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INTEGRATING POTENTIAL AND LOCAL WISDOM INTO DIGITAL BIOLOGY LEARNING: A STUDY ON E-MODULE EFFICACY FOR ENHANCING STUDENTS' CRITICAL THINKING

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ABSTRACT

Students' low critical thinking skills remain a global educational challenge, often attributed to conventional pedagogy and the lack of contextualized learning resources. This study aims to evaluate a biology e-module integrating the local potential and local wisdom of the Toraja Tribe to improve students' critical thinking skills. A pretest-posttest quasi-experimental design was used to compare a control group (using a commonly used biology textbook) and an experimental group (using an e-module on the local wisdom of Toraja). This study involved 140 grade 10 students. Data were collected using a test instrument based on the Ennis framework, and a statistical test was performed using the Mann-Whitney U test. The results showed that implementing the e-module on biodiversity significantly increased students' critical thinking skills (Sig = 0.000 < 0.05) with a large effect size (1.61), confirming the strong impact of context-based digital learning on cognitive development. Research results show that using e-modules on biodiversity significantly improves students' critical thinking skills (Sig = 0.000 < 0.05) with a large effect size (1.61), confirming the strong impact of context-based digital learning on critical thinking skills. Research results show that using e-modules on biodiversity significantly improves students' critical thinking skills (Sig = 0.000 < 0.05) with a large effect size (1.61), confirming the strong impact of context-based digital learning on critical thinking skills. These findings suggest that digitizing local potential and local wisdom is effective in bridging the gap between abstract scientific concepts and students' socio-cultural reality, thereby boosting critical thinking skills.

Keywords: critical thinking skills; e-module; local potential; local wisdom; Toraja tribe

INTRODUCTION

Improving critical thinking skills is a top priority in the learning process in educational institutions, both at the level of curriculum policy and classroom teaching practices, from elementary school to university (Bellaera et al., 2021; Kosasih et al., 2022; Maghfiroh et al., 2023; Mulyono et al., 2023). This is because critical thinking skills are an important competency for human productivity and development in the 21st century (Sarwanto et al., 2021; Lu et al., 2025; Sarvary & Schmidt, 2026; Yaemkhayai & Piyasatit, 2026). Training in critical thinking can also support the achievement of SDG 4, which aims to ensure quality education (Khaeruddin et al., 2025). In fact, globally, research on students' critical thinking skills remains relatively low, as this also holds in Indonesia (Sarwanto et al., 2021; Arifah et al., 2023).

The low level of students' critical thinking skills can be seen from several studies showing limitations in how students process information to solve problems, especially basic clarification skills, drawing basic conclusions, and difficulties in evaluating evidence (Sarwanto et al., 2021;

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Ma & Li, 2022; Calma & Davies, 2026). In fact, critical thinking skills also require students to analyze, evaluate, and develop effective solutions to various problems (Ramdani et al., 2021; Yuliastrin et al., 2023). This emphasizes that students' thinking skills are important to master. One way to develop critical thinking skills is by fostering a culture of critical thinking throughout the learning process. Teachers play an important role in equipping students with critical thinking skills by creating learning tools (Ramdani et al., 2021; Purwianingsih et al., 2022).

Learning resources, including teaching materials, are considered basic educational tools that make learning practices easier, help students understand, and even support teacher development (Abad & Hattie, 2025; Kullmann, 2025), and contribute to learning success (Syahfitri & Muntahanah, 2024). Well-designed modules have been shown to support students' learning processes and improve critical thinking skills (Ramdani et al., 2021; Pitorini et al., 2024).

However, in reality, the teaching materials, especially in biology, that are often found usually do not fully meet students' needs, because the use of language in science that is inaccurate or weak can limit students from understanding, applying, and communicating concepts, especially when using scientific language, since scientific language is different from everyday language (Ramdani et al., 2021; Hackemann et al., 2022; Suherman et al., 2023).

In Indonesia, the biology learning materials used in schools are often general in context, even though students from diverse regional and cultural backgrounds widely use them. This can make it harder for students to understand the material because the context is less familiar to their daily lives.

Teaching materials that integrate local wisdom have the potential to be an innovative solution for improving students' critical thinking skills, as stated by Ramdani et al. (2021) and Ridho et al. (2020). However, integrating local wisdom and regional potential from various ethnic groups in Indonesia into the school curriculum remains suboptimal (Sari et al., 2021; Sriyati et al., 2021; Palumpun et al., 2022). Even so, some studies have shown that this approach is effective. Integrating local wisdom into teaching materials can make biology learning more relevant to students' life contexts (Sari et al., 2021; Fadilah et al., 2024; Syahfitri & Muntahanah, 2024). This research shows that there is a gap between the need for learning materials that train critical thinking skills based on potential and local wisdom and the general-context learning materials used in schools. One of the ethnic groups in Indonesia that has a unique culture and rich natural resources is the Toraja people on Sulawesi Island, where the researcher comes from. The Toraja people make use of the biodiversity in their environment, both plants and animals, to meet various needs, including food provision, medicinal plants, natural dyes for woven fabrics, coffee production, traditional rice farming, traditional ritual tools, and more. Two main traditional rituals, Rambu Tuka' and Rambu Solo', which are large-scale funeral ceremonies (Ismail, 2019; Pora' et al., 2023), are rich in local wisdom that is relevant to be integrated into learning about Biodiversity (Layukan et al., 2016; Lobo' et al., 2021; Lumbaa et al., 2023; Tandiderung et al., 2023). Even though the Toraja are known for their rich culture and natural beauty, the implementation of learning methods that leverage local potential remains suboptimal (Palumpun et al., 2022).

Because of the limited teaching materials that accommodate the potential and local wisdom of Toraja, the researcher has digitized this potential into an e-module designed to improve students' critical thinking skills as a novelty of this study. However, the developed e-module has not yet been tested on students. This study is needed to test the impact of an e-module based on local potential and wisdom on students' thinking abilities. The teaching material is made in the form of an e-module because it is easily accessible, anytime and anywhere (Al Rawashdeh et al., 2021; Fahlevi et al., 2021), which can enhance basic understanding and confidence in critical thinking (Ramdani et al., 2021; Hikmawati et al., 2024; Schmidt et al., 2026). Khusniati et al. (2017) and Ramdani et al. (2021) reinforce that mastery of science material can significantly improve when teachers connect academic concepts with cultural context.

Based on that explanation, this study aims to gather information on the impact of e-modules grounded in the potential and local wisdom of Toraja on students' critical thinking skills, and to identify which critical thinking indicators are most influenced by their use.

METHODS

This research is a quasi-experimental study with a pretest-posttest control group design involving two groups: an experimental group and a control group. Both groups were given the same assessment before (pre-test) and after (post-test) the intervention (Fraenkel & Helen, 2023). In this

study, the control group learned using standard textbooks at school. The experimental group received a learning intervention in the form of an e-module about the potential and local wisdom of the Toraja Tribe.

The e-module used has been declared valid and shows high readability test results. The e-module was created in the Canva app and uploaded to the website heyzine.com, making it easily accessible to students. This e-module integrates the potential and local wisdom of Toraja with biology materials, especially biodiversity. The learning takes place over 4 meetings, covering the subtopics of biodiversity: Levels of biodiversity, Indonesian biodiversity, the loss of biodiversity, and Efforts to preserve biodiversity. In every meeting, students are asked to read and study the material presented in the e-module and complete the activities required by the e-module, including practicing working on critical thinking questions.

A total of 140 participants were selected for this study using convenience sampling. They were divided into two groups: a control group consisting of 70 students and an experimental group consisting of 70 students from a public high school in Toraja, Indonesia. This division was based on the availability of Biology teachers' classes. Data for this study were collected using essay questions given as pre-tests and post-tests to assess students' critical thinking skills. The instrument consisted of 10 essay questions designed to measure various critical thinking indicators: elementary clarification, basic support, inference, advanced clarification, and strategic and tactical, referring to Enns's (1985) framework, complete with a scoring rubric. An example of critical thinking questions with strategic and tactical indicators is in Figure 1.

*In Toraja culture, the spotted buffalo (*tedong saleko*) is very important for the Rambu Solo' traditional ceremony. Currently, the population of spotted buffalo is limited, while the demand is high due to its cultural and economic value. If no conservation measures are taken, the spotted buffalo could become rare or even extinct.*
*As a student who cares about biodiversity conservation, you are asked to choose one action strategy to preserve the spotted buffalo in Toraja. (**Strategies and tactics for deciding an action**)*
a) Choose one of the following two options:
• Establish a spotted buffalo conservation center (a place created to protect and care for the animals to prevent extinction) with government support.
• Provide training and support to local farmers

b) Explain why you chose that strategy over the other option, considering ecological, economic, and cultural aspects to improve traditional breeding.

Figure 1. Example of a Critical Thinking Question and indicator

Before this instrument was used in the main study, a series of pilot tests was conducted with 36 eleventh-grade students who had already studied biodiversity. The overall validity was 0.67 (high), reliability 0.80 (very high), with a moderate difficulty level and discrimination power varying between fair and good categories, so this instrument was considered suitable for use.

Data analysis was done using SPSS Version 26. It started with prerequisite tests to assess the normality and homogeneity of the data distribution. Since the sample size was greater than 50, the Kolmogorov-Smirnov test was used to assess the normality of the data distribution. The normality test results did not fully meet the criteria, so a nonparametric analysis using the Mann-Whitney U test was performed. This test is considered appropriate because it can detect differences in the average across two or more groups, even when the data are not normally distributed. This methodological approach ensures that the statistical analysis aligns with the data's characteristics, thereby maintaining the validity of the research findings and accurately reflecting the empirical conditions. To determine the extent to which the treatment affected the experimental group relative to the control group, an effect size test using Cohen's d was conducted. Although the results showed a significant difference, it is important to understand the magnitude of that effect (Cohen,

2013). Based on this analysis, conclusions can be drawn about the impact of the e-module on the potential and local wisdom of the Toraja Tribe in enhancing critical thinking skills.

RESULTS AND DISCUSSION

The results of descriptive statistical tests on student test results are shown in Table 1.

Table 1. Statistical Test Results of the Pre-test of Students' Critical Thinking Skills

Data Type		Pre-test	
		Control	Experimental
N		70	70
Mean		37.42	46.14
Minimum Score		10.00	12.00
Maximum Score		50.00	62.00
Standard Deviation		16.47	18.51
Normality Test (Kolmogorov-Smirnov, Sig = 0.05)	Sig	0,200	0,200
	Interp	Normal	Normal
Homogeneity Test (Levene's Test)	Sig	0,611	
	Interp	Homogenous	
T-test	Sig	0,036	
	Interp	Significantly Different	

Based on Table 1, there is a significant difference in pre-test scores between the experimental and control classes. This finding indicates that students' critical thinking skills in both classes are at different initial conditions. Therefore, the analysis of the improvement in students' critical thinking skills is focused on the analysis of gain score data, namely the difference between the post-test and pre-test scores between the experimental and control classes, as presented in Table 2.

Table 2. Statistical Analysis Results: Gain for Students' Critical Thinking Skills

Data	Gain	
	Control	Experimental
Number of Students	70	70
Mean	16.40	34.62
Minimum Score	2.00	4.00
Maximum Score	46.00	64.00
Standard Deviation	10.65	11.93
Normality Test	0.001 (Not Normal)	0.655 (Normal)
Homogeneity Test	0.484 (Homogeneous)	
Difference Test (Mann-Whitney U)	0.000 < 0.05 (Significantly Different)	

Based on Table 2, there is a significant difference between the experimental and control groups. To assess the level of improvement in critical thinking skills before and after treatment, we calculated the N-gain. A summary of the N-gain data for critical thinking skills is presented more briefly in Table 3.

Table 3. Results of Normalized Gain (N-gain) Analysis for Students' Critical Thinking Skills

N-Gain Calculation	Experimental Class	Control Class
Average N-Gain	0,51	0,23
Category	Medium	Low

Table 3 shows that the N-gain value in the experimental group (0.51), which used the e-module based on the potential and local wisdom of Toraja, was higher than that in the control class

(0.23), which used standard school books. The findings from this N-gain test are further explained through effect size calculations to determine the magnitude of the intervention's impact. A summary of the effect-size data on critical thinking skills is presented briefly in Table 4.

Table 4. Results of Effect Size Calculation for Students' Critical Thinking Skills

Calculation of Effect Size	
Cohen's D	1,61
Category	Large

Based on Table 4, the effect size calculation reinforces that using e-modules that combine the potential and local wisdom of the Toraja community significantly improves students' critical thinking skills. Furthermore, Figure 2 shows an increase in scores on each critical thinking indicator after the intervention in both the control and experimental classes.

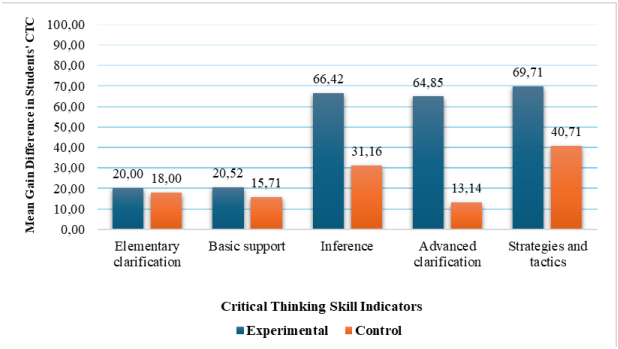

Figure 2. Discrepancy in the Average Improvement of Critical Thinking Skills Across All Indicators

Figure 2 generally shows that, across all indicators, the average scores increased more in the experimental class than in the control class, by varying amounts. The average increase in the indicators of inference, advanced clarification, and strategic and tactical skills in the experimental class was higher than in the other two indicators. Table 5 shows the N-gain for each critical thinking skill indicator during the learning process.

Table 5. N-Gain of Each Critical Thinking Skill Indicator

Indicator	N-Gain	
	Experiment	Control
Elementary Classification	0,32 (medium)	0,22 (low)
Basic support	0,54 (medium)	0,23 (low)
Inference	0,61 (medium)	0,15 (low)
Advanced clarification	0,69 (medium)	0,12 (low)
Strategic and tactic	0,53 (medium)	0,14 (low)

Based on Table 5, the increase in critical thinking skills in the experimental class was moderate across all indicators, whereas in the control class it was low. This supports the claim that using a local potential e-module grounded in Toraja cultural wisdom enhances students' critical thinking skills. To assess the extent to which the intervention influenced each critical thinking indicator in the experimental class, an effect size calculation was conducted. The results are listed in Table 6.

Table 6. Effect Size of Each Critical Thinking Skill Indicator in the Experimental Class

Indicator	Effect size
Elementary Classification	0,09 (small)
Basic support	0,24 (medium)
Inference	1,64 (large)
Advanced clarification	1,84 (large)
Strategic and tactical	0,95 (large)

Table 6 shows that the potential-based and local wisdom-based e-module for the Toraja tribe has a significant impact on the indicators of Inference, Advanced clarification, and Strategic and tactical skills of students, but a small impact on the elementary clarification indicator.

The research findings are supported by a two-way statistical test that shows a significant difference after the intervention. The increase and impact of the e-module in the experimental class, as shown by the N-gain and effect size (Tables 5 and 6), reinforce the result that using an e-module about the potential and local wisdom of the Toraja Tribe in biodiversity learning has a big effect on several indicators of students' critical thinking skills. The e-module used was deliberately designed to facilitate and train critical thinking skills. Using news articles that address issues related to Toraja's biodiversity and environment as context is considered appropriate for fostering students' critical thinking skills.

The conflicts or issues raised in the e-module include the declining population of biodiversity animals like buffaloes and pigs, which are often used in traditional ceremonies in Toraja; environmental damage caused by illegal mining; environmental damage from clearing forest land for tourism; and the continued use of animals and plants in traditional ceremonies, which could threaten their sustainability. These findings align with Purwanto et al. (2022) and Dusturi et al. (20, showing that a social-critical approach that focuses on environmental and social-scientific issues close to everyday life can boost critical thinking skills and increase students' motivation and engagement in the learning process.

E-modules that discuss environmental issues provide students with learning experiences that are contextually relevant by connecting lesson materials to real-world situations (Alfred & Kaulu, 2020; Güngör & Şenel, 2020), and encouraging students to think more deeply (Thamrin et al., 2024). Meanwhile, Sumardi et al. (2026) highlight a significant improvement in students' critical thinking skills and cultural literacy when lesson materials are integrated with culture.

In the e-module, the discussion about genetic-level biodiversity takes the example of the diversity of buffaloes used in the rambu solo' ceremony. In the same ceremony, a small hut (Lantang) made from various types of bamboo is used as an example in the discussion about species-level biodiversity. At the end of each sub-chapter in the e-module, there is a Critical Thinking Exercise section for students to complete. The context presented in the questions concerns the biodiversity of the Toraja community.

Critical thinking is developed by involving students in real problem-solving activities (Nguyen et al., 2025), and this can be nurtured in the classroom through learning that encourages students to analyze problems critically, evaluate various solution alternatives, and process information effectively to make logical decisions in problem-solving (Khaeruddin & Bancong, 2022). In the e-module, some of the real problems raised include the scarcity of pigs for traditional ceremonies, due to a roughly 70% decline in the pig population following the 2023 ASF (African Swine Fever) outbreak in Sulawesi. Students are asked to respond to the problem and are challenged to develop strategies and tactics to address it.

Problem-based learning encourages students to learn independently while also developing and enhancing their critical thinking skills, as they are trained to analyze information, evaluate evidence, and make informed decisions. The e-module developed also requires students to identify biodiversity from images/videos, and this activity can help develop collaborative skills such as communication, listening, and participation in thoughtful discussions (; Amaral, 2026; Rehman et al., 2023). In the end, it affects students' critical thinking abilities. Critical thinkers practice analyzing problems from different perspectives, considering various investigative methods, and generating several alternative solutions before making the right decision (Murawski, 2014; Yue et al., 2026).

Additionally, to better understand how critical thinking skills develop through e-modules grounded in potential and local wisdom, an analysis was conducted for each critical thinking skill indicator. This analysis was conducted to identify which indicators improved the most and which still need improvement, according to Gunawan et al. (2025) and Heliawati et al. (2022).

The first indicator of critical thinking skills is giving a simple explanation or basic clarification. This skill includes analyzing, asking and answering questions, and focusing on the core issues, which can help students understand various factors and issues more deeply (Kumala et al., 2022). The effect size value for this first indicator shows that the Toraja e-module based on local wisdom has a small impact (0.09) on the indicator of giving simple explanations. This situation might be because teachers often practice giving simple explanations when answering essay questions during daily evaluations (cognitive level C1-C3), so students already have this skill before the intervention.

From Figure 2, the average difference between pre-test and post-test scores in the experimental and control classes is not large, indicating that the ability to give simple explanations is already present in the students in the control class. This is supported by Fitriani et al. (2020), who state that generally the questions given in science learning tests are at cognitive levels C1-C3. This means that students already have

the skills to provide simple explanations, even though their scores have not yet shown optimal results.

Therefore, the skill of giving simple explanations needs to be continuously improved by training students to ask questions using strategies like 'how/ why,' analyzing arguments, and participating in teacher-monitored discussions (Menninga et al., 2022; Cantona et al., 2023; Mahmud & Mohd Drus, 2023; Uzun, 2024). Teacher support in guiding oral and written arguments, including providing a supportive learning environment, helps improve students' ability to construct arguments with claims backed by data (Telenius et al., 2020;Chang et al., 2024). Regarding the Toraja potential and local wisdom e-module, it should include more exercises on the skill of giving simple explanations.

The second indicator of critical thinking ability is basic support. Indicators for basic support in the critical thinking framework have a main component: assessing the credibility of sources and evaluating the quality of evidence (Ennis & Norris, 1989). The effect size for the experimental class indicates that the e-module on Toraja's potential and local wisdom affects the basic support indicator at a moderate level (0.24).

It seems the practice questions for the basic support indicator in the e-module do not cover all sub-indicators, especially the one on assessing the credibility of sources. The practice questions developed focus more on the sub-indicators for evaluating the quality of evidence and considering the reliability of information, so the sub-indicator on assessing source credibility is not well-practiced.

This aligns with Hidayat et al. (2023), who stated that although e-modules can generally improve critical thinking skills, their effectiveness in developing certain basic skills, like assessing source credibility or evaluating the quality of evidence, might not always make a significant difference if the module design does not explicitly target and measure those aspects. This shows that even though e-modules can significantly improve cognitive learning outcomes, a more focused pedagogical design is still needed to enhance critical thinking skills (Fauziah & Iryani, 2025).

The third indicator of critical thinking skills is inference. The inference indicator in the critical thinking framework in this study has main components: deducing and considering the results of deduction, inducing and considering the results of induction, and considering decisions (Ennis & Norris, 1989). Based on Table 5, the effect size for the inference indicator in the experimental class is 1.64, which falls into the large category. This means the local wisdom-based e-module has a significant impact.

Inference indicators in the e-module are trained through tasks in each subchapter, which challenge students to sharpen their inference skills. Inference skills are very useful for students, especially when making decisions about strategies. The e-module presentation on illegal mining in Tanah Toraja, which sparked community conflict due to biodiversity loss, makes it easier for students to understand the material because the context is local. With a local context, students will process qualitative and quantitative information objectively, connect various data, and analyze and evaluate information before drawing valid conclusions (Astuti et al., 2024).

E-modules that integrate local wisdom can make it easier for students to understand lesson material in context, potentially improving their ability to conclude information (Asrial et al., 2021; Wahyudi et al., 2025). E-modules generally significantly enhance students' cognitive learning outcomes and motivation, thereby indirectly supporting development of higher-order thinking skills, including inference (Fauziah & Iryani, 2025; Safira & Iryani, 2025) and problem-solving (Muhibuddin et al., 2023).

The fourth indicator of critical thinking skills is providing further explanation or advanced clarification. This indicator consists of two main sub-indicators: identifying terms and considering related definitions in terms of form, strategy, and content, as well as identifying assumptions (Ennis, 1985). Advanced clarification skills are an important indicator of students' high-level thinking abilities. These skills require students to analyze information and solve problems in depth, connect different pieces of information, and thoroughly explain their understanding (Listiani et al., 2025).

Based on Table 5, the effect size for the advanced clarification indicator falls into the large category (1.84), indicating that an e-module grounded in Toraja's potential and local wisdom has a significant impact on critical thinking skills. Critical thinking practice questions, particularly for the advanced clarification indicator, are rarely practiced at school. Fitriani et al. (2020) found that science questions given in science evaluations rarely assess higher-order cognitive abilities (C4-C5). Meanwhile, in the e-module, questions requiring advanced clarification skills are practiced using cases and examples from the Toraja community, making it easier for students to process information and develop critical thinking skills, and providing further explanations, thus improving students' advanced clarification abilities.

E-modules that use local wisdom help students absorb cultural values and practice observation, interviewing, and analysis skills, which are important for providing in-depth explanations. In addition, e-modules that integrate local wisdom offer a contextual learning experience, spark curiosity, and make students more engaged because the learning materials

are directly related to the surrounding environment and credible evidence (Sari et al., 2021; Astuti et al., 2024).

The fifth indicator of critical thinking skills is strategy and tactics, which consists of two main sub-indicators: deciding on actions to take and interacting with others. Table 5 shows that the effect size value of the strategy and tactics indicator is 0.95 in the large category. This means that potential- and local wisdom-based e-modules have a big impact on strategic and tactical skills. In the e-module that was developed, strategy and tactic indicators are practiced through case questions that ask students to propose action strategies to maintain the population of patterned buffaloes, even though this type of buffalo is needed for the traditional Rambu Solo ceremony in the Toraja community.

So far, the indigenous community has not made any efforts to preserve this patterned type of buffalo. Through these questions, students engage with cultural elements already familiar to them, thereby developing more effective strategies for understanding and applying academic concepts in real-world situations, according to Azzahrah et al. (2025). By integrating biological content with local wisdom, this e-module encourages a deeper connection between students and the learning materials while also prompting them to develop creative, tactical approaches to problem-solving and critical thinking (Wahyudi et al., 2025).

Based on research results, the use of e-modules grounded in local potential and the local wisdom of the Toraja ethnic group has been shown to influence students' critical thinking skills. The greatest impact was seen in the indicators of inference, further clarification, and strategies and tactics. Students' reactions to these e-modules were very positive because they were easy to understand and use. Adding local elements to local wisdom-based modules increases students' interest and motivation, which contributes to their positive response to the modules (Sriyati et al., 2021). Interactive e-modules and content based on local wisdom show that with an informative and engaging design, students' satisfaction and interest in science materials, including biology, increase when connected to local culture (Luthfiyah et al., 2025).

This finding confirms that integrating local cultural context into digital learning media effectively enhances higher-order cognitive abilities. This study provides practical contributions for the development of ethnoscience-based curricula and serves as an important reference for future learning innovations.

This study shows that integrating local potential and local wisdom with biology material helps students master critical thinking skills. In line with the Merdeka Belajar policy, which emphasizes local context, relevance, and flexibility, this research suggests that teachers should contribute by utilizing local potential and wisdom, as well as local cultural values, as learning resources to improve learning outcomes, including critical thinking skills.

CONCLUSION

Based on the research results, it can be concluded that using e-modules grounded in the potential and local wisdom of the Toraja Tribe has a significant impact on students' critical thinking skills compared to standard school textbooks. Effect size analysis shows that this intervention has a major influence, especially on indicators such as inference, advanced clarification, and strategies and tactics. These findings confirm that integrating local cultural context into digital learning media effectively strengthens higher-order cognitive abilities. This study provides practical contributions to the development of ethnoscience-based curricula and serves as an important reference for future learning innovations. The research identified a limitation: the sub-indicators of critical thinking skills were not fully covered in the e-module, so critical thinking skills were not optimally developed, especially in the basic support indicator.

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