior high school have a high level of Plant Blindness.

Another study was conducted by Wulandari et al. (2023) which was conducted in Sindai District, Kalimantan. In their research, it was stated that junior high school students in one of the schools in Sindai District still had a very alarming level of Plant blindness. This is illustrated through the Plant Blindness test results which show that there are 62% of students who have a score of less than 70. In addition, this study also revealed that high school students have lower Plant Blindness compared to junior high school students. This finding is expressed through the results of the plant blindness test which shows that there are only 24% of students who have scores below 70, while the other 76% already have scores above 70. These results indicate an imbalance between the Plant Blindness of junior high and high school students.

The limited research related to student plant blindness at the high school level is the background for this research. The results of the research conducted by Putriani et al. (2023) and Wulandari et al. (2023) are the basis that more research is needed on the level of plant blindness of high school students in other regions in Indonesia. Based on this review, this study was conducted to assess the level of plant blindness in three schools in West Java and analyze alternative solutions that can be done to overcome plant blindness in high school students.

Research Objectives

This study aims to analyze the level of plant blindness of high school students in one of the schools in Bandung City, West Bandung Regency, and Indramayu Regency and analyze alternative solutions to the problems that occur. In detail, the research objectives are as follows:

1. Analyzing the level of plant blindness of high school students in one of the schools in Bandung City, West Bandung Regency, and Indramayu Regency.

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2. Analyzing the relationship between plant blindness and plant awareness of high school students in one of the schools in Bandung City, West Bandung Regency, and Indramayu Regency.
3. Analyzing alternative solutions from the findings of the level of plant blindness of high school students in one of the schools in Bandung City, West Bandung Regency, and Indramayu Regency.

Based on the formulated research objectives, research questions were formulated to guide the research, namely:

1. What is the level of plant blindness of high school students in one of the schools in Bandung City, West Bandung Regency, and Indramayu Regency?
2. What is the relationship between plant blindness and plant awareness among high school students in one of the schools in Bandung City, West Bandung Regency, and Indramayu Regency?
3. What are the alternative solutions to the findings of high school students' plant blindness levels in one of the schools in Bandung City, West Bandung Regency, and Indramayu Regency?

METHODS

The method used in this research is descriptive cross-sectional method, which is the collection of some data at one point in time. The population of this study were students from one of the schools in Bandung City, West Bandung Regency, and Indramayu Regency. From the three schools, one class was taken as a sample using the convenience sampling technique. The sample in one of the schools in Bandung City amounted to 36 students, in one of the schools in West Bandung Regency amounted to 12, and one of the schools in Indramayu Regency amounted to 35.

Students' plant blindness level was measured using the Plant Awareness Disparity questionnaire developed by Parsley et al. (2022) and using a written test prepared based on plant blindness indicators namely; Attention, Attitude, Knowledge, and Relative Interest. The data that has been obtained through the sample is then analyzed using descriptive statistics. This analysis includes converting scores into values on each instrument used. After obtaining the score, the researcher conducted an inferential statistical analysis of the mean difference test to determine the difference in scores between schools. The analysis continued by finding the relationship between the written test results and the PAD questionnaire.

In addition to collecting quantitative data, researchers also collected qualitative data. Qualitative data collected in the form of interview data to biology teachers in each school. This data acts as additional data so that it can strengthen the discussion of quantitative results. In addition to interview data, researchers also analyzed the teaching modules used in schools. This teaching module was obtained through the Merdeka Mengajar Platform, which is a website used by teachers to obtain teaching module references that can be used at school. This qualitative data analysis was carried out by transcribing interviews into descriptions according to the answers of the interviewees. Meanwhile, the data analysis of the teaching module was carried out by analyzing the teaching module and looking for the existence of aspects of plant awareness contained in the teaching module.

RESULTS AND DISCUSSION

RQ 1: What is the level of plant blindness of high school students in one of the schools in Bandung City, West Bandung Regency, and Indramayu Regency?

After descriptive statistical analysis, it was found that there were differences in the plant blindness written test results. The results revealed that students in one of the schools in Bandung City had

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the highest average score among the three schools, which was 63. The other two schools showed similar scores, which were 44 in one of the schools in West Bandung Regency and 42 in one of the schools in Indramayu Regency. Given that the schools in Bandung City are located in urban areas, this result is interesting in Table 1. These results are also in line with research conducted by Amprazis et al. (2021) which states that students who attend schools in urban areas have better knowledge of plants compared to suburban areas.

Table 1. Statistical analysis results

	Plant Blindness Test			PAD-Index		
	Bandung City	West Bandung Regency	Indramayu Regency	Bandung City	West Bandung Regency	Indramayu Regency
Mean	63,69	44,33	42, 74	76,89	74	73,09
Min	33	20	7	59	62	35
Max	93	60	73	95	86	91
Std. Deviation	16,04	11,07	17,07	7,3	7,41	12,14
Normality (Shapiro-Wilk Test)	0,186	0,228	0,056	1,000	0,417	0,000
Kruskal-Wallis Test		0,000**			0,464	

** $p < 0,001$

This result is supported by the results of the inferential statistical analysis conducted. The mean difference test using Kruskal-Wallis was conducted because the normality test did not show significance. The results of the Kruskal-Wallis test showed that there was a significant difference in the written test results of plant blindness between the three schools. This result is reinforced by the results of interviews conducted with biology teachers in each school. In the interview, it was mentioned that learning in one of the schools in Bandung City was carried out using the constructivism approach. This approach allows students to build a concept or principle based on their initial knowledge which will then be developed through interaction during learning (O'Connor, 2022). Interaction during learning with the teacher and with classmates positively helps students to understand a concept well (Qureshi et al., 2023).

The results from one of the schools in the city of Bandung are also supported by learning outside the classroom. Based on interviews with teachers, it was found that learning is often done by observing the environment and diversity directly. For example, in biodiversity material, students are invited to analyze vegetation in the Ir. H. Djuanda Grand Forest Park, Bandung. In this activity, students are given the opportunity to observe plants and their diversity directly. The results of vegetation analysis from the activity were then discussed in class, thus providing students with an understanding of the importance of biodiversity. This positive influence is in accordance with the findings of Borsos et al. (2023) who revealed that learning carried out in the environment directly can increase students' knowledge of plant species. Coşkunserçe (2024) stated similar results, namely by giving students the opportunity to explore their environment freely by utilizing technology can increase students' awareness and knowledge of plants.

As mentioned earlier, it was found that the average results in one school in West Bandung District and Indramayu District showed a modest difference of 44 and 42 respectively. Upon further investigation, it was found that learning in both schools was mostly conducted in the classroom. In one of the schools in West Bandung Regency, learning was done by giving lectures and filling in the LKPD as an assignment. This is also unfortunate, considering that the location of the school is surrounded by many plants of various types. One of the activities carried out as a subject is agribusiness activities, where students are given the opportunity to care for plants. However, this has not been able to improve the written test results. This statement contradicts the results of research conducted by Kissi & Dreesmann (2022) which states that plant care activities

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can increase students' knowledge of plants. The increase is due to the direct contribution of students to the plant care process.

The learning process in one of the schools in Indramayu Regency was also revealed by the biology teacher through the interview process. Based on the results of the interview, it was revealed that learning biodiversity material is often carried out outside the classroom. The facilities at the school provide a large park that functions as a parking area, but this facility is often used by biology teachers to carry out learning. Learning usually begins with providing initial material about biodiversity followed by direct identification of plant morphology in the garden area (Wäldchen & Mäder, 2017). However, this learning process has not shown the expected results. Based on the written test results, students in the school have the lowest average compared to the three schools. This result is inversely proportional to the results of research conducted by Azevedo et al. (2022) who revealed that learning carried out in a direct environment, such as a park, can increase students' knowledge and awareness of plants.

The average test results of students in one of the schools in Indramayu Regency can also be caused by the use of teaching modules that are very lacking in aspects of plant awareness, namely attention, attitude, relative interest, and knowledge (Parsley, 2020). Based on the analysis of the teaching module, the learning process in the classroom does not support students to have a broad understanding of plants and their diversity. This is illustrated by the lack of plant awareness aspects in the learning objectives in Table 2, which are only 4 out of 9 learning objectives.

Table 2. Analysis of teaching modules on biodiversity materials

No	Learning Goals	Plant Awareness Aspect			
		Attention	Attitude	Knowledge	Relative Interest
1	Students are able to identify Types of Biodiversity				
2	Students are able to identify Types of Ecosystems (Water and Land).				✓
3	Students are able to identify the Distribution of Flora and Fauna in Indonesia.				✓
4	Students are able to analyze the Threats to and Efforts for the Conservation of Biodiversity.			✓	
5	Students are able to understand the Benefits and Basis of Classification of Living Organisms.		✓		
6	Students are able to understand the Taxonomic Order of Animals and Plants.				
7	Students are able to explain Binomial Nomenclature.				
8	Students are able to explain the Development of Classification of Living Organisms.				
9	Students are able to create a Cladogram.				

In line with the statement of Amprazis & Papadopoulou (2024a) in their research, learning can be done by combining aspects of plants with system thinking skills. Learning that prioritizes system thinking and problem solving can be one of the means for students to recognize and understand the importance of plants for human life and the lives of other living things. Through learning that emphasizes critical thinking, norms, and self-awareness, students are encouraged to express their perspectives on plants so as to expand students' knowledge of plants and their diversity (Kubiatko, et al., 2021). Based on the learning objectives stated in Table 2, there are no objectives in problem solving or systems thinking, which could be one of the reasons for the high plant blindness in one of the schools in West Bandung Regency and Indramayu Regency.

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Plant blindness was also measured using the PAD-Index questionnaire developed by (Parsley et al., 2022). The questionnaire focused on students' opinions or perceptions of their plant awareness. The results of this questionnaire showed that students from one of the schools in Bandung City had the lowest level of plant blindness among the three schools. This result is in line with the written test results discussed earlier. While the other two schools had an average score of 74 in one of the schools in West Bandung Regency and 73 in one of the schools in Indramayu Regency.

The differences in the results of the questionnaires in the three schools could be due to various factors. In one of the schools in Bandung City, despite not being exposed to green open spaces or abundant plant diversity, students had the lowest level of plant blindness. This is because the learning presented by the teacher has helped students to have an awareness of plants. Constructivism learning emphasizes prior knowledge to construct new knowledge. In addition, learning is also carried out by combining learning outside the classroom so that students do not only know plant diversity in theory but know it experientially.

In contrast to the learning carried out in West Bandung Regency and Indramayu Regency, learning is limited to activities in the classroom. Based on the results of interviews by teachers, on biodiversity material students are directed to work on student worksheets after the teacher's presentation. This is one of the things that is questioned, considering that biodiversity material can be observed directly in the school environment.

In contrast to the test results, the results of this questionnaire show that there is no significant difference between the three schools, indicating that students have a high perception of their level of plant awareness. This result is inversely proportional to the results of the plant blindness written test which showed low results in schools in West Bandung Regency and Indramayu Regency. These results show harmony with the results of research conducted by Dünser et al. (2024) which states that students have a high attitude towards plants but lack interest in learning about them. This is certainly a challenge for teachers to solve these problems.

RQ 2: What is the relationship between plant blindness and plant awareness among high school students in one of the schools in Bandung City, West Bandung Regency, and Indramayu Regency?

As mentioned earlier, plant blindness was measured using a written test and a questionnaire. This was done to display strong and complementary results between the test and questionnaire results. The test and questionnaire results were then examined for their relationship using the Spearman test, given that the data were not normally distributed.

Based on the Spearman test results, it was found that there was a relationship between the test results and the Plant Blindness questionnaire results in the three schools. With a significance value of 0.008 ($p < 0.05$), it was found that there was a relationship between the two with a relationship strength of 0.288 with a moderate category. Nonetheless, this shows that students who have high results on the test have plant awareness in the high category as well in Table 3.

Table 3. Test and questionnaire correlation test results

		Correlations	Test	Questionnaire
Spearman's rho	Test	Correlation Coefficient	1,000	,288**
		Sig. (2-tailed)	.	,008
		N	83	83
	Questionnaire	Correlation Coefficient	,288**	1,000
		Sig. (2-tailed)	,008	.
		N	83	83

**. Correlation is significant at the 0.01 level (2-tailed).

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The results of this relationship analysis show harmony with the results of research conducted by Pany et al. (2022) which shows that students who have awareness of plants have a higher level of understanding of plants, while students who have low awareness of plants have weaker knowledge of plants. These results suggest that plant knowledge has a strong link to plant awareness. Students will have a high knowledge of plants if their plant awareness is supported by teachers and the environment. This effort can be used as one way for teachers and the community to maintain plant diversity, especially in Indonesia.

This is reinforced by Colombari & Battisti (2023) statement that as students' knowledge of plants strengthens, awareness of plants will be able to grow on its own. Researchers also mentioned that effective learning activities by involving students in environmental projects can increase students' knowledge and awareness of plants and important environmental issues. This increased knowledge and awareness will further influence students' attitudes and behaviors towards current environmental issues.

RQ 3: What are the alternative solutions to the findings of high school students' plant blindness levels in one of the schools in Bandung City, West Bandung Regency, and Indramayu Regency?

Based on the mean difference analysis and relationship analysis, a solution is needed that focuses on the learning process. From the mean difference analysis, it was found that out-of-class learning combined with constructivism learning can have a positive influence on students' knowledge and awareness of plants. However, this learning cannot be solely applied, this is due to the need for several considerations, such as how it affects and whether it can be applied in schools. To follow up on this, a literature study was conducted to analyze various solutions to the problems found in these schools.

Research conducted by Nyberg et al. (2021) states that learning that prioritizes the emotional relationship between students and plants can be used as one of the approaches. Learning by connecting students emotionally can be an option to teach students, both animals and plants. This emotional approach can be done by prioritizing the variety of beauty, shape, color, and uniqueness of each organism to form a bond between students and biodiversity. These activities can be carried out at the beginning of learning, precisely in activities to motivate students related to their favorite specimens. This research is also in line with research conducted by Blue et al. (2023) which states that plant utilization activities that are commonly found or considered useful can be carried out in an effort to teach knowledge about plants.

Learning that prioritizes the use of students' senses can be used as one of the options to teach plant diversity. Based on research conducted by Krtková (2024) learning by prioritizing the use of the Senses can be a unique and new tool to revive students' initial interest they have experienced in nature as they come into direct contact with plants and other life forms. Learning with this approach can also arouse deeper attention, curiosity, interest, and motivation in students to learn, as seen from the way students often ask detailed questions and demand further sources of information. Learning with this approach can also be developed into learning based on critical thinking.

Research conducted by Coşkunserçe (2024) states that learning conducted outside the classroom and combined with technology in the form of PlantNet applications can be one solution to the problem of plant awareness. This is illustrated through the results of the study which revealed that students who had done this learning experienced an increase in attitudes towards biodiversity and increased knowledge of the names of plant species identified. The results of this study refer to the statement that this learning activity is an effective systematic in learning and can be utilized for biodiversity education.

From this study, there were some shortcomings and advantages. The strength of the study is the combination of technology with learning outside the classroom, making it easier for students

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to identify plants. In addition, the learning was also formulated by considering students' interests and knowledge so that students are more interested in plants after learning. However, this learning still needs to be considered, this is because the learning is only done in one class and there is no comparison between the two classes.

Another study was conducted by Borsos et al. (2023) who conducted learning outside the classroom. In this study, two classes were used as control and experimental classes. The experimental class was given treatment by doing learning in the environment directly, such as forests, fields, parks, riverbanks and lake banks, while the control class was only given learning in the classroom through lecturer presentations. Based on this treatment, the researcher revealed that students who conducted learning outside the classroom showed better knowledge compared to students who only conducted learning in the classroom as usual. Based on these results, it can be argued that learning outside the classroom can be an option to support students' knowledge and interest in plants.

Kissi & Dreesmann (2022) conducted a study that prioritized out-of-class activities by involving students in plant care activities. In this study, students were invited to plant various plants and care for them while learning about biodiversity. It was found that students who did the learning outside the classroom experienced an increase in plant knowledge, such as knowledge of plant taxonomy and plant morphology. In addition, students who experienced this learning experienced an increase in motivation, this was corroborated by students' statements which mentioned that students were interested in planting their own plants after this learning. In addition, students who did the learning mentioned that this activity can provide responsibility and enthusiasm for planting plants.

Similar research was conducted by Azevedo et al. (2022), which provides plant planting activities to students. In this study, students were actively involved in creating an educational garden at school. This learning provides positive results in results. This is illustrated through the results of students' increased knowledge in various plant topics focusing on native plants and their differences with invasive species. This positive result is also supported by the results of the questionnaire which states that learning that involves students can increase students' interest in plants, especially how plants can be transplanted.

Another study was conducted by Gubo & Schiffl (2022) who used laboratory activities as learning activities to teach the pollination process of flowering plants. In the study, students were given the chance to organize pollination by insects. This was done to increase students' interest in the pollination process, given that students were given the opportunity to try the pollination process themselves through experiments using various types of flowers. Based on this research, students increased their interest in plants and increased their knowledge related to plant parts and interactions related to plants and insects.

Based on the learning results involving students, it can be concluded that learning conducted outside the classroom by inviting students to be directly involved with plants can increase students' awareness and knowledge of plants. These activities can be combined with activities in the laboratory, this can be done to provide knowledge to students about plant species in a more advanced way. This activity can be conducted using the Environmental DNA (eDNA) practicum. In these activities, sampling activities were carried out, using wet and dry laboratories (Calderón-Sanou et al., 2020; Johnson et al., 2021). This is expected to create a holistic and dynamic learning environment that fosters botanical literacy and a deep appreciation of plants.

In a study conducted by Nunes et al. (2021) it was stated that the use of eDNA in learning can be used as an option as a means for teachers to teach biodiversity. In the learning process, the researcher provided a presentation on biodiversity and a presentation on the use of molecular tools. The activity continued by providing opportunities for students to analyze the problems given by the researcher and introduce eDNA to students. Students were then given directions to analyze the differences in species diversity contained in the QR provided. Although students did not

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directly conduct eDNA research, researchers informed how the process of obtaining a list of species existed on the student's QR.

The absence of direct student contributions during the sampling process can be said to be a shortcoming of the research conducted by (Nunes et al., 2021). Considering that direct activities and student contributions can increase students' awareness and knowledge of plants, the eDNA activities formulated by Nunes et al. (2021) should be able to be developed optimally. Following up on this, the researcher formulated the DNA Metabarcoding practicum as a means for students to develop their awareness and knowledge of plants.

Environmental DNA is a research activity that involves a collection of DNA isolated from environmental samples, while Metabarcoding is defined as mass sample analysis. When combined, eDNA Metabarcoding is defined as the analysis of a mass sample of DNA isolated from environmental samples. eDNA samples can be obtained from various materials, such as soil, water, air to plant organic waste. The samples have different sampling technique procedures (Pawlowski et al., 2020). Based on this, it can be concluded that eDNA Metabarcoding research activities include activities outside the classroom for sampling and urgently require student contributions for the sampling. In addition, this activity includes activities in the laboratory in the sample preparation process and requires bioinformatics analysis so that it requires the contribution of technology to it.

The choice of eDNA Metabarcoding as a learning solution is not without reason. The eDNA Metabarcoding study can reveal the species that once lived in the sampling environment more accurately and more. This result is illustrated through research conducted by Johnson et al. (2021) which found that there are 91 plant species consisting of weeds, herbs, and trees that can be revealed through eDNA Metabarcoding. The same researcher revealed that biodiversity observations through visual analysis can only reveal 80 plant species in the same location. These results suggest that biodiversity can be analyzed more accurately using eDNA Metabarcoding.

A similar study was conducted by Leontidou et al. (2021) that it was stated that the use of eDNA can reveal more families. For example, it was found that there are 30 families detected in the Beech and Spruce Forests, as well as 24 families in the Laarch Forest area. These results support previous research's assertion that the use of eDNA Metabarcoding can reveal a greater number of plant species compared to visual analysis.

The use of eDNA can also reveal plant species in extreme areas. One of them is in a study conducted by Carrasco-Puga et al. (2021) which revealed that 77 plant species belonging to 59 genera and 25 families were found through eDNA Metabarcoding analysis in dry areas. In addition, it was also found that there were 37 plant species detected through eDNA Metabarcoding in areas with dry land. Another result was mentioned by Varotto et al. (2021) that the use of eDNA Metabarcoding was able to reveal plant species with the most specific taxonomic resolution in the Alpine glacier region. These results show that the use of eDNA Metabarcoding is able to reveal plant species even under extreme conditions.

Although eDNA metabarcoding is assumed to facilitate students to learn about biodiversity and improve plant knowledge and awareness, further trials regarding eDNA are needed. This is done to see what kind of methods and procedures need to be conducted so that eDNA research can be applied in schools as a practicum activity. In addition, when wanting to insert eDNA as a practicum, it is necessary for the next researcher to analyze how to simplify the concept of eDNA itself so that students can easily understand the purpose of eDNA Metabarcoding.

CONCLUSION

Based on the results of the study, it was found that there was a significant difference between the three schools that were used as populations. These results show that learning conducted in schools will affect students' knowledge and awareness of plants. This is corroborated by the

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results of teacher interviews in each school which state that learning outside the classroom can provide positive results on plant knowledge and awareness. The results also revealed that there was a positive relationship between the results of the plant blindness test and the plant awareness questionnaire. This shows that students who have a high awareness of plants have a high knowledge about plants, and vice versa. Environmental DNA can be used as an option to be applied in schools as a practicum. This is because eDNA research activities combine sampling activities in a live environment so that students can observe the biodiversity in the environment. In addition, eDNA also combines practicum activities and bioinformatics analysis. Environmental DNA Metabarcoding can reveal plant species with specific resolution and more compared to visual analysis. This makes eDNA Metabarcoding a learning option through practicum activities.

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