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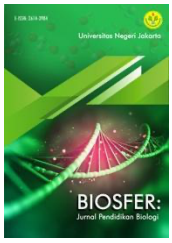

The effect of local potential-based biology learning resources on students' competencies: An in-depth analysis

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ABSTRACT

This research stems from the low utilization of local potential-based biology learning resources in schools, despite their importance in deepening biological understanding, shaping student character, and fostering environmental awareness, amid growing challenges like resource exploitation, land use change, and climate change. This study aims to assess how effective biology learning resources based on local potential affect student attitudes and learning outcomes by conducting a systematic literature review and meta-analysis using the PRISMA method on articles published between 2013 and 2024. The main data source came from Google Scholar, focusing on articles discussing the utilization of local potential as a learning resource. The uniqueness of this method lies in the categorization of articles based on dependent variables, namely student attitudes and learning outcomes. The data were analyzed descriptively for attitude variables and quantitatively using Cohen's d formula to measure the effect size on learning outcomes for articles with adequate data. The results of the analysis showed that local potential-based learning significantly impacted positively on students' attitudinal changes (including environmental awareness and conservation) and improved cognitive learning outcomes, as seen from high N-gain and effect size values. These findings support the application of contextual and constructivist approaches that are in line with the Merdeka Curriculum, which emphasizes the importance of strengthening character and sustainability. In conclusion, learning resources based on local potential can improve learning quality and shape students with character and environmental awareness, while strengthening empirical evidence on contextual biology education and learning based on local wisdom.

INTRODUCTION

Local potential is a phenomenon or event that exists in an area, one of which is natural resources (Marlina et al., 2015; Santri & Sudibyo, 2025). Local potential in the form of natural resources found in the surrounding environment can be utilized as a means to help students understand science-biology concepts and their application in everyday life (Gh, 2024), utilized as a source of independent learning (Destiara, 2020), or at school used as an interesting learning resource (Alimah, 2019; Annisha et al., 2020). Utilization of learning resources using local potential begins with exploration of the local environment in accordance with the applicable curriculum (Susilo, 2018; Herdiana et al., 2021). Biology learning integrated with local potential can motivate students to learn and develop skills according to local potential in their area (Kahar & Fadhilah, 2018). Broadly speaking, local potential is the advantage of an area that can be utilized as a learning resource in the classroom or independently. Local potential also has a positive influence on students in the classroom and is applicable in everyday life.

However, the utilization of local-based learning resources is still limited (Susilo, 2018; Kahar & Fadhilah, 2018), has not been utilized optimally (Annisha et al., 2020), and even in other studies it has not been utilized (Setyaningsih et al., 2019; Sukirno et al., 2020). Among the causes is that some biology teachers are less sensitive to local potential in their area, so students have difficulty understanding biology concepts that need to be taught directly in the field (Sukirno et al., 2020).

Another opinion that causes local potential to be rarely used as a learning resource is the view that education is carried out in the classroom (Faridah et al., 2017), and the teacher as the center of learning (Eurika & Hapsari, 2017). In addition, the lack of utilization of local potential is also caused by limited information and local potential-based learning tools (Setyaningsih et al., 2019). Sensitivity to local potential, natural resource information, and learning tools that facilitate learning activities based on local potential are needed to utilize it as a learning resource.

On the other hand, local potential also faces several threats, including unauthorized mining and forest encroachment (Mardhiah et al., 2018; Lega, 2022), exploitation (Isnandar et al., 2021; Arifin et al., 2023), land conversion (Lesmana et al., 2022; Karyati et al., 2022), environmental pollution (Jamaldi, 2017; Weningtyas & Widuri, 2022), and climate change (Alam et al., 2022; Bayau, 2023). Education holds the responsibility for facing the threat of a lack of knowledge of local potential. Especially biology education in teaching knowledge about local potential in the form of natural resources.

Biology learning based on local potential can not only enhance students' critical thinking skills but also have a positive impact on their attitudes, as evidenced by several previous studies. (Hadi & Ainy, 2020; Rahmi et al., 2023; Lidi et al., 2022) and student learning outcomes in biology learning (Wardani & Miftakhi, 2021; Turini et al., 2021; Utami & Dewi, 2021). This shows that local potential is effective in learning biology because it is proven to have a significant influence on students' attitudes and learning outcomes, and there has been no systematic study that integrates and analyzes findings in the context of biology learning. For the purpose of a more credible analysis and discussion of various research results on this topic, it is necessary to conduct a literature analysis and meta-analysis to compare and unify several similar research results.

Given the increasing number of studies examining the use of local potential in biology education, it is important to understand the consistency of these research findings. To date, there has been no systematic and integrated analysis evaluating the effectiveness of local potential-based learning in influencing students' attitudes and learning outcomes. Previous research findings remain scattered and have not been comprehensively analyzed within a unified analytical framework.

Therefore, this study employs meta-analysis combined with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) approach as a systematic guide for selecting and analyzing relevant articles. Meta-analysis is a quantitative research method that aims to summarize the results of several homogeneous studies into a single effect size (Dantes & Rati, 2020; Azkia et al., 2023). The effect size reflects the extent to which the independent variable (in this case, local potential-based learning) influences the dependent variable (students' attitudes and learning outcomes) (Agustin et al., 2021). Additionally, meta-analysis enables researchers to evaluate the consistency or inconsistency of findings from previous similar studies (Amin et al., 2020).

By applying the PRISMA steps, this study systematically identified, screened, and evaluated scientific articles using strict inclusion and exclusion criteria. Through this approach, the meta-analysis results obtained are expected to provide a more objective and credible picture of the effectiveness of local potential-based biology learning on improving students' attitudes and learning outcomes.

METHODS

Research design

This study employs a systematic literature study design, using Google Scholar as the primary data source. The research process applied the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) approach to ensure transparency and rigor in selecting relevant articles, referring to the guidelines developed by Roux et al. (2021). This design was chosen to synthesize findings from multiple studies that focus on the utilization of local potential as a learning resource.

Population and Sample

The population of this study consists of scientific articles published within the range of 2013 to 2024. The sample was selected based on specific inclusion criteria, namely: (1) articles published between 2013 and 2024; (2) articles that are open access and accessible to the public; (3) studies classified as original research publications; (4) articles whose topics focus on the utilization of local potential as a learning resource; and (5) articles written in either Indonesian or English, specifically discussing the use of local potential in learning and its effects on students' attitudes and learning outcomes. Articles that met all of these criteria were included for further analysis.

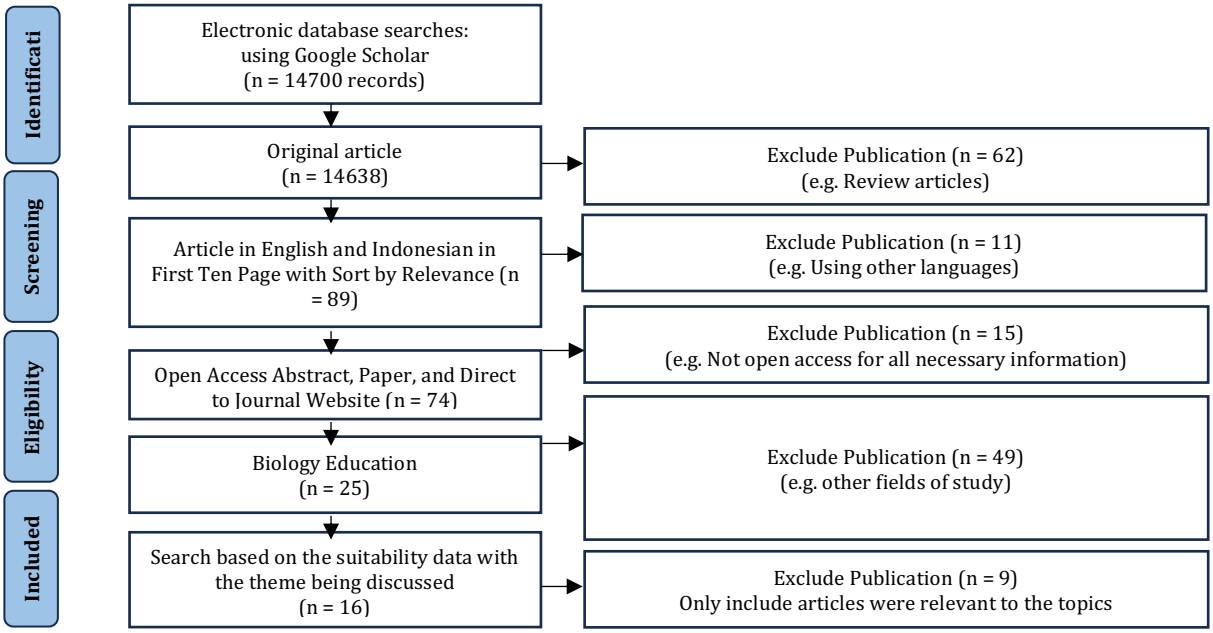

Figure 1. Article selection used in SLR using PRISMA model

Research instruments

The main instrument used in this study was a data extraction sheet, designed to systematically collect relevant information from each selected article. This sheet included fields for the article title, author(s), publication year, language, publication type, a description of the local potential used, and identification of the dependent variable—whether related to students' attitudes or learning outcomes. In addition, the sheet captured specific data such as attitude percentages or criteria and pretest-posttest scores, depending on the focus of each article.

Research procedure

The procedure of this research followed the PRISMA four-stage framework, which includes identification, screening, eligibility, and inclusion (see Figure 1). In the identification stage, relevant articles were gathered through keyword-based searches on Google Scholar. During the screening stage, article titles and abstracts were reviewed to assess their relevance to the topic. The eligibility phase involved a detailed evaluation of full texts using the established inclusion criteria. Finally, in the inclusion stage, articles that fully met all criteria were selected for analysis. After selection, articles were categorized based on their dependent variables. Articles focusing on students' attitudes reported data

in the form of percentages or attitude criteria, while those focusing on learning outcomes provided average scores from pretest and posttest assessments.

Data analysis

The data were analyzed using two approaches based on the type of dependent variable. Articles that addressed students' attitudes were analyzed using descriptive statistics, summarizing the reported percentages or categorical attitude levels. For articles focusing on learning outcomes, the analysis involved calculating the effect size using Cohen's d formula. According to Boisandi & Darmawan (2017), the effect size was obtained from the difference between post-test and pretest mean scores, adjusted for variation using the pooled standard deviation. The interpretation of effect size followed the guidelines from Taufik et al. (2022), which classify the magnitude as weak (0.00–0.20), moderate (0.21–0.50), sufficient (0.51–1.00), and strong (>1.00). These analyses were conducted to evaluate the effectiveness of local potential-based learning in enhancing students' understanding of biological concepts.

RESULTS AND DISCUSSION

Based on a search on the Google Scholar page with the keyword utilization of local potential-based biology learning resources on students' attitudes and learning outcomes, 14,700 documents were found. Based on the inclusion criteria, 16 most suitable and recommended articles were selected as shown in Table 2. Each article has a specific dependent variable as an impact of the independent variable. The dependent variables, consisting of learning interest, learner character, environmental care, and conservation concern, were included in the "attitude" aspect in three articles, while the other dependent variables were included in the "learning outcome" aspect in ten articles, and the effect size was found in five articles. Two of the 16 articles discussed both variables. This difference is significant enough to show that research still focuses more on learning outcomes than on students' attitudes.

Table 1.
List of Sample Articles

Code	Research Objectives and Author(s)	Attitude	Learning outcome	Effect size
A1	To determine how the utilization of the coastal environment can increase the interest and learning outcomes of high school students in South Kalimantan (Irwandi & Fajeriadi, 2019)	√	-	-
A2	Analyzing the effectiveness of integrating local potential on students' science process skills and conceptual understanding (Wilujeng & Suryadarma, 2017)	-	-	√
A3	Identifying types of local plants and evaluating their potential as a source of biology learning (Mumpuni et al., 2014)	-	√	-
A4	Developing biology learning resources based on local potential to improve students' science process skills (Sriyati et al., 2021)	-	√	-
A5	Analyzing the impact of implementing mangrove ecosystem teaching materials based on local potential on students' environmental awareness (Kahar, 2018)	√	-	-
A6	Developing a booklet based on local wisdom on plant material to improve the understanding of 10th grade students (Melati et al., 2020)	-	√	-
A7	Developing learning tools using the Think Pair Share model based on local potential and assessing its influence on student learning outcomes (Pagala, 2017).	-	√	-
A8	Developing a biodiversity education model based on local potential for high school/MA students (Pratiwi et al., 2019)	-	√	-
A9	Analyzing the potential use of biodiversity modules based on local wisdom and culture as alternative teaching materials for high school/MA biology (Adinugraha & Ratnapuri, 2020)	-	√	√
A10	Developing a Wakatobi-based local potential encyclopedia on mollusks as a biology learning resource (Rosnawati & Sunaryati, 2021)	-	√	-

Code	Research Objectives and Author(s)	Attitude	Learning outcome	Effect size
A11	Comparing the effectiveness of integrated science learning based on local clove leaf potential on students' generic science skills (Susanti et al., 2017)	-	-	√
A12	Developing a SETS-based biology module on environmental pollution to enhance students' conceptual understanding and environmental awareness (Lekman, 2020)	-	√	-
A13	Developing a biology module based on local coffee plant potential on inheritance patterns for Grade XII students (Rosalvin et al., 2022)	-	√	-
A14	Developing a biodiversity encyclopedia in Jepara Regency as a supplementary teaching material to improve learning outcomes and environmental conservation attitudes (Habiba et al., 2023)	√	√	-
A15	Analyzing the influence of discovery learning based on local potential on students' critical thinking skills in biology lessons (Imtihana & Utami, 2023)	-	-	√
A16	Testing the effectiveness of implementing teaching materials based on local knowledge in biology learning on environmental change topics (Hapsari & Hariyatmi, 2024)	-	-	√

Description: A = Article

Utilizing the environment as a learning medium can enhance student motivation and interest, as it provides real-life experiences that are relevant to daily life and encourages active engagement in the learning process. (Hasbiyalloh et al., 2025). Utilizing the school environment in the learning process can assist teachers, particularly in science subjects, by enabling students to engage in concrete learning experiences (Anggraini & Efendi, 2023). Utilizing the surrounding environment as a learning resource and medium not only supports the educational process but also fosters student creativity and enhances teacher competence in developing contextual and engaging learning (Mutiara, 2021; Achmad et al., 2024). Some factors that influence the utilization of the environment as a learning resource include the teacher's ability to develop learning methods, support from the school, and the availability of resources (Irwandi & Fajeriadi, 2019; Afandi et al., 2020; Malik et al., 2023). The school effectively harnesses the resources available in its environment as a means of education and shows a strong commitment to implementing environmental-based education. The primary objective is to cultivate a generation that is environmentally conscious and responsible. (Nahak, 2023; Rahmawati et al., 2024). In detail, the effectiveness of utilizing local potential as a biology learning resource on students' attitudes is presented in Table 3, while the learning outcomes are presented in Table 4, and the effect size tabulation is presented in Table 5.

Table 2.
Effectiveness on Learners' Attitudes

Code	Data Collection Technique	Research Finding
A1	Using student response questionnaires, involving five students from each school, then analyzed descriptively.	85.5% (school A), and 87.5% (school B), the average impact on attitude was positive with a percentage of 86.5%.
A5	The study used observation and interviews, then the results were analyzed with the N-gain value.	Students' environmental care attitude increased with an N-gain value of 0.32 which is classified as a moderate category.
A14	The data collection technique was done through a questionnaire.	The mean conservation attitude score of 3.56 (very good) shows that the biodiversity encyclopedia has a positive effect on conservation attitudes.

Based on the research data shown in Table 3, it can be concluded that the utilization of biology learning resources focusing on local potential has a positive impact on students' attitude development. This approach succeeded in encouraging students to show increased concern for the environment as well as better conservation attitudes. This shows that education related to the local context not only enriches cognitive aspects but is also effective in building learners' character and social values.

This finding is in line with the principle of Contextual Teaching and Learning which emphasizes

the importance of the connection between the material taught and students' real-life experiences to make learning more meaningful. In addition, this principle supports affective development, where attitudes, interests and values can be generated through relevant and contextual learning experiences (Lotulung et al., 2018; Haryanto & Arty, 2019; Tari & Rosana, 2019). This learning method is also in line with the Merdeka Curriculum policy, which prioritizes the importance of strengthening character, critical thinking skills, and concern for sustainability issues. Thus, learning resources based on local potential not only serve to improve the quality of biology learning, but also contribute to the formation of student profiles that have environmental awareness and a sense of social responsibility.

Table 3.
Effectiveness of Student Learning Outcomes

Code	Data Collection Technique	Research Finding
A3	Exploration and literature study	Students were able to classify local plants and compare their diversity between regions.
A4	N-gain	83% obtained N-gain in the medium category, while the remaining 17% obtained the high category.
A6	Test scoring	A total of 87.2% of students completed learning, while 12.8% were not complete with scores below 75.
A7	Normality test	The results of the analysis of covariance (Fhit = 4.72 > Ftab = 1.89; α = 0.05) show that the TPS model has a positive effect on student learning outcomes.
A8	Case study in the form of a survey	The lack of contextual material based on local potential demands the development of biodiversity learning resources, such as orangutans and butterflies, in the form of Android-based applications.
A9	Pretest dan Posttest	The control class score was 63.81 while the experimental class was 65.00.
A10	Test scoring	The results of the effectiveness test of local potential-based encyclopedia learning resources on the Mollusca phylum obtained an average score of 85.370, with a range of scores of 80-100, exceeding the KKM of 75.
A11	Test scoring	A total of 100% of students were completed with an average score of 80, exceeding the KKM of 70 and in the high category.
A12	N-gain and T test	Control class 0.37 while the experimental class 0.55. The t-test analysis results show a significant average difference between the control class and the experimental class.
A13	N-gain	The control class score was 62.5 while the experimental class score was 85.5, with an N-gain of 71.
A14	N-gain	N-gain 0.30 with a medium category.

Based on the information from Table 4, it can be concluded that biology learning resources that utilize local potential have proven successful in improving student learning outcomes. The learning process that is connected to the local context - for example, the exploration of biodiversity and the use of local encyclopedias - not only helps students understand the material better, but also strengthens the understanding of concepts more deeply. This increase in learning outcomes can be seen from the high average post-test scores and N-gain scores that showed a significant increase in the experimental class compared to the control class.

In theory, these results are in line with the constructivist approach in education, where knowledge is formed through concrete experiences that are relevant to students (Steffe & Ulrich, 2020). Learning resources that are integrated with local contexts allow students to connect abstract material with real situations around them, thus deepening concept understanding (Harefa, 2024). In addition, this contextual learning also supports the mastery of higher-order thinking skills by encouraging students to critically analyze, compare, and draw conclusions from phenomena in their environment (Thamrin et al., 2024). The scientific impact of these findings strengthens the argument that integrating local potential into learning materials can be an educational strategy that not only improves learning outcomes from the cognitive aspect, but is also relevant for strengthening character-based curriculum and developing students' science literacy. This research contributes to the development of a learning model based on local wisdom that is applicable, adaptive, and sustainable for biology education in the global era.

Table 4.
Tabulation of Effect Sizes Compared to the Comparison Group

Code	Effect Size	Category
A2	2.69	Strong effect
A9	0.08	Week effect
A11	9.32	Strong effect
A15	0.61	Moderate effect
A16	0.54	Moderate effect

Based on information regarding the effect size contained in Table 5, it can be concluded that the use of biology learning resources that focus on local potential has a very significant effect on improving student competence, especially in certain aspects that are emphasized with a very high effect size. This effect indicates that learning rooted in the local context is able to provide substantial differences in competency achievement when compared to the control group using traditional learning resources.

Integrating local cultural values and traditions into learning aligns with experiential learning theory, which emphasizes the importance of direct experiences in local contexts to deepen students' understanding and skills. This approach also makes learning more relevant, enjoyable, and enriches students' perspectives and social skills (Coyer et al., 2019; Amaliyah et al., 2023). Learning resources based on local potential create more concrete and relevant learning experiences, which support knowledge formation through reflection and active participation (Cottafava et al., 2019; Morris, 2020). In addition, the high effect size indicates that this learning model increases the effectiveness in transferring learning from the classroom environment to the real world, in line with the principle of learning transfer. From a scientific point of view, this strengthens the empirical evidence that the integration of local learning resources in science education not only has cultural relevance, but also provides a strong boost to students' competency achievement. It provides a solid foundation for developing a more contextualized and locally-oriented curriculum, and confirms the need for pedagogical innovations that are grounded in the environment and realities that students face.

One of the main difficulties in this study was the lack of complete statistical information in several selected articles, such as missing standard deviations, sample sizes, or significance values needed to calculate effect sizes. To address this, data estimation techniques from meta-analysis literature were applied, including converting available statistical values (e.g., t or F statistics). Attempts to contact original authors were also made, but responses were limited. This study relies on secondary data from articles meeting inclusion criteria, which may not represent all existing research on the use of local potential in biology education. Variations in study design, sample characteristics, and measurement instruments among included studies may affect the consistency of effect size estimates. Therefore, the results should be interpreted with caution and not generalized beyond the analyzed studies.

CONCLUSION

This research clearly shows that the use of local potential as a learning resource in biology teaching has a major influence on students' attitudinal development and learning outcomes. By applying a literature review method and a meta-analysis approach following PRISMA guidelines, this research successfully summarized 16 relevant articles, which indicated that learning rooted in local potential not only improves cognitive understanding but also builds character and care for the environment. These results reinforce the significance of contextual and constructivist approaches in education and support the implementation of *Merdeka* Curriculum, which emphasizes strengthening character and sustainability. This study makes a significant contribution in expanding the literature on the integration of local potential in education and recommends that we become more active in developing locally based learning tools that are relevant and applicable for the future of significant and sustainable learning.

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