Lake Toba Local Potential Utilization as a Learning Resource for Biodiversity Topic

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Abstract: Learning process based on local potential has not been widely used in education, even though it is known that integrating local potential in education will make it easier for students to master subject matter because certain objects or phenomena can be seen directly. This research aims to analyze the local potential of Lake Toba waters to be used as a learning resource, especially regarding biodiversity topic. The research was carried out using an exploratory method to analyze and select various data sources related to the potential of Lake Toba as a learning source with secondary data types. The data obtained is then compiled, analyzed and concluded to obtain research results. The research results show that Lake Toba as one of the local potentials in the North Sumatra region has met the criteria required as a learning resource including the clarity of potential, alignment with educational goals, precision in targeting, transparent exploration guidelines, and a clear definition of anticipated benefits. Thus, it can be concluded that the local potential of Lake Toba can be used as a learning resource on biodiversity material in class X SMA/MA.

Keywords: Biodiversity; Lake Toba; Learning resouces; Local potential

Introduction

Indonesia has a lot of natural wealth that is spread all over the region. This natural wealth is one of the advantages that should be utilized for the development of science in Indonesia. One of them is by utilizing this natural wealth to be applied in the field of education. In line with this, the Merdeka Curriculum is currently being implemented in education emphasizes on learning that can be applied in everyday life, where students are confronted with real objects related to the subject. In the implementation of the Merdeka Curriculum there are spaces allocated to include local characteristics and potential in learning both by developing them into special subjects, integrating local potential in subjects and through strengthening the profile Pancasila student. However, in practice, the integration of local potential has not been optimally carried out by teachers as educators, with general examples being presented so that students are not able to interact directly with learning objects in real life (Khairani et al., 2023; Wahyuni et al., 2022).

Biology is one of the subjects that can be integrated with real objects and phenomena that occur in everyday life in the learning process. According to the Permendikbud No. 103 of 2014 that every biology teacher must be able to initiate contextual biology learning by paying attention to various local potentials in the surrounding environment as learning resources that students can see directly.

The development of regional excellence education in teaching biology has the potential to create contextual learning in accordance with the characteristics of each region (Mumpuni, 2013). Contextual learning is a model that require teacher incorporates real-world elements into the classroom, while encouraging students to associate the knowledge they have acquired with situations and events that occur in everyday life (Lubis et al., 2019). The application of contextual learning that connects concepts in subject matter with real situations in everyday life is expected to provide significant benefits for students in obtaining a more fluent understanding of the material. This approach allows the subject matter to become more familiar to students, so

that it is no longer felt as an abstract concept, but becomes something that is more familiar and familiar to them (Haryanto, 2018). Finally, the knowledge gained by students through a contextual learning approach will be reapplied in everyday life situations.

To combine local potential with the learning process, an accurate evaluation is required. This is important so that existing natural resources can be aligned with the aims and needs of learning, given the large variations in student backgrounds, including different social, environmental, economic and cultural aspects (Situmorang, 2016). One form of integrating local potential into learning is to make these potentials as a source of learning. Learning resources are everything that supports learning (Haryanto, 2018). According to Suratsih (2010) Learning resources refer to all elements that help students in the learning process, including in terms of accessing information, pursuing knowledge, experiencing experiences, and developing skills. To effectively harness the potential of the local resources for educational purposes, the following factors should be taken into account: the clarity of the existing potential, its relation to learning objectives, the accuracy of the goals to be achieved, the completeness of the information presented, firm guidelines for exploration, and clear expected results Djohar in (Suhardi, 2007).

There are a lot of research showing that integrating local potential into learning greatly influences student learning outcomes, one of which is a study conducted by Palumpun et al. (2022), showing that integrating Toraja local potential into e-modules can train students' learning independence. Likewise, research conducted by Febriyanda et al. (2022), it is suggested that the inherent local capabilities can serve as a valuable educational resource within the field of Biology, especially focusing on topics such biodiversity, flora, and ecology. Numerous other studies indicate that incorporating indigenous components within the educational journey effectively empowers students to adeptly delve into and grasp biological insights. This approach concurrently contributes to heightening students' consciousness regarding their duty towards the encompassing milieu, a facet nurtured by this pedagogical experience (Derevenskaia, 2014; Yew & Goh, 2016). Using local potential as a learning resource can facilitate students towards actual experiences and situations. This is related to natural conditions that are more real, actual and can be accounted for accurately. This approach allows for more meaningful learning, facilitates student personality development, and makes learning activities more interesting while stimulating student learning activities (Sagala et al., 2021).

An indigenous asset with substantial potential for integration into the educational process is Lake Toba.

Lake Toba, which is rich in natural diversity, can be integrated into various aspects of the school curriculum, especially in biology lessons which discuss biodiversity. Unfortunately, until now, the utilization of Lake Toba's valuable potential in the context of education has not reached its full potential, especially for students who live around the lake (Lubis & Djulia, 2018).

Lake Toba has gained considerable renowned for its status as Indonesia's most expansive lake, holding the distinction of also being the world's largest tectonic-volcanic lake. The area it covers encompasses the North Sumatra province and is bordered by seven adjoining districts. Apart from its beauty, Lake Toba is faced with a number of environmental issues which have attracted national attention. Among these problems, water pollution is one of the main concerns triggered by human activities that pay little attention to environmental protection of lakes. The effects of the damage that occurred in Lake Toba are expected to affect the ecosystem of living things that depend on this lake (Lubis et al., 2019). Therefore, education needs to be given to all parties regarding the importance of preserving Lake Toba, including through the integration of real case-based learning about Lake Toba in the school environment.

Based on the above background, it is necessary to assess the inherent water capabilities in Lake Toba. This assessment holds promise for its application as an educational resource, particularly concerning the realm of biodiversity. The envisioned outcome of this study is to furnish educators with insights for the seamless incorporation of these findings into classroom instruction. This alignment with both student learning outcomes and educational goals is sought after. Furthermore, the outcomes of this inquiry unveil avenues for the creation of persistent pedagogical materials. Embracing an educational approach centered around local potential not only enhances students' education but also nurtures their environmental consciousness, as evidenced by their endeavors to combat diverse threats that impede the sustainability of the environment in their day-to-day existence.

Method

This study was carried out with an exploratory approach to investigate local potential that can be applied as learning material in Biology subjects, especially regarding biodiversity, at the tenth grade level of SMA/MA. This research contains two main stages, such as data acquisition and analysis process. In the initial stage, information was collected related to the local potential found in Lake Toba in the form of biodiversity and threats to the environment in Lake

Toba. The type of data obtained is secondary data from accurate and reliable literature which is then compiled, analyzed and concluded so that results are obtained in the form of potentials found in the waters of Lake Toba to be used as a learning resource for students. The use of Lake Toba potential as learning resource went through analysis process to get the clarity of potential, suitability to learning objectives, accuracy of target, clarity of information revealed, clarity of exploration, and clarity of expected gain. The biodiversity data obtained is grouped based on levels and the environmental threats presented are selected to suit the learning topic and students' needs.

Result and Discussion

Identification of Lake Toba Potentials
Biodiversity in Lake Toba

Derived from the outcomes of the research, it was determined that the biodiversity within Lake Toba includes plankton, fish, aquatic vegetation, and benthic organisms (Lukman, 2013). The phytoplankton community in Lake Toba consists of various classes whose data can be seen in table 1. There are 11 species from class Chlorophyceae, 4 species from class Cyanophyceae, and there are 10 species from class Chrysophyceae that are identified. These number of species is considered low while there is no kind of species that are dominant. This indicate the water conditions of Lake Toba is infertile (Sulawesty in (Lukman, 2013)).

Each group or type of phytoplankton has different characteristics in responding to changes in its environment. Phytoplankton as primary producers in waters plays an important role as food for various aquatic organisms and is one of the parameters of the fertility level of waters. The abundance of phytoplankton in water indicates that the productivity of that water is high. Phytoplankton will respond to changes in water conditions in the form of changes in abundance, number of species and community structure (Rahman et al., 2016). Therefore, water quality influences the community structure of plankton (Rahmah et al., 2022).

Beside of phytoplankton community, there are also 14 species of fish that are known to live in Lake Toba and can be seen in table 2. Some of these fishes species are introduced fish. The species *Neolissochilus (Lissochilus) thienemanni* is known to be an endemic fish species in Lake Toba, but its existence are unknown. The index of variation and distribution of fish species in Lake Toba is in the minimal category, while the dominance index is relatively high (Qomaria, 2023). Some factors that affect the low variation of fish in lake Toba caused by the low variation of plankton and benthic animal asa the source of food for fish, the low water quality and also the invasion of predatory fish that prey on other types of fish in Lake Toba.

Table 1. Phytoplankton Composition in Lake Toba

Class	CHLOROPHYCEAE		
Familia	*Chlorococcales*	*Zygnematales*	Ulothrichales
Species	*Choelastrum microporum*	*Cosmarium contractum*	*Ulothrix variabilis*
	Dictyosphaerium sp.	*Staurastum acanthastrum*	*Ulothrix zonata*
	Pediastrum duplex	*Staurastum braciathum*	
	Scenedesmus quadricauda	*Staurastum multispiniceps*	
		Staurastum prionotum	
Class	CYANOPHYCEAE		
Familia	Chroococcales	*Nostocales*	Oscillatoriales
Species	*Gloeocaosa sp*.*	*Anabaena vigueri*	*Oscillatoria bornetii*
	*Microcytis aeruginosa**		
Class	CHRYSOPHYCEAE	PHYRROPHYCEAE	
Familia	Pennales	Centrales	Dinocontae
Species	*Cymbella tumida*	*Melosira granulata*	*Peridinium sp.*
	Navicula radiasa		
	Navicula falaisiensis		
	Navicula lacustris		
	Nitzschia linearis		
	Pinnularia nobila		
	Synedra acus		
	Synedra ulna		

Note:* Colony

Table 2. Types of Fish in Lake Toba

Indonesian Name	Local Name	Latin Name
Mujahir	Jahir	*Oreochormis mossambicus*
Mas	Mas	*Cyprinus carpio*
Lele	Sibahut	*Clarias batrachus*
		Clarias nieuhofi
Jurung	Ihan	*Lissochilus sp.*
Nilem	Bulan-bulan	*Osteochillus hasselti*
Bilih	Pora-pora	*Puntius binotatus*
Tawes	Paitan	*Puntius gonionotus*
		Puntius javanicus
Gabus	Haruting	*Ophiocephalus striatus*
Gurami	Kalui	*Osphronemus goramy*
Sepat	Sepat	*Trichogaster trichopterus*
Uceng	Insor	*Nemachilus fasciatus*
Wader	Siburicak	*Rasbora jacobsoni*
Guppy	Ikan Bunting	*Lebistes reticulatus*
Kepala Timah	Kalatima	*Aplocheilus panchax*

Benthic animal communities in Lake Toba mainly consist of types of freshwater molluscs, the existence of

which can be seen in table 3. Among them there is a type of mollusk endemic to Lake Toba, namely *Corbiculla tobae*. This clams also known have negative impact to freshwater ecosystems and human economy (Bespalaya et al., 2021). The waters of Lake Toba tend to be muddy, sandy and rocky. These water conditions are ideal for benthic animals to live. This is the reason why various types of benthic animals can be found in the waters of Lake Toba (Lubis et al., 2019). Calm waters of Lake Toba allow the formation of silt and accumulation of organic material at the bottom of the lake. This is generally influenced by increased activity on land. Benthic animals play an important role in fresh waters to decompose organic materials and as a food source for fish.

Table 3. The types of benthic animal in Lake Toba

Indonesian Name	Latin Name
Brotia	*Brotia costula*
Susuh Duri	*Thiara scabra*
Melania Berlapis	*Melanoides granifera*
Keong Assassin	*Anentome Helena*
Onga Jawa	*Lymnaea rubiginosa*
Kerang Keranjang	*Corbicula tobae*

Table 4. Kinds of Aquatic Plants Found in Lake Toba

Common Name	Genus	Characteristic
Pondweed	*Potamogeton*	Submerged, rooted at the lake bottom
Water Milfoil	*Myriophyllum*	Submerged, rooted at the lake bottom
Najas	*Najas*	Submerged, rooted at the lake bottom
Hornworts	*Ceratophyllum*	Submerged, rooted at the lake bottom
Bladderwort	*Utricularia*	Submerged, rooted at the lake bottom
Hydrilla	*Hydrilla*	Submerged, rooted at the lake bottom
Nitella	*Nitella*	Submerged, rooted at the lake bottom
uskgrass	*Chara*	Submerged, rooted at the lake bottom
Waterlily	*Nymphaea*	Sticking out, rooted at the lake bottom
	Nelumbium	Sticking out, rooted at the lake bottom
Eceng Gondok	*Eichornia*	Floating
Dampyang	*Azolla*	Floating
Rumput bebek	*Lemna*	Floating
	Spirodella	Floating

The last is 14 types of aquatic plants found in the waters of Lake Toba and can be seen in table 4. The main characteristics are plants that are sink and rooted at the lake bottom, sticking out and rooted at the lake bottom and some kinds of floating plants. The presence of aquatic plants is one of the biotic factors which shows that the waters of Lake Toba can support the survival of aquatic organisms in it such as fish. Aquatic plants greatly influences the abundance of freshwater fish, in wich increased density of aquatic plants will increase the abundance of young and small fish as well. However, excessive plant growth is also not good, this is because the water layer becomes dense with aquatic plants, thereby suffocating other aquatic organisms, especially fish, and leads to a decline in fish populations (Ismail et al., 2018).

Threats to Biodiversity in Lake Toba
Low Biodiversity in Lake Toba

The Finding of the study conducted by Tobing et al. (2017) indicate a reduced presence of phytoplankton and benthos populations in Lake Toba. As it is known that the plankton community plays an important role in the food chain as a source of nutrition for fish. With the low population of phytoplankton and benthos, the diversity of fish species in Lake Toba is also relatively low (Hutajulu & Harahap, 2023).

Threats to Lake Toba Endemic Fish

Figure 1. The Batak fish (*ihan*) species *Neolissochilus thiemanni*

In addition to the decreasing biodiversity in Lake Toba, various threats also lurk with several types of endemic fish that inhabit the waters of this lake, some of which have even become extinct. One of them is a fish known in the Batak language as "ihan," which belongs to the *Lissochilus sp*. This fish is one of the rare endemic species. The Batak people recognize several species of *ihan* that have similar characteristics, including the species *Neolissochilus thiemanni* and *Labeobarbus soro*. The *Neolissochilus thiemanni* (figure 1) species, which is another endemic species of Lake Toba, is now even hard to find. Factors of various origins contribute to the endangerment of native fish species in Lake Toba, with human actions emerging as the primary catalyst (Panjaitan et al., 2022), including the existence of diverse predatory fish types such as glass fish, betutu fish, and tilapia fish is frequently observed. These fish varieties commonly originate from external regions and possess the capacity to swiftly adjust and flourish, enabling them to assertively control their environment. Other factor is

the lack of knowledge among Lake Toba fishermen regarding the life cycle of Batak fish. Usually, fishermen catch fish in the estuary of the river that connects Lake Toba, which actually acts as a fish spawning ground. As a result, the fish caught are often included in the spawning stage at the mouth of the river. The last is poor water quality as a result of sewage pollution.

Fish Cultivation with Floating Net Cage System

According to the study conducted by CARE IPB in Hikam (2021), the number of fish cage managed by the community was 10,574 units and cage owned by the private sector was 602 units. The presence of these suspended net enclosures significantly impacts the water quality within Lake Toba due to the discharge of feed and fish detritus (Harianja et al., 2018). While it cannot be denied that raising fish using suspended net cages constitutes a substantial economic venture, without meticulous oversight and effective regulation, there is a looming possibility of environmental harm occurring in the Lake Toba aquatic environment, potentially escalating over time.

Conservation of Biodiversity in Lake Toba

Methods that have been implemented to address these risks involve the management of household waste, including the establishment of domestic wastewater treatment facilities. In addition, other steps involve preventing the penetration of predatory fish species that can harm other fish, as well as public education and campaigns. Another approach taken is the regulation of fish farming with a floating net cage system that pays attention to environmental aspects (Napitu et al., 2022).

Strategies in Reducing the Negative Impacts of Floating Net Cage on Lake Toba

Some steps that can be taken to reduce the negative impact of floating net cages on Lake Toba include changing fisheries policies towards sustainable management, setting limits on floating net cage production, enforcing strict policies to maintain the balance of nature, conducting outreach , as well as fostering cooperation between all parties in preserving the environment in the waters of Lake Toba (Hutajulu & Harahap, 2023).

Control of Environmental Pollution

The contamination of Lake Toba's waters arises from a multitude of contributing elements. In addition to the cultivation of aquatic life utilizing aquaculture, another influential aspect involves the release of waste into the lake's aquatic environment, stemming from household, agricultural, and livestock-related waste. Consequently, it becomes imperative to develop remedies to mitigate the repercussions stemming from

this pollution. These include the establishment of a Wastewater Management Facility and Waste Segregation Minimization Infrastructure, the implementation of stringent legal frameworks, and the incorporation of socio-economic and cultural strategies.

Increasing Community Knowledge and Skills

Improving community knowledge and skills regarding the sustainable use of aquatic resources, which includes knowledge of environmental needs, the right frequency and time for fishing, the type of gear that is appropriate to use and the amount/quantity of fish that can be caught.

Integrating of Local Resources into Biology

In the context of this research, there are Numerous facets associated with Lake Toba exhibit potential that can be harnessed for educational purposes. This is due to efforts to introduce students to the richness of the environment around them, which will ultimately stimulate the development of adaptable behavior and patterns of thinking (Irwandi & Fajeriadi, 2020). To effectively capitalize on the educational prospects offered by local resources, the process of analysis must be conducted in alignment with the criteria pertinent to learning materials.

Clarity of Potential

The environment of Lake Toba consists of biodiversity in the form of fish, aquatic plants as well as benthic animals and phytoplankton, but threats to the lake environment still occur today. Thus, various efforts to preserve the biological conservation of Lake Toba have been carried out, but it cannot be denied that these efforts have not been maximized and require contributions from all parties. In this regard, when applied in learning, students will be able to understand various biodiversity in Lake Toba, be able to analyze various threats to the environment in lake waters and find solutions to existing environmental problems.

According to Muhammad (2018), it was stated that Learning resources need to be designed to assist students in acquiring and retaining information and knowledge over extended periods, concurrently enhancing the targeted skills. This empowers students to acquire the essential information, knowledge, experiences, and skills required to effectively tackle the challenges presented by their surroundings.

Suitability to Learning Objectives

Based on the verification analysis that has been realized in Teacher literature (Puspaningsih et al., 2021) and Student books (Puspaningsih et al., 2021), published by Kemendikbudristek, it was found that local potential for Biodiversity in the Lake Toba region is aligned with

the educational intentions of the biodiversity learning materials, that expect student to be able to identify the biodiversity level, describe Indonesian biodiversity and its threats, and find the best solution to conserve the environtment. The suitability of Lake Toba potential to learning objectives can be observed in table 5.

Table 5. Suitability of Lake Toba Potential to Learning Objectives

Learning Objectives	Verification Result	
	Yes	No
Able to identified the biodiversity level	✓	-
Able to describe Indonesian biodiversity and its threats	✓	-
Able to find the best solution to conserve biodiversity	✓	-

Accuracy of Target

The accuracy of target consist of two aspect such as the object and subject (Febriyanda et al., 2022). In this study, the target is to use the biodiversity of Lake Toba as well as every threats and conservation process occurred in it as the learning resources for biodiversity topics in biology class. While this research is intented to the students of grade X in senior high school.

Clarity of Information Revealed

The analysis reveals that Lake Toba's waters hold potential as an educational resource for teaching biodiversity to X Grade students in high school.

First, related to the level of biodiversity in Lake Toba in the form of phytoplankton species, fish species, aquatic plant species and benthic animal species. In each category, various species have been recorded that come from the same and different class, family or genus (Qomaria, 2023). When linked to the topic of biodiversity, the potential within the Lake Toba region can serve as an instructional reservoir for students to grasp biodiversity, ranging from the species level to possibly even the genus level, considering the various hybrids originating from the same species.

Second, related to preservation threats of living things in the ecosystem in Lake Toba and their causes. Some of them are the decline in water quality and the threat of extinction of fish species endemic to Lake Toba. The decline in water quality results from a variety of factors, including the discharge of waste such as agricultural residues, household effluents, and even waste from the hospitality sector. In addition, the utilization of Lake Toba's waters for fish cultivation utilizing suspended net systems is an addition among the factors contributing to the decline in water quality due to the accumulation of chemical compounds both from leftover fish feed and fish manure resulting from cultivation so that they become toxic to living fish in

Lake Toba. This circumstance was aggravated by the constrained inflow of river water into Lake Toba's perimeters (Lukman et al., 2021).

Another matter demanding attention is the jeopardy faced by indigenous fish species within Lake Toba, as it has been acknowledged for an extended period that Lake Toba hosts unique fish species endemic to its water. The species *Neolissochilus thiemanni* is a type of endemic fish to Lake Toba whose existence is no longer known. Apart from that, there are also *pora-pora* fish from the *Puntius binotatus* species, which until now have been very rare. Several factors contributed to the occurrence of this phenomenon. In addition to the deterioration in water quality in the vicinity of Lake Toba, the situation can also be linked to fishing methods that are not environmentally viable and the introduction of fish species from outside the region. A notable proportion of these non-native species were deliberately released into the ecosystem by governing bodies in an attempt to stimulate the regional economy. However, in reality, newcomer fish or so-called exotic species often become predators for other fish and even bring new diseases to the waters of Lake Toba. One example is the glass fish which preys on the eggs of other fish and not infrequently preys on small fish (Panjaitan et al., 2022).

Third, regarding efforts to conserve biodiversity in the waters of Lake Toba, various efforts have been made, such as managing domestic wastewater, conducting counseling or public campaigns, managing fish farming with a floating net frame system and preventing the entry of predatory fish species into the waters of Lake Toba. Regarding wastewater management, it can be done by using microorganisms in the bioremediation process, both household waste, hotel waste, restaurants, and so on. In addition, counseling or public campaigns can also be carried out to build and increase public awareness (Simanjorang et al., 2022).

Regarding the management of fish farming using the floating net cage system, it can be done with the obligation for fish cultivators to have a good and correct fish cultivation certificate from the Ministry of Maritime Affairs and Fisheries as well as National Institutions and water quality adjustments stipulated by government regulations. Furthermore, it is necessary to limit and determine the location of the net cage in accordance with the Spatial Layout Plan for Lake Toba waters (Sibarani, 2020).

Clarity of Exploration

In an exploratory guide, well-defined operational protocols become imperative. These encompass the delineation of research specimens, temporal and spatial activity mapping, and variables under study, requisite tools, procedural methodologies, data processing

modalities, and ultimate deductions. Nevertheless, within the current inquiry, the untapped potential of Lake Toba's biodiversity as a direct scholastic resource in the realm of biological education is conspicuous by its absence. The exigency for meticulously outlined and systematic operating procedures are underscored. The aqueous milieu presents constraints wherein not the entire spectrum of biodiversity is amenable to scrutiny, grounded in student safety considerations and the scarcity of essential investigative instruments. Learners can embark on exploitative learning ventures, unearthing conundrums poised for resolution via the scientific paradigm. This iterative process serves to nurture cogitation and honing of cognitive faculties (Maryati & Susilo, 2014).

Clarity of Expected Gain

The availability of educational materials is anticipated to aid students in enhancing their competencies across cognitive, affective, and psychomotor domains. By prioritizing instructional engagements connected to the immediate milieu, it holds the potential to stimulate students' intellectual perspectives and enhance comprehension of study content. Furthermore, students can garner an array of concepts and learn to apply them to practical challenges in real-world situations (Marianti & Kartijono in (Maryati & Susilo, 2014)). Students can also acquire skills development, develop awareness, discipline, honesty, diligence, curiosity, cooperative, creative and critical thinking attitude (Febriyanda et al., 2022).

Conclusion

Based on the conducted research findings, it can be deduced that Lake Toba's biodiversity includes a variety of phytoplankton types, diverse fish species, aquatic plants, and benthic animals. By analyzing the Learning Outcomes, it comes to the point that the local potential of Lake Toba's waters can be utilized as an educational resource for biodiversity topics in tenth-grade classes. Proper assessment should be undertaken to integrate local potential with the curriculum to align with educational objectives and student needs. The local potential within Lake Toba, suitable for learning resources, includes levels of biodiversity variety, threats to biodiversity, their causes, and environmental preservation efforts to counteract the deterioration of biodiversity in Lake Toba's waters.

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