

## Effectiveness of Indigenous Knowledge-Oriented Instructional Modules to Promote Biodiversity Literacy

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### ABSTRACT

Biodiversity literacy (BL), which includes biodiversity knowledge (BK) and biodiversity awareness (BA), is essential to address the problem of biodiversity loss. There has been no precedent for teaching biodiversity topics by combining Western science with indigenous knowledge through a contextual Indigenous Knowledge-oriented Instructional Module (IKIM). This study highlights the significant role of the IKIM module in improving biodiversity literacy, demonstrating its effectiveness in integrating Western science and indigenous knowledge. A quasi-experimental design with a non-equivalent group design was employed, comprising a pre-test and a post-test. The IKIM is based on contextual theory and constructivism, which includes a series of instructional steps, such as stimulation, discussion of Western science, exploration of indigenous knowledge, and reflection. The findings indicated that the experimental group exhibited a more pronounced enhancement in biodiversity literacy scores than the control group. The experimental group showed a 6.72-point increase in biodiversity knowledge (BK) and a 10.92-point increase in biodiversity awareness (BA), while the control group showed a 1.40-point BK increase and a -0.12-point BA decrease. Hypothesis testing confirmed a significant difference in gain scores for both biodiversity knowledge and awareness between groups. The significance value is as follows: The p-values for the two tests were 0.000 and 0.001, respectively, with a significance level of  $\alpha \leq 0.05$ . The findings

indicate that IKIM, based on contextual theory, was an effective intervention for enhancing BL. The results suggest that IKIM enhances biodiversity literacy and aids contextual efforts to mitigate its loss.

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## INTRODUCTION

There has been a significant decline in biodiversity recently (Cipullo, 2016), resulting in biodiversity loss (Kaşot & Özbaş, 2015). Biodiversity literacy (BL) must be promoted as a primary strategy to prevent biodiversity loss. Biodiversity literacy (BL) is comprised of two key elements: biodiversity knowledge (BK) and biodiversity awareness (BA) (Moss et al., 2014a; World Wildlife Fund (WWF) & World Council for Environmental Education (WCEE), 1996). The definitions of BK and BA were analyzed from the following documents: the Convention on Biological Diversity (CBD, 2013), Next Generation Science Standards (NGSS, 2013), the United Nations (UN, 2018), and the Indonesian curriculum. Based on this analysis, biodiversity knowledge (BK) can be defined as the ability to know about the diversity of organisms on Earth, including different levels of biodiversity (genetic, species, and ecosystem diversity), the value of biodiversity, factors that affect biodiversity, the role of ecosystems for biodiversity, threats and preservation of biodiversity, and environmental conservation. Meanwhile, BA can be defined as attitudes and actions towards the diversity of organisms, including threats and preservation of biodiversity.

The lack of understanding, knowledge, and awareness of biodiversity evidences the continued low status of BL in society (Barrutia et al., 2022; Moss et al., 2014a; Pedrera et al., 2021). The general public remains limited in its comprehension

of biodiversity (Hooykaas et al., 2020), including among younger demographics (Barrutia et al., 2022; Pedrera et al., 2021). Younger generations also often fail to recognize the intrinsic value of plants (Pedrera et al., 2021). Furthermore, there is a lack of understanding about the extent of biodiversity (Schneiderhan-Opel & Bogner, 2020a), as well as a dearth of knowledge about animal species native to specific areas (Hooykaas et al., 2019; Randler & Heil, 2021). Moss et al. (2014a) also found that some respondents initially demonstrated a lack of pro-biodiversity actions.

A study on BL was conducted with 1,065 high school students from March to June 2023. BL was measured using validated instruments, both test and non-test, demonstrating content and criterion validity. A multiple-choice test comprising 23 items assessed biodiversity knowledge (BK). In addition, a 30-item Likert-scale questionnaire assessed biodiversity awareness (BA). The results demonstrated that the average biodiversity knowledge (BK) was 48.39, indicating that the students were in the low criteria range. Most students (78.59%) were classified within the low criteria. Low BK was evident in the distribution of scores across the various indicators, including ecological principles and processes (47.97-low), problems and issues associated with biodiversity (50.34-low), and the investigation of biodiversity problems and action strategies (43.29-low).

The average biodiversity awareness (BA) was 72.09, within the sufficient criteria. Many students (44.13%) were

classified within the low criteria. The overall average of this BA is sufficient, as evidenced by the percentage of each indicator, including sensitivity and positive values towards biodiversity (74.51-sufficient) and personal and community efficacy related to biodiversity (behavior predictors) (70.23-sufficient). Students' knowledge can foster positive perceptions of biodiversity (Paradise & Bartkovich, 2021). Positive perceptions promote successful, long-term biodiversity conservation (Bennett, 2016). Improved understanding of biodiversity can also foster a sense of responsibility and commitment to biodiversity awareness (Adinugraha et al., 2024).

Low levels of biodiversity knowledge are influenced by several factors, including the lack of individual participation in biodiversity-related activities (Hooykaas et al., 2020), curriculum changes that have occurred over recent decades (Gerl et al., 2021), and a lack of skills to identify species (Paradise & Bartkovich, 2021). Promoting biodiversity literacy (BL) represents a crucial first step in preserving and conserving biodiversity (Hooykaas et al., 2019; Oliveira et al., 2019; Schneiderhan-Opel & Bogner, 2020a). Promoting BL can be achieved by incorporating biodiversity-related topics into the educational curriculum (Koulouri et al., 2022; Schneiderhan-Opel & Bogner, 2020a; UN, 1992).

Contextual learning theory and social constructivism are relevant approaches to fostering biodiversity literacy (BL) through real-world exploration of the surrounding environment. Contextual learning prioritizes

a student-centered approach by connecting abstract concepts to real-world experiences (Suryawati, 2018), making learning more meaningful and engaging (Westera, 2011), thereby enabling students to construct new knowledge (Hudson & Whisler, 2007) in a meaningful and engaging manner (Johnny, 2008). Similarly, social constructivism supports learning through flexible, collaborative experiences, allowing students to engage in active peer-to-peer interactions (Palit, 2018; Shah, 2019) and enhancing knowledge comprehension (Akpan et al., 2020).

Improving low BL can be done by implementing contextual learning theory, which encompasses a specific form of learning centered on biodiversity exploration. Students may engage in exploratory learning by visiting biodiversity-rich locations (Kamudu et al., 2022; Moss et al., 2014a; Schneiderhan-Opel & Bogner, 2020a). Such site-based exploratory learning has enhanced biodiversity literacy (Kamudu et al., 2022; Moss et al., 2014b, 2014a). Areas rich in biodiversity often have inhabitants who adhere to Indigenous knowledge (Adam et al., 2019; Gonçalves et al., 2021; Ishtiaq et al., 2013; Malekani, 2020; Selemanni, 2020). However, previous research has predominantly focused on either biodiversity literacy through site-based exploration or the separate role of Indigenous knowledge in environmental education. Limited research has explored how contextual learning theory can bridge these two dimensions by integrating Indigenous knowledge into biodiversity literacy programs. This

study addresses this theoretical gap by implementing the Indigenous Knowledge-oriented Instructional Module (IKIM), which systematically integrates Indigenous knowledge within a contextual learning framework to enhance biodiversity literacy.

Indigenous knowledge (IK) is also called local wisdom in some academic studies. IK comprises principles, skills, practices, rituals, and customs developed by a specific race or tribe and transmitted from generation to generation (Adam et al., 2019; Ksenofontov et al., 2019). IK is often found in biodiversity-rich regions inhabited by these groups (Adam et al., 2019; Gonçalves et al., 2021; Ishtiaq et al., 2013; Malekani, 2020; Selemani, 2020). One community that has retained IK is the Somongari Javanese community, residing in Somongari Village, Kaligesing District, Purworejo Regency, Central Java Province. During the observation period from January to August 2022, several instances of IK were identified that are still preserved by the Somongari Javanese community. These include traditional rituals, traditional coconut sugar production, and the utilization of animals in the community yard. To enhance learning experiences, IK and biodiversity can be integrated into instructional modules through multimedia content, interactive case studies, and hands-on activities, fostering deeper engagement with indigenous knowledge and biodiversity.

Instructional modules are teaching materials designed to foster student autonomy. They comprise objectives, sequences of learning activities, provisions,

and evaluation (Robinson & Crittenden, 1972; Utomo et al., 2020). Instructional modules about biodiversity have been developed by Schneiderhan-Opel & Bogner (2020b) to promote biodiversity conservation, with forest ecosystems as one example. Mumpuni et al. (2022) have developed instructional modules based on local wisdom regarding using plants for local communities. Existing instructional modules often separate Indigenous Knowledge (IK) and Western science instead of integrating them. Western science relies on empirical research, while IK encompasses traditional knowledge. Bridging these perspectives enhances biodiversity understanding. However, many modules lack a structured framework for integration, missing opportunities to make biodiversity education rigorous and culturally relevant. Students may struggle to connect scientific concepts with practical Indigenous wisdom without a clear strategy. Closing this gap is essential for fostering holistic biodiversity literacy.

Integrating these two knowledge systems means creating a complementary framework where scientific methodologies enhance the validation of IK while IK provides context-specific insights that Western science may overlook (Chakrabarty et al., 2022; Wilder et al., 2016). In the case of the Somongari Javanese community, ensuring that IK is incorporated into instructional modules will help contextualize biodiversity education, making it more relevant and applicable to students' lived experiences. Therefore, developing Indigenous Knowledge-Oriented

Instructional Modules (IKIM) is crucial for enhancing biodiversity literacy (BL).

This study aims to investigate the implementation of the learning process using indigenous knowledge-oriented instructional modules (IKIM) and to evaluate the effectiveness of this learning approach on BL. Biodiversity education is crucial, as it is designed to support BL effectively. Mumpuni et al. (2022) found that using instructional modules enhances knowledge about biodiversity. Moreover, instructional modules are crucial for cultivating pro-environmental conduct and biodiversity awareness (Schneiderhan-Opel & Bogner, 2020b). Instructional modules facilitate responsive, interactive, and effective learning in science (Bockholt et al., 2003; Haris & Osman, 2015; Verleger et al., 2005). As demonstrated by the studies of Moss et al. (2014a, 2014b) and Kamudu et al. (2022), inviting students to visit biodiversity sites can also enhance their biodiversity literacy. Therefore, this study hypothesizes that IKIM can positively impact biodiversity literacy, which includes biodiversity knowledge (BK) and biodiversity awareness (BA). The module allows students to learn about biodiversity and IK simultaneously. Learning using IKIM will enhance biodiversity knowledge and awareness, thus contributing to efforts to prevent biodiversity loss.

## METHODS

### Participants and Procedures

This study employed a quasi-experimental design utilizing the pre-test-post-test

non-equivalent group design. A quasi-experimental approach was chosen because it allows for investigating the effects of the instructional intervention in a natural classroom setting while maintaining a degree of control. Randomized controlled trials were not feasible due to ethical and practical constraints in school environments. The study employed a two-group design, comprising an experimental group (A) and a control group (B), with 25 high school students in each group. Participants were selected based on comparable academic performance, demographic characteristics, and school availability to ensure validity and minimize selection bias.

The gender distribution in Group A was 70% male and 30% female, while in Group B, it was 60% male and 40% female. The regional distribution in Group A included 40% of students from Purworejo and 60% from other areas, while Group B included 50% of students from Purworejo and 50% from other areas. The student population in both groups included individuals from diverse ethnic backgrounds, including Javanese, Papuan, Nusa Tenggara, Batak, and Chinese. The respondents were adolescents aged 14 to 18. Group A received instruction using the IKIM media, while Group B received instruction using textbooks without the IKIM media. Both groups were given a pre-test before Learning Meeting 1 and a post-test after Learning Meeting 8.

### Data Collection

The data on the implementation of learning using IKIM was analyzed qualitatively,

covering the structure of IKIM, its distinctive characteristics, and how it integrates Western science with local knowledge. The development of IKIM involved integrating indigenous knowledge (IK) with Western biodiversity science. Examples of this integration include the use of plants and animals in traditional ceremonies, the utilization of local plants and animals for food production, and the role of backyard animals in supporting agroecosystems. These practices were aligned with Western scientific theories on biodiversity, such as ecosystem dynamics and species interdependence, to create a comprehensive instructional module. The validated instruments used included a 23-item multiple-choice test for evaluating BK and a non-test questionnaire comprising 30 items for evaluating BA. The BL instrument was adapted from the original WWF and WCEE (1996) versions and was validated for content and criterion. Content validation was conducted by three experts, each of whom is an expert in biology, botany, and environmental learning. Criterion analysis was performed using corrected item correlation with the IBM SPSS Statistics 20 application.

### **Data Analysis**

The data analysis was conducted in two stages: descriptive and inferential. Descriptive analysis focused on implementing learning via the IKIM media and biodiversity literacy (BL) scores. Furthermore, a descriptive analysis was conducted on the BL scores, including BK and BA. Descriptive analysis

was performed by summing the BK and BA scores and transforming them into percentages. Furthermore, the scores were transformed into percentages and classified into three categories: high (excellent and above average), sufficient (average), and low (below average and failure). According to the criteria established by Briggs et al. (2023), the criteria above are calculated based on the percentage score as follows: “excellent” (90%-100%), “above average” (80%-89%), “average” (70%-79%), “below average” (60%-69%), and “failure” (0%-59%).

Inferential analysis was conducted to determine the appropriate statistical test for comparing the gain scores between the experimental group (Group A) and the control group (Group B). The gain scores were calculated as the difference between each group’s post-test and pre-test scores. An independent samples t-test and the Mann-Whitney U test were used to compare the gain scores between the two groups, as the focus was on examining differences between groups rather than within groups. The statistical hypotheses were formulated as follows: the alternative hypothesis ( $H_1$ ) stated a significant difference in BK gain scores between Group A, which was treated with IKIM, and Group B, which did not receive IKIM treatment. Similarly, for BA gain scores, the alternative hypothesis ( $H_1$ ) proposed a significant difference between Group A and Group B. Before conducting the t-test, the data analysis requirements were tested. Normality was assessed using the Shapiro-Wilk test, and homogeneity of variances was tested using Levene’s test. All

statistical analyses were performed using the IBM SPSS Statistics 20 application.

The Shapiro-Wilk test shows that the Sig. Value of the experimental BK gain scores (BK-A) is 0.004, while the Sig. Value of the control BK gain scores (BK-B) is 0.040. The Sig. value is  $<0.05$ , so the BK-A and BK-B gain scores data are not normally distributed. The Sig. value of the experimental BA gain scores (BA-A) is 0.493, while the Sig. Value of the control BA gain scores (BA-B) is 0.913. The Sig. value is  $> 0.05$ , so BA-A and BA-B gain scores are normally distributed. The Levene Test shows that the Sig. The value of gain scores, BK, is 0.387, and BA is 0.449. The Sig. value is  $> 0.05$ , so the data of the BK and BA gain scores are homogeneous. BK-A and BK-B gain scores data were tested using the Mann-Whitney U test, while BA-A and BA-B gain scores data were tested using the independent-sample T test.

## RESULTS AND DISCUSSION

### Implementation of IKIM in Learning

The IKIM, developed in this study, can be accessed via the link: <https://bit.ly/3REpiUn> or <https://bit.ly/biodiversityindigenous> (Adinugraha et al., 2023). IKIM offers a synthesis of contemporary Western scientific knowledge and traditional indigenous knowledge. IKIM is designed to support BL according to the development of local and global biodiversity and environmental issues. BL in IKIM encompasses several interconnected concepts, specifically BA and BK. BK covers concepts such as the principles of biodiversity, ecosystems,

biodiversity value, species diversity, and conservation strategies. BA includes concepts related to personal and social awareness, sensitivity, and positive values. These concepts are interconnected, as depicted in the concept map of BL presented in Figure 1.

Each learning activity in IKIM is based on contextual theory and consists of four sequential steps: stimulation, discussion of modern or Western science, exploration of Indigenous knowledge (IK), and reflection. The discussion step reflects the Western science approach, while the exploration step highlights the role of Indigenous knowledge in complementing biodiversity insights derived from Western science. Through IKIM media, students engage in collaborative learning within heterogeneous groups. In this context, 'heterogeneous' refers to group members with diverse attributes, including academic performance, competencies, and regional backgrounds. Teachers play a crucial role in facilitating these groups' formation while guiding students' learning processes. The instructional activity steps in IKIM are illustrated in Figure 2.

The stimulation provided in IKIM is initially presented as visual and textual representations at the outset of learning activities. The teacher performs apperception activities to create an atmosphere conducive to mental preparation, attracting the students' attention and focusing on the forthcoming lesson (Howard, 2002; Puteri, 2018). The images in the module are contextualized, focusing specifically on biodiversity and



thinking through the lens of biodiversity presented in IKIM. The Western scientific content under discussion is knowledge about nature that emerged in Europe around the 16<sup>th</sup> century (Cohen, 2010). The content of modern science discussed is derived from the Convention on Biological Diversity (CBD, 2013), Next Generation Science Standards (NGSS, 2013), the United Nations (UN, 2018), Indonesian curriculum, and references to both books and journals. Integrating Western science and IK is necessary to enhance biodiversity knowledge (Chakrabarty et al., 2022; Wilder et al., 2016).

The exploration of indigenous knowledge (IK) in IKIM is conducted through student activities aimed at collecting data about using plants and animals in traditional rituals, traditional coconut sugar production, and the exploitation of yard animals to benefit the ecosystem. IK provides knowledge of local practices on local biodiversity (Baul & McDonald, 2014; Malekani, 2020), which is transferred through communication between generations (Ksenofontov et al., 2019). IK also contains noble values that support positive characteristics such as non-discriminatory actions and mutual respect between students. Positive character possessed by students can promote ethical behavior among students (Singh, 2019). Students must foster cultural values through contextual knowledge based on surrounding cultural experiences (Triyanto & Handayani, 2020). The instructional design of IKIM is flexible, allowing adaptation to different

Indigenous Knowledge systems, making it a viable approach for diverse cultural contexts, including non-Indigenous students.

Reflection on IKIM is carried out at the end of the learning activity or as a closing. Students reflect by filling in the self-reflection sheet on IKIM. Although there is no precise consensus, reflection is constructing personal and internal knowledge through voluntary and repeated consideration and interpretation of one's experiences or beliefs (Tracey et al., 2014). Reflection is necessary for students to revisit what they have learned for improvement and deep learning (Chang, 2019). The findings of Ravana et al. (2023) said that sometimes activities in books focus too much on discussion but neglect feedback and reflection. Reflection at the end of learning activities in IKIM aims to determine the achievement of learning objectives before continuing with the following learning activity.

The student activities conducted within the framework of IKIM are founded upon the tenets of social constructivism. Vygotsky first proposed the social constructivist learning theory in 1968 (Akpan et al., 2020). This theory posits that all meaningful learning generates personal meaning through the individual's cultural knowledge and understanding (Palit, 2018). Constructivist activities have been demonstrated to enhance literacy (Ardiansyah & Ujihanti, 2018) by fostering active creation, interpretation, and reorganization of student knowledge (Shah, 2019). The social constructivist approach facilitates student interaction through

collaboration with guidance from the facilitator (Akpan et al., 2020; Palit, 2018).

Collaborative activities in IKIM are designed to develop cognitive knowledge in and outside the classroom. The development of cognitive knowledge is not an automatic process; instead, it is actively constructed within the learning environment (Liu & Matthews, 2005). A flexible and responsive learning environment is essential for effective constructivist teaching (Shah, 2019). If the activities mentioned above cannot be conducted outside the classroom, students may opt to engage in virtual visits via video links embedded within the IKIM platform. The images and video links are also related to the IK content, which results from research on the Somongari Javanese community using the principles of ethnobiology. As a field of study that examines the relationship between humans and organisms within the domains of biology, ecology, and culture (Albuquerque et al., 2014; Pierotti, 2020), ethnobiology is particularly relevant for understanding the indigenous knowledge of the Somongari Javanese community.

The IKIM media was implemented to promote BL by enhancing students' BK and BA. The IKIM media was developed based on eight key characteristics, including 1) an attractive appearance; 2) a communicative approach; 3) the inclusion of modern or Western science content; 4) the presentation of indigenous knowledge content; 5) a constructivist foundation; 6) literacy activities; 7) 21<sup>st</sup>-century skills; and 8) character education. Figure 3 provides an overview of the learning activities conducted using IKIM in the experimental group.

### Effect of IKIM on Biodiversity Literacy (BL)

#### *Description of Biodiversity Literacy (BL) Data*

The mean BL post-test score (a combination of BK and BA scores) in Group A was higher than in Group B. The difference between the mean pre-test and post-test scores in Group A was also greater than in Group B. However, Group B also showed an increase in BL scores. BL can be promoted through learning activities (Koulouri et al., 2022;



Figure 3. Implementation of the use of IKIM: (a) Student learning activities in class; (b) Student learning activities in Somongari Village

\*Note: Photos have received permission from the school and students to be published

Schneiderhan-Opel & Bogner, 2020a; UN, 1992). During the pre-test, the mean BL-A score was lower than that of BL-B. However, in the post-test, the mean BL-A score exceeded that of BL-B. The increase in BL scores between the pre-test and post-test was more significant in Group A (17.64 points) compared to Group B (1.28 points). BK-A scores increased more than BK-B scores. The BA-A score increased more than the BA-B score, which decreased by only 0.12 points. The data is presented in Figure 4.

When group A was given the pre-test, the average percentage score of BK-A and BA-A per indicator was lower than BK-B and BA-B. After being treated, the average post-test percentage score of BK-A and BA-A per indicator (4 out of 5) surpassed BK-B and BA-B. In addition to the increase in post-test scores, the difference in the scores for each indicator

between the post-test and pre-test of group A was higher than that of group B. This increase in the percentage score indicates that IKIM can contribute to the increase in BL scores from pre-test to post-test in group A. Comparative data on the average increase in each indicator before and after the implementation of learning is presented in Table 1.

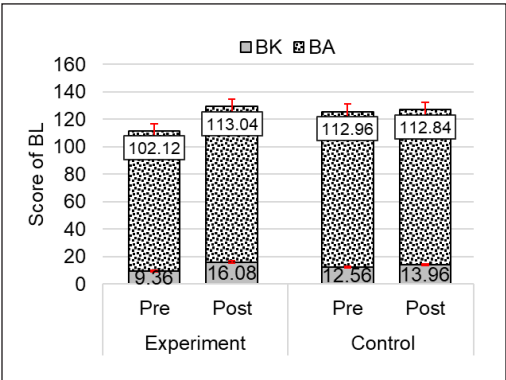


Figure 4. Mean BL score of control and experimental groups

Table 1  
Comparison of average improvement per BL indicator before and after learning implementation

| Variable               | Indicators                                                              | Experiment (A) (%) |           | The difference (%) | Control (B) (%) |           | The difference (%) |
|------------------------|-------------------------------------------------------------------------|--------------------|-----------|--------------------|-----------------|-----------|--------------------|
|                        |                                                                         | Pre-test           | Post-test |                    | Pre-test        | Post-test |                    |
| Biodiversity knowledge | 1 Ecological principles and processes related to biodiversity           | 38.00              | 74.80     | 96.84              | 48.00           | 60.00     | 25.00              |
|                        | 2 Problems and issues related to biodiversity                           | 42.40              | 69.60     | 64.15              | 60.00           | 64.80     | 8.00               |
|                        | 3 Biodiversity problem investigation and action strategies              | 44.00              | 54.67     | 24.24              | 58.67           | 49.33     | -15.91             |
| Biodiversity awareness | 4 Sensitivity and positive values of biodiversity issues                | 70.34              | 78.15     | 11.11              | 78.77           | 77.05     | -2.19              |
|                        | 5 Have beliefs about the personal and societal efficacy of biodiversity | 66.35              | 73.22     | 10.35              | 72.66           | 73.84     | 1.68               |

In the BK variable, the sub-indicator that experienced a high increase in group A was sub-indicator 1.3, while the lowest was sub-indicator 3.2. The sub-indicator that experienced a high increase in group B was sub-indicator 1.3, while the lowest was sub-indicator 3.1. In the BA variable, the sub-indicator that experienced a high increase in group A was sub-indicator 4.1,

while the lowest was 5.3. The sub-indicator that experienced a high increase in group B was sub-indicator 5.3, while the lowest was sub-indicator 4.2. A comparison of the differences in improvement of each sub-indicator is presented in Table 2.

Learning biology using IKIM could increase the number of high-criterion students on the BK and BA scores. In the BK

Table 2  
*Comparison of improvements in each sub-indicator between experimental and control groups*

| Variable               | Indicator                                                               | Subindicator                                                                                                      | Experiment (%) | Control (%) |
|------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|----------------|-------------|
| Biodiversity knowledge | 1 Ecological principles and processes related to biodiversity           | 1.1 Explain the diversity at the genetic, species, and ecosystem levels.                                          | 80.00          | 29.55       |
|                        |                                                                         | 1.2 Identify ecological factors that affect biodiversity.                                                         | 45.83          | 0.00        |
|                        |                                                                         | 1.3 Analyze the indirect biodiversity values, including cultural, recreational, and ecological values.            | 158.06         | 42.50       |
|                        | 2 Problems and issues related to biodiversity                           | 2.1 Analyze the human activity factors and political, economic, and social issues that lead to biodiversity loss. | 79.59          | 12.00       |
|                        |                                                                         | 2.2 Explain the direct value of biodiversity in terms of consumption and production.                              | 60.00          | -11.11      |
|                        |                                                                         | 2.3 Explain the role of science and technology in biodiversity.                                                   | 43.75          | 17.95       |
|                        | 3 Biodiversity problem investigation and action strategies              | 3.1 Analyze environmental and biodiversity issues.                                                                | 33.33          | -26.67      |
|                        |                                                                         | 3.2 Predict strategies to address environmental and biodiversity issues.                                          | -7.14          | -10.53      |
|                        |                                                                         | 3.3 Relate sustainable development goals to environmental and biodiversity issues.                                | 71.43          | -10.00      |
| Biodiversity awareness | 4 Sensitivity and positive values of biodiversity issues                | 4.1 Have sensitivity to biodiversity.                                                                             | 11.71          | -1.84       |
|                        |                                                                         | 4.2 Have positive values towards biodiversity.                                                                    | 10.14          | -2.70       |
|                        | 5 Have beliefs about the personal and societal efficacy of biodiversity | 5.1 Have a locus of control.                                                                                      | 12.20          | 1.90        |
|                        |                                                                         | 5.2 Have an assumption or personal responsibility for biodiversity.                                               | 8.50           | 0.27        |
|                        |                                                                         | 5.3 Have social responsibility for biodiversity.                                                                  | 7.25           | 2.51        |
|                        |                                                                         |                                                                                                                   |                |             |

variable, there was an increase in the number of high-criterion students in groups A and B. The number of high-criteria BK-A students was higher than BK-B. In the BA variable, there was an increase in the number of students meeting high criteria in group A but a decrease in group B. The increase in group A proves the statement that the module can present interactive instructions (Haris & Osman, 2015; Verleger et al., 2005) so that

it can increase student learning motivation and help teachers facilitate the teaching and learning process (Syafii & Yasin, 2013). Learning the topic of biodiversity in both experimental and control groups reduced the number of BK and BA students. The data is presented in Figure 5.

BL promotion can improve understanding of biodiversity value knowledge (Moss et al., 2014a) and student

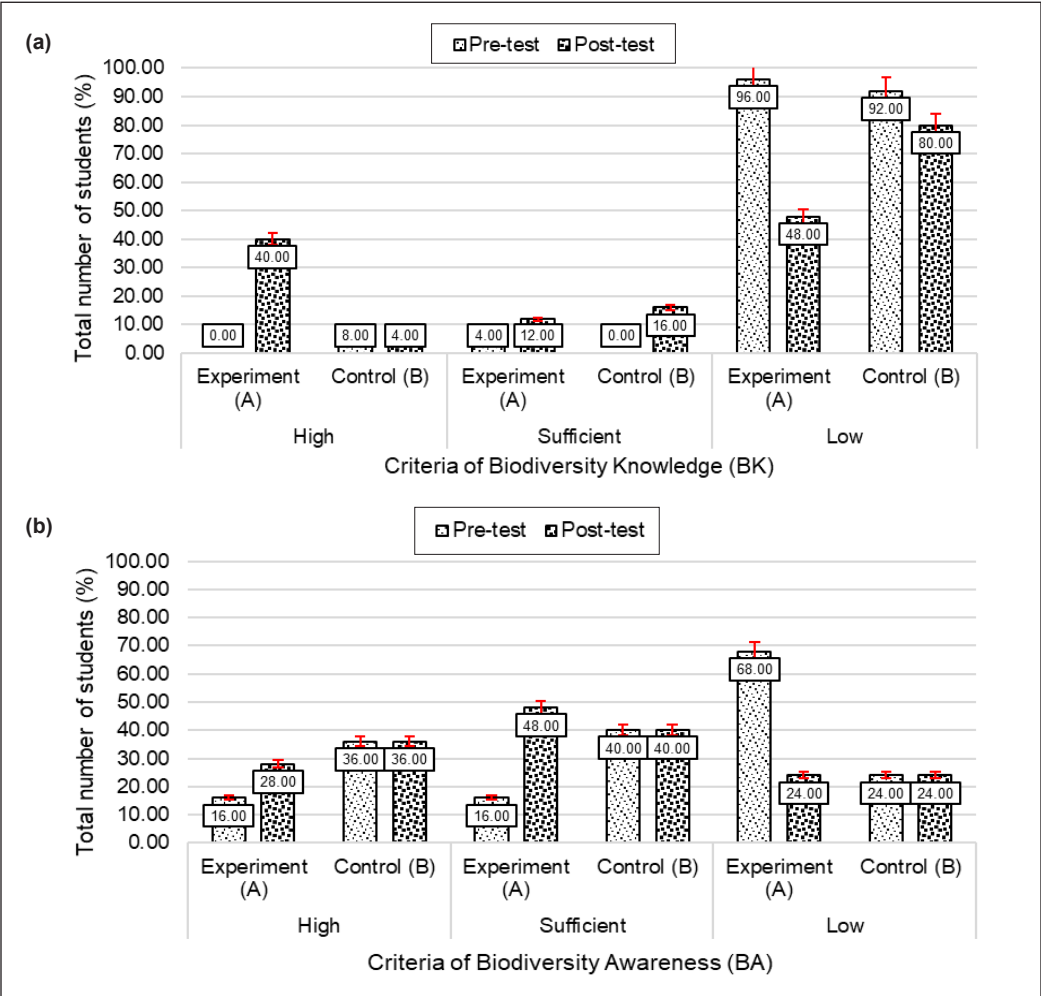


Figure 5. Biodiversity literacy criteria of students in groups A and B: (a) Biodiversity Knowledge (BK); and (b) Biodiversity Awareness (BA)

Source: Authors' work

knowledge of species diversity (Barrutia et al., 2022). This statement is supported by the data on the average BK and BA scores, which increased more in group A than B. The increase in BL score and percentage in group A needs to be tested against the increase in BK and BA scores in the two groups to determine significance. The difference test was conducted to compare the pre-and post-test gain scores of BK and BA between groups A and B. The increase in biodiversity knowledge (BK) helped shape students' positive perceptions of biodiversity (Paradise & Bartkovich, 2021) because knowledge is the most significant influence in creating biodiversity awareness (BA).

**Hypothesis Testing of the Effect of IKIM on BL**

***Effect of IKIM on Biodiversity Knowledge (BK)***

The Mann-Whitney U test was used to compare the final BK scores of groups A and B because the data were not normally distributed. Based on the output table of the Mann-Whitney U Test results, the Sig. = 0.000 value is obtained, which means that the Sig. Value is smaller than the Sig. Value.  $\leq \alpha$  0.05. Thus,  $H_0$  is rejected, and  $H_1$  is accepted, so there is a difference in BK gain scores between group A treated with IKIM and group B without IKIM treatment. The Mann-Whitney U Test statistic is presented in Table 3.

The difference in BK gain scores needs to be seen based on descriptive analysis to determine whether there is a significant

effect. Based on the results of descriptive analysis, the mean rank value of Group A is 34.94, and the mean rank of Group B is 16.06. This mean rank data shows an increase in the gain scores of Group A after getting the IKIM treatment, which is higher than Group B. Therefore, IKIM treatment has a significant effect on BK. The description of the data on BK gain scores is presented in Table 4.

Table 3  
*Statistic test Mann-Whitney U Test gain scores BK at pre-test–post-test non-equivalent group design*

| Biodiversity knowledge (BK) |         |
|-----------------------------|---------|
| Mann-Whitney U              | 76.500  |
| Wilcoxon W                  | 401.500 |
| Z                           | -4.598  |
| Asymp. Sig. (2-tailed)      | 0.000   |

Table 4  
*Data description of gain scores BK at pre-test–post-test non-equivalent group design using Mann-Whitney U Test*

| Group | N  | Mean rank | Sum of Ranks |
|-------|----|-----------|--------------|
| A     | 25 | 34.94     | 873.50       |
| B     | 25 | 16.06     | 401.50       |

***Effect of IKIM on Biodiversity Awareness (BA)***

An independent-sample T-test was used to compare the increase in BA scores of groups A and B because the data were normally distributed. Based on the output table of the independent-sample test results, the Sig. = 0.001 value is obtained, which means that the Sig. The value is smaller than the Sig. Value.  $\leq \alpha$  0.05. Thus,  $H_0$  is

rejected, and H1 is accepted, so the gain scores BA between group A treated with IKIM and group B without IKIM treatment. The independent-sample T-test statistic is presented in Table 5.

The difference in BA gain scores should be analyzed using descriptive analysis to determine its significance. Descriptive analysis shows that the mean gain score of group A (10.92) increased after treatment, whereas group B (-0.12) decreased. This indicates that IKIM treatment has a significant effect on BA. The description of the BA gain score data is presented in Table 6.

The analysis showed a significant increase in the experimental group’s BK and BA gain scores after receiving IKIM treatment, which was higher than in the control group. The significant increase in

BK and BA scores means that learning using IKIM can be used to support BL. Activities in IKIM that invite students to visit biodiversity-rich sites and learn about indigenous knowledge have been proven effective in teaching BL. The results of Moss et al.’s (2014a) research on activities to visit places related to biodiversity successfully improve the understanding of biodiversity knowledge. Research by Kamudu et al. (2022) also said that students who visit biodiversity-rich areas will experience an increased understanding of the importance of biodiversity, conservation measures, and endemic species.

Incorporating IKIM activities involving students learning Indigenous knowledge has also been demonstrated to be an effective pedagogical approach to teaching BL. IKIM

Table 5  
*Statistic test independent-sample T Test gain scores BA pre-test–post-test non-equivalent group design*

| Equal<br>variances | Levene's<br>Test for<br>Equality of<br>Variances |       | t-test for Equality of Means |        |                    |                    |                          |                                                 |        |
|--------------------|--------------------------------------------------|-------|------------------------------|--------|--------------------|--------------------|--------------------------|-------------------------------------------------|--------|
|                    | F                                                | Sig.  | t                            | df     | Sig.<br>(2-tailed) | Mean<br>Difference | Std. Error<br>Difference | 95% Confidence<br>Interval of the<br>Difference |        |
|                    |                                                  |       |                              |        |                    |                    |                          | Lower                                           | Upper  |
| Assumed            | 0.582                                            | 0.449 | 3.532                        | 48     | 0.001              | 11.040             | 3.125                    | 4.756                                           | 17.323 |
| Not<br>assumed     |                                                  |       | 3.532                        | 45.895 | 0.001              | 11.040             | 3.125                    | 4.748                                           | 17.331 |

Table 6  
*Data description of gain scores BA at pre-test–post-test non-equivalent group design using independent-sample t-test*

| Group | N  | Mean    | Std. Deviation | Std. Error Mean |
|-------|----|---------|----------------|-----------------|
| A     | 25 | 10.9200 | 12.17552       | 2.43510         |
| B     | 25 | -0.1200 | 9.79507        | 1.95901         |

provides knowledge about local practices related to local biodiversity (Baul & McDonald, 2014; Malekani, 2020), which is transferred through communication between generations (Ksenofontov et al., 2019). The ecological approach introduced by IK provides a distinctive and comprehensive understanding of biological systems (Adam et al., 2019), contributing to expanding biodiversity inventories, monitoring, and species recovery initiatives (Wilder et al., 2016). The effectiveness of IK in conserving biodiversity has been demonstrated in numerous studies (Kosoe et al., 2020; Ogar et al., 2020). In particular, IK is an invaluable tool in biodiversity conservation (Ali, 2021; Kosoe, 2020). The instructional design of IKIM can be adapted to various educational contexts by integrating region-specific Indigenous knowledge, ensuring its applicability across different cultural and ecological settings, particularly through modifications in instructional steps and learning activities that align with local traditions and ecological practices

One limitation of this study is that the IKIM effectiveness test was conducted with only two classes: one experimental group (A) and one control group (B). Future studies could expand the sample size and include a broader range of participants to enhance generalizability. Indigenous knowledge-oriented learning should be further mainstreamed in biodiversity education. Future research could explore approaches to integrating Indigenous knowledge or local wisdom in biodiversity education at a broader scope (Adinugraha, 2022) at a

broader scope such as incorporating diverse cultural perspectives, integrating Indigenous knowledge into multiple subjects, applying it across different education levels, utilizing digital technology, or expanding its implementation to global contexts.

Indonesia is rich in culture and biodiversity that can be used as a means of science learning (Zubaidah & Arsih, 2021), such as *Randai* (Arsih et al., 2019), medicinal plants (Azis et al., 2020; Lestari et al., 2020), and animals for medicine (Supiandi et al., 2023). Learning using IKIM is expected to be our contribution as a global community to support the SDGs document, namely goal number 15 on living on land or terrestrial ecosystems, and the Aichi Biodiversity Targets document. In addition, IKIM is the first step in preventing biodiversity loss through education, incorporating virtual field trip videos and interactive links to support online and hybrid learning, ensuring wider accessibility and engagement with Indigenous knowledge.

## CONCLUSION

The Loss of biodiversity represents a significant challenge that can be addressed by incorporating biodiversity-related learning into educational curricula. Biodiversity-related knowledge is acquired through visits to sites that exemplify biodiversity and exposure to indigenous knowledge. Such learning must be supported by instructional modules, such as the Indigenous Knowledge-Oriented Instructional Modules (IKIM), which have been successfully implemented. Implementing IKIM in biology learning

can enhance students' biodiversity literacy (BL). The analysis demonstrated that the mean post-test score for BL, a composite of biodiversity knowledge (BK) and biodiversity awareness (BA) scores in Group A, was higher than in Group B. This increase was substantiated by hypothesis testing. This increase was confirmed by hypothesis testing on the gain scores for BK and BA. The results of the analysis indicate that the IKIM treatment exerts a significant influence on both BK and BA. The significant effect on BK and BA indicates that IKIM can support the promotion of biodiversity literacy (BL). IKIM presents a combination of modern or Western science content and indigenous knowledge delivered through a four-step process: stimulation, discussion of Western scientific concepts, exploration of indigenous knowledge, and reflection. This research recommends that the learning should incorporate IKIM-based learning modules, which blend Indigenous knowledge and modern science, into biology curricula to enhance students' biodiversity literacy (BL).

Additionally, teachers may consider exploring local indigenous knowledge and integrating it with learning topic theories from Western science relevant to the biology curriculum. This combined approach can help contextualize learning. IKIM, based on contextual theory, can be a novel pedagogical tool for teaching science, particularly biology. Promoting BL through IKIM based on contextual theory is expected to contribute to addressing and resolving biodiversity loss and other environmental

issues. This study fills a theoretical gap by demonstrating how contextual learning theory can integrate Indigenous knowledge and Western science in biodiversity education. IKIM bridges these aspects within a structured contextual learning framework, enhancing biodiversity literacy through a culturally relevant approach. These findings highlight the importance of contextual learning in making science education more inclusive and meaningful.

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