DIGITAL-BASED SCIENCE LEARNING THROUGH ENDEMIC BIODIVERSITY AND LOCAL POTENTIAL IN NORTH SUMATRA

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Abstract: *This article aims to analyze the effectiveness of digital-based science learning through the integration of endemic biodiversity and local potential of North Sumatra. The use of e-modules based on ferns studied in the Bukit Barisan Grand Forest Area, Karo Regency, was studied in class X of MAN 1 Medan. This study also examines the endemic biodiversity and local potential of North Sumatra which are utilized as learning resources as secondary data with a literature review. The results of the study showed an average of 3.40 with very good criteria in the aspects of material, language, module operation, and display. The findings of the literature study indicate that the integration of digital technology in a local context can improve scientific literacy, learning motivation and student awareness of the environment, as well as help teachers present real and contextual learning in the era of digital transformation.*

Keywords: *Digital Learning, Endemic, Biodiversity, Local Potential, North Sumatera*

Introduction

In the 21st century, rapid technological developments have led to an even faster dissemination of information due to easy internet access. Teachers, as facilitators, can also contribute to the exchange of educational information. The obligation to master technology and education requires the integration of technology into learning (Wahidin et al., 2025).

Innovations in digital-based science learning through the use of e-learning platforms, virtual simulations, interactive videos, and digital project-based learning can improve conceptual understanding, critical thinking skills, problem-solving, scientific literacy, and digital literacy (Dana, 2025). The use of interactive learning applications, multimedia, and more enjoyable and immersive learning videos for students can increase their learning interest (Muslimah, 2024). Science learning supported by technology is more effective than conventional learning. The integration of technology offers more interactive, engaging, and relevant learning for students (Paling & Suparyono, 2024).

The success of this digital innovation is supported by the availability of digital instructors, teacher readiness, and active student engagement. This innovation has great potential as a learning model that can be scaled up in other schools for scientific literacy in the digital age (Dana, 2025). The integration of local wisdom into digital learning has been shown to improve various educational outcomes, significantly increasing learning outcomes compared to conventional teaching methods (Jusriadi et al., 2025).

Digital technology enables personalized learning experiences, allowing educators to meet individual students' needs and learning styles. Adaptive learning platforms can analyze student performance data and provide targeted interventions to effectively address learning gaps. This individualized approach has been shown to significantly improve student achievement (Subroto et al., 2023). While these technological advances have positive impacts, they also have the

potential to undermine modernization and globalization, which can threaten traditional and cultural values. Digital learning based on local potential can integrate modern knowledge and enhance conservation understanding (Mutia & Amrul, 2024).

The role of teachers in the digital era has undergone significant transformation along with technological advancements. Therefore, teachers must possess the competencies to integrate technology into effective learning processes (Komang et al., 2024). Digital transformation makes education accessible and allows for independent learning anywhere and anytime, addressing time constraints. Technology has transformed modern classrooms, equipped with various digital tools and resources that can facilitate learning (Subroto et al., 2023).

The use of electronic teaching materials has not been effectively utilized in learning, and textbooks have not been distributed evenly across schools. 90% of students still lack textbooks to guide their learning, due to their lack of availability from schools and their relatively high cost (Suryani Ela et al., 2018). Quality education is education that enhances local potential in students' self-development, strengthening their national identity and sense of belonging (Wigunani, 2023).

The use of technology must be balanced with the use of local contexts that are inseparable from students' environments and cultures. These contexts are used to enhance students' learning motivation, critical thinking skills, and scientific literacy. Digital media platforms enable pedagogical practices that place teachers and students at the center of the world, connected to educational practices in schools (Hobbs & Coiro, 2019).

North Sumatra boasts cultural diversity, rich local wisdom, and local potential that support environmental conservation. Exploring this diversity can preserve medicinal plants and the environment through cultural, ecological, and social aspects (Handayani et al., 2025). Learning processes based on local potential have not been widely utilized. This local potential must be utilized for scientific development. Indonesia possesses natural resources spread throughout its territory (Manalu & Suhartini, 2023).

Utilizing local resource potential for educational purposes must consider the following factors: 1) clarity of information and the availability of potential; 2) the relevance of potential objectives to learning; 3) accuracy of the objectives to be achieved; 4) completeness of the information presented; 5) clear guidelines for exploration and expected outcomes (Suhardi, 2007). Difficulties in learning about plants are caused by the wide variety of plant species with difficult terminology, and learning methods that are difficult for students to understand. Learning is easier through practical work or field observations (Shofiyati et al., 2020).

Method

This research was conducted to test the effectiveness of an electronic module on ferns (Pteridophyta) observed in the Bukit Barisan Grand Forest area of Karo Regency. The plant data was then integrated into biology lessons for 10th-grade students at MAN 1 Medan. The instruments used in the study were expert validation sheets (materials and media), and an effectiveness questionnaire (using aspects of material, language, operation, and display). Data were analyzed using a t-test.

Data on endemic biodiversity and other local potentials were reviewed using a literature review to identify the diversity of local potential in North Sumatra that can be utilized in the form of teaching materials.

Result and Discussion

Elektronik Modul Pterodophyta

This research produces a product in the form of a website-based e-module on the material Pteridophyta (Ferns) intended for grade X high school students. The website-based e-module can be accessed at https://sites.google.com/ and can be accessed using mobile devices such as smartphones, tablets, laptops and computers. Research and development of the e-module product was carried out using the ADDIE development model, which consists of five stages, namely: Analysis, Design, Development, Implementation, and Evaluation.

The Bukit Barisan Forest Park (Tahura Bukit Barisan) is located in Karo Regency, a highland tropical rainforest region, home to a rich biodiversity and natural panoramas. The Bukit Barisan Forest Park is divided into nine forest areas. The research site for fern identification was the Tahura forest within the Tahura tourism park itself, adjacent to the Bukit Barisan Tahura management office. The Tahura is located in the Brastagi tourist area, a popular destination for tourists seeking natural scenery, vegetable shopping, cattle ranching, mountain walks, and more (Puspita et al., 2022).

The Bukit Barisan Tahura was chosen because it is a conservation area with a high fern diversity. Fern discoveries made in January 2022 were dominated by ground-dwelling ferns, although some species also cling to trees. Ferns found in the Bukit Barisan Tahura comprise three classes: Equisephyta, Lycopodinae, and Pteropsida. Psilopsida were not found due to the forest's distance from water sources. Pteropsida is the most abundant class of Pteridophyta. Many species of Lophosoria aquadprinnata are found along the paths surrounding the Bukit Barisan Forest Park. The abundant plant diversity in the Bukit Barisan Forest Park makes its ferns a potential resource for module materials. The electronic display of the module is as follows:

Figure 1: Electronic Modul Laptop Version

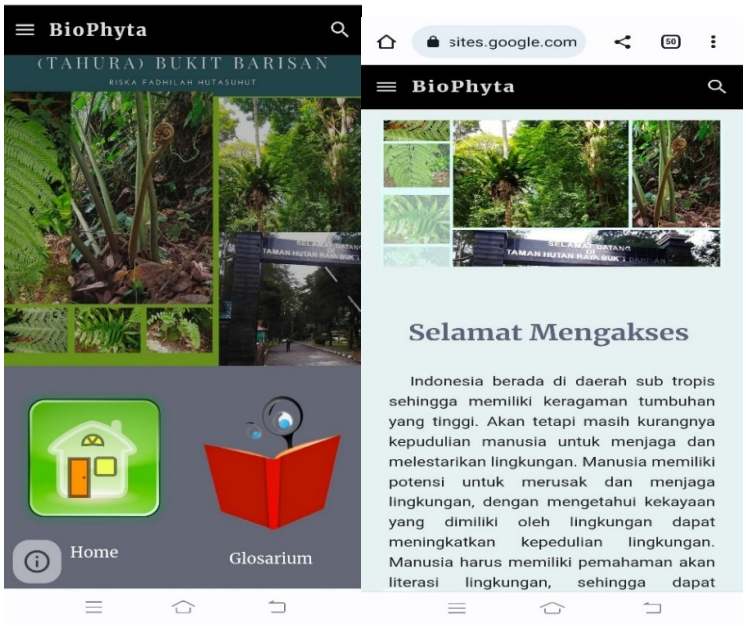

Figure 2: Electronic Modul Smartphone Version

Effectiveness of Electronic Modules

Aspect	Average	Total Score	Criteria
Material Aspect	3,52	450	Very good
Language Aspect	3,31	106	Very good
E-modul Operation Aspect	3,30	317	Very good
Visual Aspect	3,38	540	Very good
Average	**3,40**	**1413**	Very good

The results of the e-module effectiveness assessment conducted by students showed that the effectiveness of the e-module in terms of material, language, e-module operation, and display aspects had an average value of 3.40, which was stated in the very good criteria. The module contains very good material, very good readability, very good operation, and very good display. This proves that the website-based e-module is effective for use in biology learning on the Pteridophyta material, with some input provided by expert practitioners.

Local and Endemic Potential of North Sumatra

North Sumatra's local potential demonstrates the ecological and cultural richness inherent in the region. The most prominent and rare endemic animal of North Sumatra is the Tapanuli orangutan (Pongo tapanuliensis), which lives endemic to Batang Toru (Nater et al., 2017). The Dolok Sibual-buali Nature Reserve (CADS) serves as a conservation area for orangutans (Rizky et al., 2018). The Sumatran orangutan (Pongo abelii) and the Tapanuli orangutan (Pongo tapanuliensis) are distinct (Haryanto et al., 2019).

Figure 3: *Pongo abelii and Pongo tapanuliensis*
Sources: (Haryanto et al., 2019).

The Tapanuli orangutan featured in an e-booklet provides in-depth conservation knowledge and can also add variety to biology lessons. Research shows that 85.7% of students agreed to use e-booklets as learning media. Furthermore, 91.4% of students also needed conservation-based learning to enhance their knowledge (Hidayat et al., 2025).

Lake Toba, as one of North Sumatra's local potentials, meets the criteria for use as a learning resource due to its clear potential, alignment with learning objectives, defined objectives, transparent exploration guidelines, and clear benefits. Lake Tiba can be incorporated into Biodiversity materials. The data found that there are many types of fauna in Lake Toba, such as: Tilapia (Oreochormis mossambicus), Goldfish (Cyprinus carpio), Catfish (Clarias batrachus), Jurung (Lissochilus sp.), Nilem (Osteochillus hasselti), Bilih (Puntius binotatus), Tawes (Puntius gonionotus), Snakehead (Ophiocephalus striatus), Gourami (Osphronemus goramy), Sepat (Trichogaster trichopterus), Guppy (Lebistes reticulatus), and Tinhead Fish (Aplocheilus panchax) (Lubis & Djulia, 2018; Manalu & Suhartini, 2023).

The utilization of local potential in North Labuhanbatu Regency based on an electronic module was categorized as very good and effective, with a percentage score of 94.22% (very valid), a readability score of 89.66% (very good), a posttest average of 81.81%, and a classical completion rate of 84.05% (very good). The development of an electronic module on local potential in North Labuhanbatu Regency was declared feasible based on validity, readability, and effectiveness as a teaching material (Azmi et al., 2023).

The development of an integrated encyclopedia of the local potential of North Sumatra's Balakka plant (Phyllanthus emblica L.) demonstrates that the integration of local potential is feasible, practical, and effective as a teaching material in learning. The results of the expert assessment research by material experts with a percentage of 80%, media experts with a percentage of 90.9%, biology subject teachers with a percentage of 75%, practicality by students with a percentage of 90.4%, and product effectiveness seen from the Learning Completeness formula with a percentage of 87.30% (Ananda et al., 2024).

Research on local plants used as traditional medicinal plants in the Karo community identified 81 species of local medicinal plants from 39 botanical families, with the Zingiberaceae family dominating (13 species, 16.05%), followed by Asteraceae (7 species, 8.64%), Piperaceae, and Fabaceae (5 species each, 6.17%). Ginger (Zingiber officinale) was the most commonly used plant in three different locations. The most commonly used plant parts were the leaves (48.15%), rhizomes (22.22%), and fruit (13.58%) (Handayani et al., 2025).

In addition to biodiversity, cultural riches such as the Batak traditional dish, Ikan Arsik, can also be used as a learning resource. As an ethnoscience, Ikan Arsik can be viewed from a scientific perspective, aligning with school learning. The ingredients used in making Ikan Arsik are derived from local plants and animals of North Sumatra, and its flavor and processing methods can be explored through science lessons. The spicy, salty flavor of arsik, experienced after eating, is a natural flavor produced by the sense of taste (Hutasuhut & Syamsuyurnita, 2025).

Naniarsik (arsik fish) has a seasoning that permeates the fish, with functional characteristics that help maintain body health. The functional aspects of this seasoning include antioxidants, anti-inflammatory, antiviral, anti-microbial, and other infectious disease prevention actions (Pardede, 2021).The cooking process until it reaches the boiling point changes the antinutrient compounds, affecting the delicious taste and doneness of the arsik (Sundari et al., 2015). The changes in state during cooking also affect the physical shape, size, aroma, and color of the food (Silla et al., 2023).

Local potential-based learning also instills environmental literacy values in students, with 69% of students enthusiastic about working to protect and preserve the environment, 73.1% of students showing sensitivity to their surroundings, and 88.6% of students being able to plan to instill environmental values in their daily lives. These attitudes will increase students' environmental sensitivity by fostering a desire to protect and preserve living things in their respective areas (Hutasuhut & Djukri, 2024).

Conclusion

The results of the study indicate that digital-based science learning that integrates local potential and endemic biodiversity can provide a more contextual, meaningful, and relevant learning experience for students. The use of an electronic fern-based module received an excellent rating. This study emphasizes the importance of digital learning innovation and the richness of local biodiversity in developing adaptive, sustainable, and 21st-century science learning.

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