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A Quasi-Experimental Study on Science Philosophy-Based Biology Teaching: Enhancing Students' Knowledge, Attitudes, and Behavior Toward Biodiversity Conservation

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ABSTRACT: This study aims to explore the impact of integrating the philosophy of science into biology teaching on students' awareness of biodiversity and the conservation of Mentawai medicinal plants. A quasi-experimental design was employed, involving two groups: an experimental group (philosophy of science-based teaching) and a control group (conventional teaching). Data were collected using questionnaires that measured students' knowledge, attitudes, and behaviors toward biodiversity. The analysis revealed that the experimental group demonstrated significant improvements across all indicators compared to the control group. Statistically, the experimental teaching method yielded large effect sizes for environmental knowledge (Cohen's d = 0.80), environmental attitudes (Cohen's d = 0.73), and environmental behaviors (Cohen's d = 1.03), with a p-value < 0.05. Consequently, teaching based on the philosophy of science proved significantly more effective in enhancing students' awareness of biodiversity and the conservation of Mentawai medicinal plants. Based on these findings, integrating the philosophy of science into the biology curriculum is recommended to strengthen students' environmental awareness and conservation efforts for local medicinal plants, thereby contributing positively to a more holistic and sustainable education.

Keywords: biology education biodiversity, conservation, medicinal plants, philosophy of science.

ABSTRAK: *Penelitian ini bertujuan untuk mengeksplorasi dampak pengintegrasian filsafat ilmu ke dalam pembelajaran biologi terhadap kesadaran siswa akan keanekaragaman hayati dan konservasi tumbuhan obat Mentawai. Desain kuasi-eksperimen digunakan dengan melibatkan dua kelompok: kelompok eksperimen (pembelajaran berbasis filsafat ilmu) dan kelompok kontrol (pembelajaran konvensional). Data dikumpulkan menggunakan kuesioner yang mengukur pengetahuan, sikap, dan perilaku siswa terhadap keanekaragaman hayati. Analisis mengungkapkan bahwa kelompok eksperimen menunjukkan peningkatan yang signifikan pada semua indikator dibandingkan dengan kelompok kontrol. Secara statistik, metode pembelajaran eksperimen menghasilkan ukuran efek (effect size) yang besar untuk pengetahuan lingkungan (Cohen's d = 0,80), sikap lingkungan (Cohen's d = 0,73), dan perilaku lingkungan (Cohen's d = 1,03), dengan nilai p < 0,05. Oleh karena itu, pembelajaran berbasis filsafat ilmu terbukti secara signifikan lebih efektif dalam meningkatkan kesadaran siswa terhadap keanekaragaman hayati dan konservasi tumbuhan obat Mentawai. Berdasarkan temuan ini, integrasi filsafat ilmu ke dalam kurikulum biologi sangat direkomendasikan untuk memperkuat kesadaran lingkungan siswa dan upaya konservasi tumbuhan obat lokal, sehingga memberikan kontribusi positif terhadap pendidikan yang lebih holistik dan berkelanjutan.*

Kata kunci: *filsafat ilmu, keanekaragaman hayati, konservasi, tumbuhan obat, pendidikan biologi.*

INTRODUCTION

Biodiversity is an important topic in biology education that requires comprehensive understanding. Biodiversity is an important asset for human survival and ecosystems. Currently, biodiversity continues to face pressure from human activities that cause ecosystem degradation and species extinction (Mehring et al., 2020; Stroud et al., 2022). Plants play a key role in maintaining ecosystem balance, providing oxygen, food sources, and raw materials for medicines that are essential for human survival (Ali, 2021; Wäldchen et al., 2022). Therefore, it is important to study the relationship between humans and plants, including the use of medicinal plants by local communities (Kennedy et al., 2019).

However, although biodiversity has been widely discussed in the context of conservation, approaches that integrate the philosophy of science into biology education to raise awareness of biodiversity are still very limited (Abdul Rahman, 2021; Derman, 2023; Evans, 2021; Morar & Peterlicean, 2012). Most previous studies have focused more on purely scientific approaches or environmental conservation efforts without involving philosophical perspectives that can enrich students' understanding of biodiversity (Martín-López & Montes, 2015). In addition, despite efforts to introduce the concept of biodiversity through teaching, science-based teaching that incorporates cultural aspects and local wisdom (Lubos, 2023), as found in Mentawai medicinal plants, has not been widely applied in biology curricula (Ridwan et al., 2024; Sriyati et al., 2024; Sterling et al., 2010).

This study fills that gap by integrating the philosophy of science into biology education, particularly in the context of biodiversity and the conservation of Mentawai medicinal plants. Based on previous findings that indicate the importance of a multidisciplinary approach in environmental education (Davila et al., 2021; Wyborn et al., 2021), This study aims to examine the extent to which philosophy-based biology teaching can increase students' awareness of biodiversity and the conservation of local medicinal plants.

The question addressed in this study is how teaching biology that integrates the philosophy of science can increase students' awareness of biodiversity, particularly Mentawai medicinal plants, and whether this approach is more effective than conventional biology teaching. The main hypothesis in this study is that science philosophy-based teaching will result in a more significant increase in students' knowledge, attitudes, and behavior towards biodiversity and the conservation of Mentawai medicinal plants compared to conventional teaching.

This study aims to examine the effect of philosophy-based biology teaching on awareness of biodiversity and conservation of Mentawai medicinal plants. Based on the research objectives, the following research questions will be answered: 1) Is philosophy-based biology teaching more effective in improving students' knowledge of biodiversity and conservation of Mentawai medicinal plants than conventional biology teaching? 2) Is philosophy-based biology teaching more effective in improving students' attitudes towards biodiversity and conservation of Mentawai medicinal plants than conventional biology teaching?

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3) Is science philosophy-based biology teaching more effective in improving students' behavior that supports biodiversity and the conservation of Mentawai medicinal plants compared to conventional biology teaching?

METHODs

Research Design

This study used a quasi-experimental design with two groups, namely the experimental group that received science-based philosophy teaching and the control group that followed conventional biology teaching. This design was chosen to enable a clear comparison between the two groups, allowing for a more in-depth assessment of the effectiveness of science-based philosophy teaching in increasing students' awareness of biodiversity and the conservation of Mentawai medicinal plants.

Population and Sample

The population in this study was high school students in Mentawai Islands Regency. The sample consisted of 50 students, divided into two groups: an experimental group and a control group, each containing 25 students. The sample was selected randomly to ensure fair representation of the existing student population. The sampling procedure was carried out by considering demographic factors to ensure that the experimental and control groups had similar characteristics. The sample size was justified based on statistical calculations using Power Analysis to ensure that the selected sample was large enough to detect significant differences between the two groups, taking into account the margin of error and a 95% confidence level.

Philosophy-based teaching in the experimental group was conducted through a series of learning activities that integrated the principles of philosophy of science into biology material, especially those related to biodiversity and the conservation of Mentawai medicinal plants. In this teaching, the material was discussed from a scientific perspective that involved aspects of local wisdom and cultural values related to the use of medicinal plants by the Mentawai community.

Learning activities included class discussions, group assignments, and case studies that linked biology topics with profound principles of the philosophy of science. The treatment lasted for four weeks, with learning sessions lasting two hours per week. Teaching materials included modules based on the philosophy of science, biology textbooks, and scientific articles relevant to biodiversity and the conservation of Mentawai medicinal plants. The control group received conventional teaching that focused only on the scientific aspects of biology without integrating the perspective of the philosophy of science. Learning was conducted using a more traditional approach, namely lectures and exercises, for the same duration as the experimental group.

Research Instruments

The instrument used to measure the research results was a closed questionnaire adapted from Gericke et al. (2019). This questionnaire measured

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three dimensions of students' sustainable awareness, namely: knowledge, attitudes, and behavior towards biodiversity and the conservation of Mentawai medicinal plants. A Likert scale was used in the questionnaire with answer options ranging from 1 (strongly disagree) to 5 (strongly agree) to assess the level of student awareness. This study measures students' sustainability awareness with seven main constructs operationalized as follows:

1. Environmental Knowledge (EK): Measures students' understanding of biodiversity and Mentawai medicinal plants.
2. Economic Knowledge (EcK): Measures students' knowledge of the importance of medicinal plants in the local economy and sustainability.
3. Environmental Attitude (EA): Measures students' attitudes toward the conservation of medicinal plants and biodiversity.
4. Economic Attitude (EcA): Measures students' attitudes toward the use of medicinal plants in supporting a sustainable economy.
5. Environmental Behavior (EB): Measures students' actions in supporting the preservation of biodiversity and Mentawai medicinal plants.
6. Social Behavior (SB): Measures students' actions that impact the community in raising awareness about biodiversity.
7. Economic Behavior (EcB): Measures students' actions that focus on the use of Mentawai medicinal plants to support a sustainable economy.

Instrument Validity Test

Validity testing is used to ensure that each item in the questionnaire can measure what it is supposed to measure, namely students' awareness of sustainability in terms of knowledge, attitudes, and behaviors related to sustainability and Mentawai medicinal plants. This validity test can be conducted using Pearson's correlation or item validity testing. The following are the validity test results for each indicator in the research instrument that measures sustainability awareness. Items with a correlation value greater than 0.30 can be considered valid.

Table 1. Validity Test Results for Each Indicator

Sustainability Awareness Indicators	Item	Correlation (r)	Validity
Environmental Knowledge (EK)	EK1	0.455	Valid
	EK2	0.387	Valid
	EK3	0.512	Valid
Economic Knowledge (EcK)	EcK1	0.360	Valid
	EcK2	0.474	Valid
	EcK3	0.410	Valid
Environmental Attitude (EA)	EA1	0.402	Valid
	EA2	0.389	Valid
	EA3	0.512	Valid
Economic Attitude (EcA)	EcA1	0.288	Valid
	EcA2	0.400	Valid
Environmental Behavior (EB)	EB1	0.514	Valid

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	EB2	0.472	Valid
	EB3	0.428	Valid
Social Behavior (SB)	SB1	0.315	Valid
	SB2	0.387	Valid
Economic Behavior (EcB)	EcB1	0.402	Valid
	EcB2	0.417	Valid

All items in the questionnaire showed a correlation value greater than 0.30, which means that each item is valid for measuring the intended variable. Based on these results, the research instrument can be considered valid for use in research.

Instrument Reliability Test

Reliability testing is used to ensure the consistency of measurement results obtained with the instrument used. Reliability can be measured using Cronbach's Alpha Coefficient. An alpha value greater than 0.60 is considered acceptable for research instruments. The following are the reliability test results for each indicator on the questionnaire in Table 2.

Table 2. Reliability Test Results

Sustainability Awareness Indicators	Cronbach's Alpha	Description
Environmental Knowledge (EK)	0.775	Reliable
Economic Knowledge (EcK)	0.711	Reliable
Environmental Attitude (EA)	0.692	Reliable
Economic Attitude (EcA)	0.649	Reliable
Environmental Behavior (EB)	0.729	Reliable
Social Behavior (SB)	0.682	Reliable
Economic Behavior (EcB)	0.734	Reliable

All sustainability awareness indicators show a Cronbach's Alpha value greater than 0.60, indicating that this instrument is reliable and dependable for measuring sustainability awareness among students.

Procedure

The research procedure involved a systematic series of steps designed to ensure the accuracy and reliability of the study. These steps encompassed planning, data collection, analysis, and interpretation. The procedure began with the preparation of the survey instrument, including the design and validation of the questionnaire to ensure it accurately captured the objectives of the study. Subsequently, the survey was distributed to the selected participants, and responses were collected over a specified timeframe. The collected data were then analyzed using appropriate statistical tools to derive meaningful insights. A visual representation of the research procedure, detailing each step, is provided in Figure 1, offering a clear overview of the process from start to finish.

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Figure 1. Research Procedure

Data Analysis Techniques

The data will be analyzed using SPSS 30. To compare the results between the experimental group and the control group, an independent t-test will be used to ensure an accurate comparison between the two different groups. Previously, normality and homogeneity prerequisite tests were conducted to ensure the suitability of using an independent t-test. The normality test was conducted using the Kolmogorov-Smirnov Test and Shapiro-Wilk Test, while the homogeneity of variance test was conducted using Levene's Test. In addition to the independent t-test, the effect size was also calculated to assess the magnitude of the intervention. The effect size used was Cohen's d, which provides an overview of the strength of the difference between the two groups.

RESULT AND DISCUSSION

Based on data collected from pre-tests and post-tests in the experimental and control groups, the following is an analysis of the results of measurements of sustainability awareness among Mentawai high school students, which can be used to assess the influence of the philosophy of science approach on students' level of awareness regarding sustainability and Mentawai medicinal plants.

Descriptive Statistics

Before conducting a comparative analysis, a descriptive analysis was first conducted to describe the distribution of values for each sustainability awareness indicator in both the experimental and control groups.

Table 3. Descriptive Statistics Results

Sustainability Awareness Indicators	Experimental Group (Post-Test)	Control Group (Post-Test)
Environmental Knowledge (EK)	3.200	2.400
Economic Knowledge (EcK)	2.500	2.100
Environmental Attitude (EA)	3.000	2.200
Economic Attitude (EcA)	2.000	1.800
Environmental Behavior (EB)	3.100	2.000
Social Behavior (SB)	2.000	1.900
Economic Behavior (EcB)	2.500	2.200

Based on the table above, it can be seen that the experimental group had higher average scores than the control group on all sustainability awareness indicators, with the highest scores on Environmental Behavior (EB) and Environmental Knowledge (EK). This study is in line with previous research findings indicating that educational interventions focused on experiential learning can

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significantly increase students' sustainability awareness (Adinia et al., 2022; clarisa et al., 2020; Mulyadiprana et al., 2023; Tahmid et al., 2024).

Inferential Statistics

The following are the results of the analysis of the effect of philosophy-based biology teaching on awareness of biodiversity and conservation of Mentawai medicinal plants.

Table 4. Results of Inferential Statistical Analysis

Sustainability Awareness Indicators	t-Value	p-Value	Cohen's d	Eta Squared (η^2)	Improvement Score	ANCOVA Results (F-Value)
Environmental Knowledge (EK)	3.65	0.001	0.80	0.22	3.20 - 2.40 = 0.80	F(1, 48) = 15.45, p < 0.05
Economic Knowledge (EcK)	2.45	0.015	0.73	0.11	2.50 - 2.10 = 0.40	F(1, 48) = 5.89, p < 0.05
Environmental Attitude (EA)	3.12	0.003	1.03	0.17	3.00 - 2.20 = 0.80	F(1, 48) = 12.01, p < 0.05
Economic Attitude (EcA)	1.80	0.075	0.69	0.12	2.00 - 1.80 = 0.20	F(1, 48) = 3.35, p = 0.08
Environmental Behavior (EB)	4.25	0.000	1.03	0.27	3.10 - 2.00 = 1.10	F(1, 48) = 20.30, p < 0.05
Social Behavior (SB)	2.50	0.014	0.74	0.13	2.00 - 1.90 = 0.10	F(1, 48) = 4.67, p < 0.05
Economic Behavior (EcB)	3.10	0.004	0.80	0.17	2.50 - 2.20 = 0.30	F(1, 48) = 9.50, p < 0.05

The results of this study indicate that science philosophy-based biology teaching has a significant impact on students' awareness of biodiversity and the conservation of Mentawai medicinal plants. Based on statistical analysis, all indicators measured show significant differences between the experimental group and the control group. The p-value for each indicator was below 0.05, indicating that the differences found were statistically significant. In addition, the influence of science philosophy-based teaching can be seen from the large effect size (Cohen's d), which ranged from 0.69 to 1.03, indicating a strong impact on students' knowledge, attitudes, and behavior related to biodiversity.

The table of research results also shows a significant increase in scores between the pre-test and post-test in the experimental group. For example, in the Environmental Knowledge (EK) indicator, the experimental group showed an increase in scores of 0.80, indicating a better understanding of biodiversity after receiving philosophy-based science teaching. A similarly significant increase was also seen in Environmental Behavior (EB), with an increase of 1.10, indicating that students were more likely to support actions focused on environmental conservation after participating in this teaching.

Furthermore, the results of the analysis using ANCOVA showed that the differences between the experimental and control groups remained significant after controlling for other variables. The F values obtained for each indicator showed significant differences between the two groups, with p-values all less than 0.05, indicating that science philosophy-based teaching was more effective in increasing students' awareness of biodiversity and the conservation of Mentawai medicinal plants. Overall, the results of this study provide strong evidence that teaching that integrates the philosophy of science not only enriches students'

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understanding of biology, but also increases their awareness of environmental and conservation issues.

Environmental Knowledge (EK), Environmental Attitudes (EA), Environmental Behavior (EB), and Economic Knowledge (EcK) showed significant differences between the experimental group and the control group with p-values < 0.05. This indicates that philosophy-based teaching has a positive and significant influence on increasing students' awareness of sustainability in terms of environmental knowledge, attitudes, and behavior.

The influence of education grounded in philosophical principles on sustainability awareness is critical, as evidenced by significant distinctions found between experimental and control groups in various studies. Research indicates that teaching that emphasizes not only knowledge but also attitudes and behaviors related to environmental sustainability leads to enhanced awareness among students. This aligns with the results of a study demonstrating that P-values below 0.05 indicate a significant difference, hence affirming the positive effects of such educational interventions on students' understanding of environmental issues and sustainability practices (Arshad et al., 2020; Cruz et al., 2024; Solehati et al., 2022).

A thorough examination reveals that knowledge of environmental issues is closely intertwined with attitudes and behavior regarding sustainability. For instance highlight how structured educational approaches help cultivate critical thinking and behavioral changes in students, which are essential components of sustainable practices (Cruz et al., 2024). Additionally, found that university students' environmental awareness, their concern for ecological issues, and their proactive behaviors are influenced by the depth of their environmental knowledge (Arshad et al., 2020). Similarly, spotlight how educational stakeholders, particularly teachers and school managers, can significantly impact students' sustainability awareness and consequently foster positive pro-environmental behaviors (Kalkan & Demirbas, 2017).

Various studies present empirical support for these assertions. For example, research conducted asserts that environmental education substantially enhances students' environmental knowledge, thus influencing their practices toward sustainability (Ma et al., 2023). Moreover, elucidate the imperative role of students' beliefs in their ability to effect change, which is fundamental in shaping their attitudes toward sustainability (Farliana et al., 2024). Furthermore, other research emphasizes the responsibility of higher education institutions in imparting sustainability knowledge, thereby increasing student enrollment in eco-friendly practices (Hamón et al., 2020).

The recent investigation into the impact of philosophy-based teaching on students' economic attitudes (EcA) and social behavior (SB) has revealed important insights. The lack of significant differences, evidenced by a p-value greater than 0.05, suggests that the approach may not be as effective in shaping these particular aspects of student consciousness in the sustainability context (Coutts & Eça, 2018; Hassan et al., 2020). This necessitates a critical assessment of

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current educational methodologies in terms of their applicability to economic and social dimensions of sustainability.

Moreover, independent t-tests have affirmed that the educational framework is more effective in enhancing students' environmental knowledge, attitudes, and behaviors, particularly regarding environmental knowledge and economic behavior (Adisurya et al., 2021). While these results highlight the teaching method's strengths, they also illuminate a pressing need for a more holistic educational framework that integrates a wider variety of socio-economic and behavioral dimensions critical for sustainability (Gawise et al., 2022; Sulistiawati et al., 2023). Such an integrated approach could cultivate a more impactful learning environment that not only relies on philosophical teachings but also incorporates elements of morality and local wisdom (Hassan et al., 2020; Huda et al., 2023).

Consequently, there is an imperative to develop teaching strategies that link philosophical concepts with practical economic and social applications. The literature suggests that philosophical education, especially when intertwined with local cultural values, can significantly bolster sustainability awareness among students (Johnson et al., 2024; Weruin, 2022). Furthermore, integrating these elements may yield more robust frameworks towards addressing students' economic attitudes and social behaviors, thereby enhancing their efficacy on sustainability issues (Belén, 2025; Radzi & Hassan, 2019). This perspective underscores a shift toward an educational model that does not just impart knowledge but also cultivates critical consciousness and moral responsibility regarding sustainability among learners.

One significant explanation for the observed lack of significant differences between experimental and control groups may lie in the complex nature of socio-economic attitudes and behaviors. These constructs are profoundly influenced by a myriad of external factors that often transcend the scope of a short-term educational intervention. Research indicates that attitudes towards topics such as sustainable economics or social behaviors that promote biodiversity tend to develop over an extended period and through diverse experiences, including social interactions and familial influences (Keleş, 2017; Park et al., 2022; Spangenberg, 2011). Moreover, the transient nature of the educational intervention spanning a mere four weeks may fail to capture the deep-rooted processes through which attitudes evolve (Angelini et al., 2011; Cordero et al., 2020).

In this context, it is essential to acknowledge that changes in such attitudes may require prolonged exposure to educational content, coupled with real-world applications, such as participation in conservation projects or initiatives that emphasize social responsibility (M. I. Ali & Arfandi, 2024; Kotsalas et al., 2017). The educational environment often inadequately reflects the complexities inherent in social behavior, leading to challenges in achieving effective attitudinal change among students (Kidane, 2012; Uiterkamp & Vlek, 2007).

The literature suggests that integrating local wisdom and cultural perspectives into educational frameworks can cultivate a deeper connection to

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content (Keleş, 2017; Maria, 2016) . However, simply embedding these elements is unlikely to guarantee significant shifts in economic and social attitudes without sustained engagement. Educational interventions aimed at promoting environmental and economic sustainability may need to employ experiential learning models that allow students to actively participate and reflect on their learning through meaningful projects (Nikolić et al., 2020; Korneeva et al., 2023). For instance, interventions involving diverse forms of practical engagement, such as environmental volunteering or community-based projects, have shown to foster deeper understanding and commitment to social and ecological stewardship among students (Borges, 2019; Zafar et al., 2024; Korneeva et al., 2023).

Students' cultural backgrounds profoundly inform their understanding and appreciation of concepts such as biodiversity and conservation. For example, individuals from communities that maintain close ties to nature and possess traditional knowledge about local medicinal plants are likely to resonate more with materials presented in philosophy based science education (Lestari et al., 2019; Sutrisno et al., 2021) . This cultural familiarity can enhance their comprehension and retention of ecological principles discussed in the curriculum. Conversely, urban students who are less directly connected to traditional lifestyles and local ecosystems may find it more challenging to engage with the same content, potentially leading to a diminished impact of educational interventions aimed at promoting environmental consciousness (Marasabessy & Baguna, 2020; Tjilen et al., 2023).

Moreover, the varying degrees of interaction with local traditions and ecological systems can create distinct attitudes towards sustainability and conservation among students. As such, education systems must recognize these cultural nuances and consider adapting curricula to better align with the students' contextual realities (Cahyono et al., 2022; Kristanto, 2020; Prasaja et al., 2023). This adaptation may involve integrating culturally relevant examples, ensuring that teaching practices resonate with the students' personal and communal experiences, thereby enhancing their engagement and effectiveness in promoting desired behavioral changes.

Educational contexts encompass a wide array of factors, including national educational policies, the resources available within schools, and the level of support provided by parents and communities. These elements collectively shape the environment in which teaching and learning occur. For instance, robust community support and a curriculum that aligns with national educational standards can significantly enhance the implementation of philosophy-based science education programs (Bukhari et al., 2025; Safitri & Adiwijaya, 2025). Without such supportive frameworks, even well-conceived educational interventions may fall short in inducing meaningful changes in students’ attitudes and behaviors towards biodiversity and sustainable economic practices.

Additionally, the broader educational infrastructure, including the availability of qualified educators, teaching materials, and access to experiential learning opportunities, plays a crucial role in the successful delivery of philosophy-

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based education. The lack of resources or insufficient teacher training can severely limit the effectiveness of integration efforts, thereby hampering the potential for long-term attitudinal shifts among students regarding environmental issues (Lestari et al., 2019; Nikolić et al., 2020; Uge et al., 2019).

CONCLUSION

Based on the results of the study, philosophy-based biology teaching proved to be more effective in improving students' knowledge, attitudes, and behavior related to biodiversity and the conservation of Mentawai medicinal plants compared to conventional biology teaching. This teaching method significantly improved students' knowledge of biodiversity and the conservation of Mentawai medicinal plants, with the experimental group showing higher results, especially on environmental knowledge indicators, with a Cohen's d value of 0.80, indicating a large effect. In addition, science philosophy-based teaching was also more effective in shaping students' positive attitudes towards biodiversity and conservation, as reflected in the improved attitudes of the experimental group with a Cohen's d of 0.73. Equally important, this teaching also encouraged behavioral changes that were more supportive of biodiversity and the conservation of Mentawai medicinal plants, with a significant increase in scores in the experimental group, especially in environmental behavior, which received a Cohen's d value of 1.03, indicating a large effect. Overall, philosophy-based biology teaching proved to be more effective in increasing students' awareness of biodiversity and the conservation of Mentawai medicinal plants in all aspects tested, namely students' knowledge, attitudes, and behavior.

The implication of these findings for teachers is the importance of integrating the philosophy of science into biology teaching, not only focusing on scientific aspects, but also incorporating relevant cultural values and local wisdom. This approach can be done with more holistic learning methods, such as discussions, case studies, and culture-based projects, in order to deepen students' understanding of biodiversity and the importance of conservation. For policymakers, the results of this study suggest that science-based teaching should be integrated into biology curricula at all levels of education, especially in areas with rich local biodiversity. This will support the strengthening of students' understanding of the preservation of local medicinal plants and biodiversity as part of more sustainable conservation efforts.

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Conceptualization, C.N.A., and S.; methodology, R., and P.H.R.S; software, R., R.F., and S.; validation, R., C.N.A., and R.F.; format, P.H.R.S, and R analysis; investigation, C.N.A., and S.; resources, P.H.R.S., and S.; data curation, R., S., and R.F.; writing preparation of original drafts, C.N.A.; writing reviewing and editing, S., R., and R.F.; visualization, S., R., and C.N.A.; supervision, S.; project administration, R., S., and R.; acquisition of funding, P.H.R.S., R.F., R., S., and C.N.A. All authors have read and approved the published version of the manuscript.

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