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Biodiversity Literacy and Tradition: Development of Student Worksheets Based on the Local Potential of the Indahan Tupporobu Dish for Biology Learning

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ABSTRACT

Indonesia is a country with high levels of biodiversity (megabiodiversity), but student literacy related to biodiversity is still relatively low. This study aims to describe the feasibility, practicality, and effectiveness of Student Worksheets based on local potential, which are expected to improve student learning outcomes in biodiversity literacy. This study involved students from SMAN 4 Padangsidimpuan, grade X. This research is a Research and Development (R&D) study that adapts the 4D model from Thiagarajan, Semmel, and Semmel, which consists of the Define, Design, Develop, and Disseminate stages. However, this study was only conducted up to the Development stage due to time constraints. The Student Worksheets developed was verified by subject matter experts, with verification results showing a very high level of validity and no need for revision, namely 84% by subject matter experts and 85% from the analysis of student response test results, categorized as very good. The effectiveness test results showed that the Student Worksheets based on local potential is effective in improving students' biodiversity literacy, with an N-gain value of 0.36 (moderate category). Therefore, this Student Worksheets is suitable for use as a learning tool in biology education, particularly for topics related to biodiversity.

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INTRODUCTION

Indonesia is known as an archipelagic nation with the second-highest level of biodiversity in the world after Brazil, containing approximately a quarter of the world's flowering plant species, most of which are endemic (Kusmana & Hikmat, 2015; Setiawan, 2022). This biodiversity goes hand in hand with cultural diversity reflected in indigenous traditions, including traditional wedding ceremonies (Azhari et al., 2020). One example is the Indahan Tupporobu dish, a typical

Batak Mandailing dish from Padangsidimpuan, North Sumatra, which reflects the connection between local biodiversity and philosophical, symbolic, and spiritual values (Parsadaan, 1993).

Integrating local potentials such as Indahan Tupporobu into biology learning serves a dual role: preserving cultural knowledge while providing a contextual learning experience. Approaches based on local wisdom and regional potential have been proven to bridge traditional knowledge with modern science, strengthen students' connection to their environment, and support the achievement of the Pancasila student profile and 21st century skills (Ramdiah et al., 2020; Leksono, 2016; Sahoo & Mohammed, 2018). However, preliminary studies indicate that the implementation of biodiversity literacy in biology learning in secondary schools is still suboptimal.

Several studies emphasize the importance of utilizing local potential in science education. Local wisdom values have been proven to be integrated into teaching materials, including student worksheets, to enhance learning effectiveness while introducing regional culture (Safitri et al., 2023; Arianty et al., 2021; Saputri et al., 2022; Prastowo, 2011; Utami, 2016). Furthermore, several studies have developed student worksheets based on local potential in the context of biodiversity, for example, on the utilization of mangrove forests in Bengkulu or the local culture of West Kalimantan (Ganda, 2023; Monalia, 2023). However, studies on the biodiversity contained in traditional dishes such as Indahan Tupporobu and its potential to improve students' biodiversity literacy are still very limited.

Based on this, this study aims to develop and test the feasibility, practicality, and effectiveness of a student worksheet based on the local potential of Indahan Tupporobu as a contextual learning medium for improving secondary school students' biodiversity literacy.

RESEARCH METHODS

This research is a type of research and development (R&D) that adapts the 4D model from Thiagarajan, Semmel, and Semmel (1974), which consists of the Define, Design, Develop, and Disseminate stages. This model was chosen because it provides a systematic flow in designing learning tools based on needs and expert validation, as well as allowing the integration of local values into educational products. However, due to time and resource constraints, this research was only carried out up to the Develop stage, so the resulting product has not yet undergone a widespread distribution process.

In the Define stage, needs analysis was conducted through a study of the 10th-grade biology curriculum, identification of student characteristics, and exploration of local cultural valuethrough

direct observation and interviews with Mandailing Batak traditional leaders in Padangsidimpuan. This information was used to design relevant and contextual content.

The Design phase involved designing the Student Worksheets structure, integrating biodiversity content with local potential through the context of the traditional Indahan Tupporobu dish. The Student Worksheets was designed using an informative visual approach and exploratory activities, such as classifying food species, analyzing symbolic values, and group discussions on the connection between culture and biodiversity concepts.

During the development stage, the Student Worksheets were validated by two subject matter experts, two media experts, and two education practitioners using an assessment instrument that covered content, media presentation, and language. The instrument validation uses a 5-point Likert scale (1 = very poor to 5 = very good) adapted from the assessment criteria used previously (Riduwan, 2012; Sugiyono, 2017). Details of the Likert scale categories can be seen in Table 1.

Table 1. Likert Scale and Assessment Categories

Score	Quantitative Category	Reporting Results
1	Very Poor	Not valid
2	Poor	Less valid
3	Fair	Fairly valid
4	Good	Valid
5	Very Good	Very Valid

The trial was conducted on 64 tenth-grade students at a high school in Padangsidimpuan. School selection was conducted using a purposive sampling method based on certain considerations, namely the school's location close to an area that holds traditional wedding ceremonies with Indahan Tupporobu dishes, thus fitting the local research context. From this school, two classes were selected using a simple random sampling method to serve as the experimental and control classes. Inclusion criteria included students actively taking biology, while exclusion criteria were students with conditions that hindered participation or absence during the pretest and posttest. To reduce potential bias during group learning, group arrangements followed the pattern commonly used in the school, and were facilitated by researchers and teachers to ensure all students participated equally. The experimental class used a student worksheet based on Indahan Tupporobu, while the control class used a conventional student worksheet or a grade 10 biology textbook for high school/Islamic high school.

The research design employed a quasi-experimental method with a pretest-posttest design and an unequal control group (Creswell, 2014). To ensure initial equivalence, pretest data analysis was conducted, including normality and homogeneity tests. Since the variance between groups was

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not homogeneous, the nonparametric Mann–Whitney U Test was used to analyze differences in learning outcomes. Statistical analysis was performed using SPSS version 26 software with a significance level of 0.05, and learning outcome improvement was measured through the calculation of Normalized Gain (N-gain).

RESEARCH RESULT

The development of Student Worksheets based on local potential in the subject of biodiversity in this study is guided by the 4D development model, which consists of four stages: define, design , develop, and disseminate. The stages can be described as follows:

Define Stage

Based on interviews with traditional elders and indigenous Batak Mandailing people in Padangsidimpuan City, information was obtained regarding traditional wedding ceremonies, the types of dishes served, and the biodiversity contained in the ingredients used in these dishes, particularly Indahan Tupporobu. This dish reflects local richness through the use of various plant and animal species.

Information about the species used in the ceremony can be seen in Table 1, which provides a summary of the types of plants and animals in the Indahan Tupporobu dish. The table lists the local names, scientific names, and plant families, indicating the diversity of species involved. Additionally, the parts of the plants utilized, such as rhizomes, stems, leaves, and fruits, are also displayed, reflecting the local community's deep knowledge of plant morphology and function within a cultural context. The identification revealed 35 plant species from 18 families, with the Zingiberaceae family (ginger, turmeric, galangal) being the most dominant (14.3%). The materials are used specifically as food, tools, and decorations in traditional ceremonies.

Tabel 1. List of Indahan Dishes

No	Dish name and local name	Ingredient names and scientific names	Diversity level	Utilization category
1.	Gulai rendang goat/monkey head. (Hambeng ni simaradang tua-an old goat *(Capra aegagrus hircus.))*	Ginger (*Zingiber officinale*), shallots (*Allium cepa* var. *aggregatum*), garlic (*Allium sativum*), red and green chili (*Capsicum annuum*), galangal (*Alpinia galanga*), lemongrass (*Cymbopogon citratus*), turmeric (*Curcuma longa*), bay leaf (*Syzygium polyanthum*), gongseng coconut (*Cocos*	**1.Gene level:** Red, green chili. **2.Species level Zingiberaceae family:** Ginger, galangal, turmeric. **Family Poaceae** (grasses): Lemongrass **Family Arecaceae:** Coconut palm). **Family Apiaceae:** Coriander	Food ingredients

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No	Dish name and local name	Ingredient names and scientific names	Diversity level	Utilization category
		nucifera), asam potong or asam gelugur/keping (*Garcinia atroviridis*), coriander (*Coriandrum sativum*), and pepper (*Piper nigrum*).	**Family Clusiaceae** : Cut tamarind **Family Piperaceae**: Peppercorns **Lauraceae family:** Bay leaf **Myristicaceae family:** Nutmeg **Genus Allium:** onion, white, chive	
2.	Fish curry (carp, river fish) Majalaya carp, punten carp.	Ginger (*Zingiber officinale*), shallots (*Allium cepa* var. *aggregatum*), garlic (*Allium sativum*), red and green chili (*Capsicum annuum*), galangal (*Alpinia galanga*), lemongrass (*Cymbopogon citratus*), turmeric (*Curcuma longa*), bay leaf (*Syzygium polyanthum*), gongseng coconut (*Cocos nucifera*), asam potong or asam gelugur/keping (*Garcinia atroviridis*), coriander (*Coriandrum sativum*), and pepper (*Piper nigrum*).	**1.Gene level:** Red, green chili. **2.Species level** **Zingiberaceae family:** Ginger, galangal, turmeric. **Family Poaceae** (grasses): Lemongrass **Family Arecaceae :** Coconut palm). **Family Apiaceae:** Coriander **Family Clusiaceae**: Cut tamarind **Family Piperaceae**: Peppercorns **Family Lauraceae:** Bay leaf **Family Myristicaceae:** Nutmeg **Genus Allium:** onion, white, chive	Food ingredients
3.	Gulai rendang ayam kampung/pet elu (Manuk-pogang-chicken) Roast)	Ginger (*Zingiber officinale*), shallots (*Allium cepa* var. *aggregatum*), garlic (*Allium sativum*), red and green chili (*Capsicum annuum*), galangal (*Alpinia galanga*), lemongrass (*Cymbopogon citratus*), turmeric (*Curcuma longa*), bay leaf (*Syzygium polyanthum*), gongseng coconut (*Cocos nucifera*), asam potong or asam gelugur/keping (*Garcinia atroviridis*), coriander (*Coriandrum sativum*), and pepper (*Piper nigrum*).	**Gene level**: Red, green chili **Species level** **Zingiberaceae family**: Ginger, galangal, turmeric. **Family Poaceae** (grasses): Lemongrass **Arecaceae family:** Coconut palm). **Family Apiaceae:** Coriander **Clusiaceae Family:** Cut tamarind **Family Piperaceae:** Peppercorns **Lauraceae family:** Bay leaf **Myristicaceae family:** Nutmeg **Genus amillum:** onion, white, chive	Food ingredients
4.	River shrimp/gala	ginger (*Zingiber officinale*), shallots (*Allium cepa* var. *aggregatum*), garlic (*Allium*	**Gene level**: Red, green chili **2.Species level**	Food ingredients

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No	Dish name and local name	Ingredient names and scientific names	Diversity level	Utilization category
	shrimp curry, peci	*sativum*), hobo onion (*Allium chinense*), galangal (*Alpinia galanga*), lemongrass (*Cymbopogon citratus*), turmeric (*Curcuma longa*), bay leaves (*Syzygium polyanthum*), roasted coconut (*Cocos nucifera*), coriander (*Coriandrum sativum*), and peppercorns (*Piper nigrum*).	**Zingiberaceae family:** Ginger, galangal, turmeric. **Family Poaceae** (grasses): Lemongrass **Arecaceae family:** Coconut palm). **Family Apiaceae:** Coriander **Family Piperaceae:** Pepper **Lauraceae family:** Bay leaf **Genus Allium:** onion, white, chive	
5.	Vegetable curry of young jackfruit *Artocarpus heterophyllus.*	ginger (*Zingiber officinale*), shallots (*Allium cepa* var. *aggregatum*), garlic (*Allium sativum*), hobo onion (*Allium chinense*), red and green chilies (*Capsicum annuum*), lemongrass (*Cymbopogon citratus*), galangal (*Alpinia galanga*), turmeric (*Curcuma longa*), bay leaves (*Syzygium polyanthum*), coconut for coconut milk (*Cocos nucifera*), *coriander* (*Coriandrum sativum*), and peppercorns (*Piper nigrum*).	**Gene level**: red chili, green chili **Species level** **Zingiberaceae family:** Ginger, galangal, turmeric. **Family Poaceae (grasses):** Lemongrass **Arecaceae family:** Coconut palm). **Family Apiaceae:** Coriander **Family Piperaceae:** Pepper **Lauraceae family:** Bay leaf **Genus Allium:** onion, white, chive	Food ingredients
6.	Kale clear vegetable, yam leaf vegetable, katu leaf vegetable and Japanese shur.	Rimbang or tekokak (*Solanum torvum*), green eggplant (*Solanum melongena*), rambu (*Musa paradisiaca*, long bean (*Vigna unguiculata* ssp. *sesquipedalis*), and chickpea (*Phaseolus vulgaris*).	**Species level: Fabaceae family: chickpea**, string bean.	Food ingredients
7.	Serving place	Bamboo apus (*Gigantochloa apus),* bamboo wulung (*Gigantochloa atroviolacea).*	**Species level** **Bambusa family:** Apus bamboo, wulung bamboo	Utensils: dish container
8.	Burangir - Betel	*Betel* (*Piper betle*)	**Piperaceae family.**	Equipment
9.	Itak food	Sticky rice (*Oryza sativa*), Brown sugar - Sugar from *Arenga pinnata* (aren) or *Borassus flabellifer* (lontar), Young coconut / coconut milk / gongseng (*Cocos nucifera)*	**Species level** **Family Arecaceae:** Coconuts)	Foodstuff: supporting food

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No	Dish name and local name	Ingredient names and scientific names	Diversity level	Utilization category
10.	Sasagun food	Glutinous rice (*Oryza sativa*), Brown sugar - Sugar from *Arenga pinnata* (aren) or *Borassus flabellifer* (lontar), Young coconut / coconut milk / gongseng (*Cocos nucifera).*	**Species level** **Family Arecaceae:** Coconuts)	Foodstuff: supporting food
11.	Mandatory food	Glutinous rice (*Oryza sativa*), Brown sugar - Sugar from *Arenga pinnata* (aren) or *Borassus flabellifer* (lontar), Young coconut / coconut milk / gongseng (*Cocos nucifera),* Pandan leaves - *Pandanus amaryllifolius*	**Species level** **Arecaceae family:** Coconut Coconut-moisture) **Pandanaceae family:** fragrant pandan leaves.	Foodstuff: supporting dish
12.	Serving accessories	Paper flowers (*Bougainvillea spp.*), breadfruit leaves (*Artocarpus altilis*), banana leaves (*Musa paradisiaca*), banyan tree leaves (*Ficus benjamina*), green betel (*Piper betle*), gambier (*Uncaria gambi*r), and soda (whiting) (*Calcium hydroxide*).	**Gene level**: paper flowers (red, orange, yellow, white) **Species level** **Family Piperaceae:** betel green	Equipment: as a container decoration
13.	Sambal padati	Coconut (*Cocos nucifera*), fresh anchovies (*Stolephorus* spp.), ginger (*Zingiber officinale*), red chili (*Capsicum annuum*), shallots (*Allium cepa* var. *aggregatum*), and garlic (*Allium sativum*).	**Gene level**: red chili pepper **Species level** **Genus Allium: shallots**, white onions. **Family Zingiberaceae:** Ginger **Family Arecaceae:** Coconuts)	Food ingredients: supporting dishes
14.	Sambal starch	Coconut for coconut milk (*Cocos nucifera*), kecepek prawns or kopek anchovies (rice anchovies) - commonly *Stolephorus indicus* or *Engraulis spp.*, ginger (*Zingiber officinale*), red chili (*Capsicum annuum*), turmeric (*Curcuma longa*), *galangal* (*Alpinia galanga*), shallots (*Allium cepa* var. *aggregatum*), garlic (*Allium sativum*), asam potong or asam gelugur/keping (*Garcinia atroviridis*), and asam belimbing (*Averrhoa bilimbi*).	**1.Gene level**: red chili **2. Species level** **Genus Allium: shallots**, garlic. **Family Arecaceae:** Coconut (coconut-almond) **Family Zingiberaceae:** Ginger, galangal, turmeric. **Family Poaceae (grasses):** Lemongrass **Genus Allium:** onion, **white, chive** **Genus Stolephorus spp. or Anchoa spp.:** kecepek shrimp/ an**chovy** kopek (rice anchovy).	Foodstuff: supporting food

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Classification of Plant Species by Plant Families Utilized in Tupporobu Indahan Dishes

Plants used in various culinary dishes and traditional ceremonies are classified based on their botanical families. From the identification results, 35 plant species belonging to 18 families were found. Figure 1 shows that the Zingiberaceae family is the most utilized, with the highest usage rate reaching 14.3%. Interviews with indigenous people showed that plants from the Zingiberaceae family, such as ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), and galangal (*Alpinia galanga*), are commonly used as the main spices in traditional Indahan Tupporobu dishes, such as chicken curry, shrimp curry, and goat curry. Plants from this group are believed to not only add a distinctive flavor, but are also efficacious as body warmers and cold remedies, in accordance with their traditional medicine principles.

Besides Zingiberaceae, some other families that are also often used include Arecaceae (coconut/coconut milk), Alliaceae (shallots, garlic, chives), and Poaceae (lemongrass). In traditional wedding processions, the ingredients of Indahan Tupporobu dishes not only function as food ingredients, but also contain symbolic meanings that symbolize fertility, protection, and blessings.

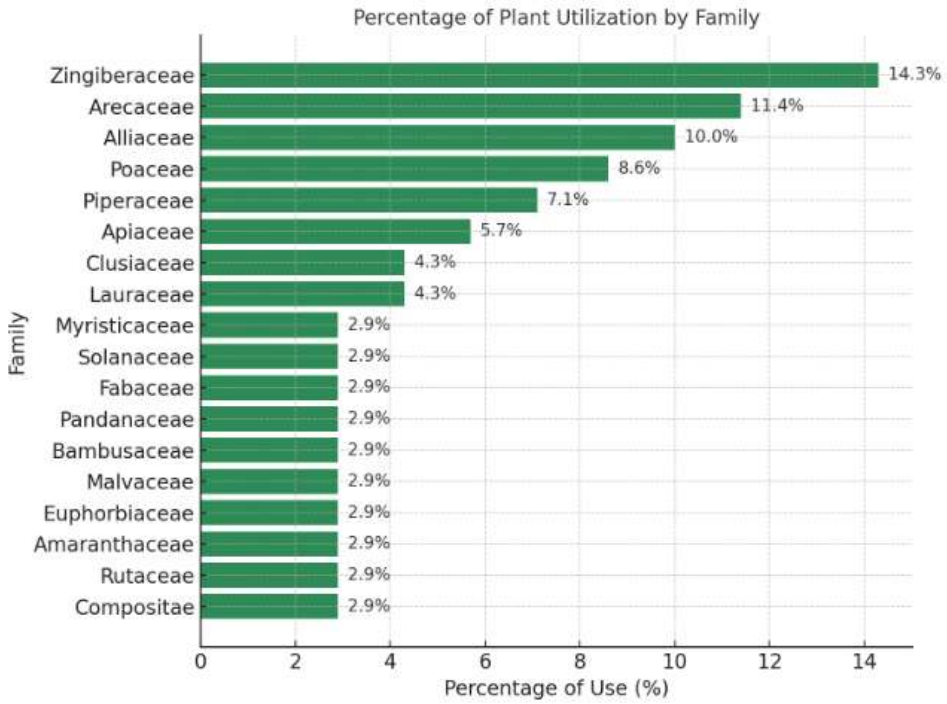

Figure 1. Percentage of utilization by family

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Design Stage

The design stage begins with the preparation of a preliminary draft of the Student Worksheet based on local potential, integrating biodiversity learning materials through the use of local species found in the traditional dish Indahan Tupporobu. This design is formulated to support active student engagement in the learning process, enhance biodiversity literacy, and strengthen understanding of the local cultural context embedded in students' daily lives.

The initial development of learning tools at this stage aims primarily to strengthen students' biodiversity literacy. The development process is carried out through four main stages: the development of assessment instruments in the form of pre-tests and post-tests, the selection of an Student Worksheets model appropriate to the characteristics of the students and the material, the determination of the Student Worksheets presentation format, and the design of the structure and content of the initial Student Worksheets.

In this design stage, the Student Worksheets structure is organized with consideration of the interconnection between biodiversity concepts and local wisdom values. The Student Worksheets is structured to include several key components, such as: a cover page, usage instructions, learning outcomes aligned with the Merdeka Curriculum, group identities to support collaborative learning, contextualized concise materials, two inquiry-based main activities, and a reflection and conclusion section. The general design of the Student Worksheets and its components can be seen in the figure 2.

a. Brief Material

b. Activity 1

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c. Activity 2

d. Conclusion

Figure 2. Design and Components of the Student Worksheet Based on Indahan Tupporobu

Figure 2 illustrates the design of the Student Worksheet based on Indahan Tupporobu. This Student Worksheet consists of four main components: a. Brief contextual material related to biodiversity, b. Activity 1 which guides students to identify local biodiversity, c. Activity 2 which encourages cooperation through the creation of creative bulletin boards, and d. conclusion section that provides space for students to reflect on their learning outcomes.

The material presented covers three levels of biodiversity: genetic, species, and ecosystem. This material is directly linked to various local food ingredients used in Indahan Tupporobu. The learning activities are designed in the form of two main activities: (1) identifying biodiversity based on observations of local ingredients, and (2) creating a creative bulletin board that showcases the scientific classification and cultural value of each ingredient used in the dish.

This Student Worksheets design combines a scientific approach with local cultural context. The instructional components of the Student Worksheets include a taxonomic classification table, activity guidelines, observation columns, exploratory questions, and supporting visuals in the form of images of relevant local plant and animal species. This design is intended to support the development of critical thinking skills, scientific communication, and a comprehensive understanding of biodiversity around the students.

The final product of this stage is an initial prototype of Student Worksheets based on the local potential of Tupporobu, which is then reviewed and validated by expert lecturers before being implemented in a limited trial stage with students.

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Development Stage

At the research and development stage, the data obtained was used to develop learning tools in the form of Student Worksheets. The Student Worksheets products developed were validated by subject matter experts, media experts, and through student response tests, as shown in Table 2.

Table 2. Analysis of Material Expert Validation Results

Assessment Aspect	Percentage (%)	Feasibility Criteria
Material / content	86%	Very valid, no need for revision
Presentation	83%	Valid, no revision needed
Language	83%	Valid, no revision needed
Average	84 %	Very valid, no need for revision

Based on Table 2, the results of validation by subject matter experts show that the aspects of subject matter/content (86%), presentation (83%), and language (83%) are in the valid to highly valid category, with an average percentage of 84%. According to Anikan's (2013) validity criteria, this score falls into the highly valid category and does not require revision. Therefore, the Student Worksheets based on the local potential of Indahan Tupporobu is deemed suitable for use as a learning resource in biodiversity education.

Table 3. Analysis of Student Response Test Results

Assessment Aspect	Percentage (%)	Feasibility Criteria
Presentation	84%	Very Good
Material/content	85%	Very Good
Benefits	87%	Very good
Average	85%	Very good

Based on Table 3, the results of the student response test to the Student Worksheets device showed an average percentage of 85%, with a very good criterion. The presentation aspect scored 84%, the material/content 85%, and the benefits 87%, all of which were in the good to very good category. Referring to Purwanto (2009) assessment criteria, these results indicate that the locally-based Student Worksheets developed is highly valid and suitable for use as teaching material in biology education, without requiring revisions.

Student learning outcomes were assessed based on the average pretest and posttest scores of the experimental and control groups in the Biodiversity Literacy Test. The test results were subjected to statistical tests for normality, homogeneity, and differences in average learning outcomes between the experimental and control groups. The statistical test results for the pretest scores of the experimental and control groups are presented in Table 4.

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Table 4. Results of Statistical Test of Biodiversity Literacy Pretest Data

Data	Pre test	
	Class	
	Experiment	Control
Total	32	32
Average score	77.16	53.06
Normality	0.274	0.246
Interpretation of normality	Data is normally distributed	Data is normally distributed
Homogeneity test	0.00	
Interpretation of homogeneity data	Not homogeneous (there are significant differences in variance)	
Mean difference test (Pairedsample T-tests)	0.00	
Interpretation of mean difference test	There are significant differences	

Based on Table 4, the statistical analysis of the pretest data shows that both the experimental and control classes have normally distributed data, as indicated by the significance values of 0.274 and 0.246 (> 0.05). However, the homogeneity test result of 0.00 (< 0.05) indicates that the data variances are not homogeneous. Therefore, the mean difference was tested using the independent samples t-test, which resulted in a significance value of 0.00 (< 0.05). This means there is a significant difference between the pretest scores of the two classes, with the experimental class scoring higher on average. Thus, it can be concluded that the initial abilities of students in both groups were not at the same level.

Table 5 shows that the posttest data for students' biodiversity literacy skills in the experimental group is normally distributed (p = 0.215), while the control group data is not normally distributed (p = 0.020). Since the assumption of normality is not met for both groups, the Mann–Whitney U test was used to compare the average posttest scores between the experimental and control groups. The result shows a significance value of 0.000 (< 0.05), indicating that there is a statistically significant difference in students biodiversity literacy scores between the experimental and control classes. This suggests that the use of the Student Worksheets based on local potential had a positive impact on students' understanding of biodiversity concepts.

Table 5. Statistical Test Results of Biodiversity Literacy Posttest Data

Data	Post test	
	Class	
	Experiment	Control
Total	32	32
Average score	86.00	65.00
Normality	0.215	0.020

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Interpretation of normality	Data is normally distributed	Data is not normally distributed
Mean difference test (Mann Whitney U test)	0.00	
Interpretation of mean difference test	There are significant differences	

The characteristics of Student Worksheets based on the local environment and culture have been proven to contribute positively to improving students' biodiversity literacy. The presentation of material through a contextual approach linking species classification with components of the traditional dish Indahan Tupporobu, the symbolic meaning of food ingredients, and collaborative discussion activities highlighting the relationship between ecology and local culture, has fostered students' understanding that is not only factual but also reflective.

The interactive, visual, and experience-based format of the Student Worksheets encourages active student participation in the learning process. The use of supporting images, classification tables, and questions based on exploration of the surrounding environment makes learning feel more relevant and meaningful to students. The effectiveness of using this Student Worksheets in improving biodiversity literacy was analyzed using the Normalized Gain (N-gain) calculation, as shown in Table 5.

Table 5. N-gain Score

Group	N-gain Score	Interpretation
Experiment	0.36	Moderate
Control	0.24	Low

The N-gain score of the experimental group of 0.36 indicates a moderate increase, according to Hake's (1999) classification. This value is significantly higher than that of the control group (0.24), which used conventional Student Worksheets without a local approach. Although it has not yet reached the high category, this achievement still indicates the effectiveness of Student Worksheets in strengthening the understanding of biodiversity concepts. The moderate improvement may be influenced by the limited duration of Student Worksheets use, the nature of activities that are not yet fully project based or field based learning, and the varying backgrounds of the students.

Thus, learning based on local potential which brings the material closer to the students' culture and environment has proven to support the strengthening of ecological literacy. Student Worksheets designs that emphasize the meaningfulness and interconnectedness of concepts can encourage students to think critically and develop a concern for biodiversity sustainability issues.

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DISCUSSION

The results of the study indicate that integrating local potential into the development of learning tools, particularly through Student Worksheets based on Indahan Tupporobu, has a positive impact on improving students' biodiversity literacy. Theoretically, these findings reinforce the contextual learning approach (CTL), which emphasizes that learning will be more meaningful if it is linked to students' real experiences and social environment (Johnson, 2002). By incorporating local cultural elements as the learning context, Student Worksheets bridges the gap between scientific knowledge and local values that are familiar to students.

Additionally, learning based on local wisdom contributes to strengthening social constructivism in science education. Students build new knowledge through social interaction and reflection on their community's culture. The involvement of traditional leaders and symbolic exploration in Indahan Tupporobu creates a space for dialogue between biological concepts and social values, which theoretically supports the formation of holistic ecological literacy (Roth, 1992).

From a practical perspective, students' responses to the content, presentation, and usefulness of the Student Worksheets indicate that the design of the learning tool has met the feasibility indicators. The response rate for content and presentation aspects each reached 84%, while the usability aspect reached 87%, falling into the “good” and “very good” categories (Purwanto, 2009). This indicates that the use of locally based Student Worksheets can enhance students' motivation, engagement, and interest in biology learning. Additionally, the improvement in learning outcomes in the experimental group, as indicated by an N-gain score of 0.36 (moderate category according to Hake, 1999), suggests that integrating cultural values into biology learning has the potential to activate critical thinking skills and conceptual understanding. Although this improvement has not yet reached the high category, these results indicate that the locally-based approach is worthy of further development with more in-depth implementation strategies, such as project-based learning or field activities.

However, this study has limitations that need to be noted. The difference in pre-test scores between the experimental and control groups, although not statistically significant, may influence the interpretation of learning outcomes as it indicates variations in students' initial abilities. Additionally, although the homogeneity of variance test showed relative equality between groups, external factors such as intrinsic motivation and classroom dynamics still have the potential to influence the results. These limitations are important considerations for more cautious interpretation of the findings and for improving the design of future research.

The practical implications of these findings include recommendations for educators to explore the potential of local culture and environment as sources of learning. In addition to bringing students closer to biodiversity issues in a contextual manner, this approach also fosters ecological awareness and appreciation of cultural heritage. For curriculum developers, this research supports the need for teaching materials that are tailored to the socio-ecological context of students and do not rely entirely on generic national textbooks.

CONCLUSION

This study shows that the traditional wedding ceremony of the Batak Mandailing community in Padangsidimpuan City has a rich culture that is reflected in the traditional dish Indahan Tupporobu. This dish contains 35 plant species from 18 families, with the Zingiberaceae family dominating as the main spice and traditional medicine. This finding reinforces the theoretical contribution that local cultural elements can serve as cognitive references in biology education, particularly in biodiversity-related content. Integrating scientific concepts with local cultural values in the Student Worksheets makes learning more contextual, relevant, and meaningful for students.

Practically, the Student Worksheets based on Indahan Tupporobu demonstrates high validity with an average score of 90.28% (content 91.67%, language 88.89%, media 90.28%) and has a positive impact on improving learning outcomes. This is evident from the N-gain value of the experimental group at 0.32 (moderate category), higher than the control group at 0.24 (low category). However, these findings are still limited to the Develop stage of the 4D model and implementation in one school. Therefore, further research with a randomized experimental design and cross-school implementation is needed to assess the sustainability and adaptability of this Student Worksheets in various learning contexts. Thus, the Student Worksheets based on the local potential of Indahan Tupporobu has strong potential to become a harmonious model of contextual science learning that integrates scientific knowledge and local wisdom.

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