JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

THE INQUIRY ETHNOBOTANY LEARNING MODEL: AN INSTRUCTIONAL DESIGN MODEL TO ENHANCE STUDENT ENVIRONMENTAL LITERACY

Endang Sri Lestari,
Sajidan Sajidan,
Fitria Rahmawati,
Meti Indrowati

Abstract. *Environmental literacy related to the utilization of medicinal plants in the community provides a foundation for the younger generation to take an active role and form an attitude of care and responsibility for environmental sustainability. The current research aims to introduce the Inquiry-Etnobotany (IEb) learning model to enhance students' environmental literacy. The research design applied a pretest-posttest control group design to assess the effectiveness of the IEb model intervention, comparing it with the inquiry and discovery learning models. Upon analysis, notable differences emerged between the pre-test and post-test results across various learning models. Specifically, the IEb model exhibited a substantial difference, indicating significant progress in student outcomes. Similarly, the inquiry model showcased an improvement, while the discovery learning model displayed a slightly smaller change. Furthermore, the disparities between pre-test and post-test outcomes were evident across the different schools involved in the study. The IEb model has a significant impact on enhancing students' environmental literacy. However, the research results in each school also demonstrate that various learning models enhance students' understanding of environmental issues despite the different levels of effect.*

Keywords: *inquiry model, ethnobotany, environmental literacy, medicinal plants, live laboratory*

Endang Sri Lestari, Sajidan Sajidan, Fitria Rahmawati, Meti Indrowati
Sebelas Maret University, Indonesia

Introduction

Indonesia popularly serves as a live laboratory due to its alleged possession of 30,000 plant species out of approximately 40,000 known worldwide (Food and Agriculture Organization, 2020). Around 9,000 plant species are credited with medicinal properties; however, according to the Food and Agriculture Organization's 2020 report, only 1,000 plant species are currently utilized for medicinal ingredients (Food and Agriculture Organization, 2020). Understanding the diversity of medicinal plants enables communities to identify plant species with medicinal value and appreciate the uniqueness and benefits of each plant variety (Martín, 2015). The community's utilization of medicinal plants relates to environmental literacy (Dabaghian et al., 2023). Understanding environmental literacy provides a foundation for the younger generation to actively engage and cultivate a caring and responsible attitude toward environmental sustainability (Rahmawaty, 2020).

Literacy terminology has been widely discussed since the 21st century (Affandy et al., 2019; Pratiwi et al., 2019; Trilling & Fadel, 2009). It differs from the ability to read and write; it has a broader context. Environmental literacy has also been stated in the P21 framework for 21st-century learning, making environmental literacy a theme in 21st-century learning (Global Partnership for Education, 2020). The necessity of environmental literacy has been included in the P21 framework as a theme in 21st-century education, ensuring that future generations have the knowledge, skills, and awareness needed to maintain environmental sustainability.

Unfortunately, society's recognition of medicinal plants differs from that of the current millennial generation. The results of studies (Harfouche et al., 2021; Linger, 2017; Ojalehto et al., 2017; Templeman et al., 2018) have found that students have been skeptical or doubtful of belief claims related to the utilization of medicinal plants as traditional medicine. Students' skepticism about the benefits of medicinal plants may have been due to the lack of evidential support (Ojalehto et al., 2017), differences with modern medical approaches (Linger, 2017), cultural influences and myths (Templeman et al., 2018), safety and risk (Harfouche et al., 2021), and negative experiences or

https://doi.org/10.33225/jbse/24.23.377

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

testimonies (Templeman et al., 2018). The skeptical perception of medicinal plant knowledge as superstitious may vary among students. It could have been influenced by cultural background (Harfouche et al., 2021), education (Linger, 2017), and experience (Ojalehto et al., 2017). Skeptical students could have been given an opportunity for educators and herbal health professionals to provide scientific and evidence-based information on the use of medicinal plants so that students could make more informed decisions about medicinal plants.

Research Problem

Biology courses at the secondary education level still need to fully integrate knowledge of medicinal plants into the curriculum (Linger, 2017). Educational authorities have designed school curricula to focus on more general biology concepts, such as cell biology, genetics, ecology, etc. Meanwhile, educational authorities have yet to prioritize introducing medicinal plants despite their inclusion in the fields of botany and ethnobotany (Harfouche et al., 2021; Kamaraj et al., 2023). Knowledge of medicinal plants could have helped students understand environmental science and conservation (Bruschi et al., 2019). Students could have learned about maintaining biodiversity and the role of medicinal plants in the ecosystem. Knowledge of how people have utilized medicinal plants sustainably could have opened insights into the conservation of natural resources and the environment (Kamaraj et al., 2023).

Research Aim and Research Questions

The current research aims to introduce the inquiry-ethnobotany (IEb) model to enhance students' environmental literacy. In the IEb model, the implementation of learning enables students not only to learn about plants conventionally but also to understand biodiversity from the perspective of human culture and history, linking scientific knowledge with local wisdom and building awareness of the importance of environmental conservation. Hopefully, the research findings provide an in-depth understanding of the IEb model for educators, education policymakers, and stakeholders to improve student learning in terms of environmental literacy, facilitate bridging the gap between modern science and local knowledge, and encourage awareness of the importance of preserving the environment for a sustainable future.

The IEb model, implemented in the learning process, goes beyond conventional plant learning by incorporating perspectives on biodiversity from cultural and historical viewpoints. It connects scientific knowledge with local wisdom and fosters awareness of the importance of environmental conservation. The research findings are expected to provide a deep understanding of the IEb model for educators, education policymakers, and stakeholders, facilitating student learning in environmental literacy. It bridges the gap between modern scientific and local knowledge and promotes awareness of the importance of environmental preservation for a sustainable future. Through this study, the following essential research questions were proposed: (1) how does the implementation of the IEb model impact students' understanding of biodiversity and environmental issues?; and (2) to what extent does the IEb model facilitate the integration of scientific knowledge with cultural and historical perspectives on biodiversity?.

Theoretical Framework

Inquiry Learning Model

The inquiry model has five stages (Wenning & Khan, 2011), which are often referred to as the inquiry cycle or scientific cycle, starting from Observation, Manipulation, Generalization, Verification and Application or the acronym "OMGVA". The inquiry learning model proposed by (Wenning, 2011a) is a learning model that combines concepts from scientific learning with students' cognitive levels. The inquiry learning model is designed to provide flexibility in adapting the inquiry learning process according to cognitive abilities (Wenning, 2005).

The inquiry model enables teachers to adapt learning to students' cognitive development level (Chen et al., 2022). Teachers can choose stages that match students' abilities to ensure that the learning process is truly relevant and meaningful for students (Wenning, 2005). The stages in the inquiry model proposed by (Wenning, 2011a) have a hierarchical nature that reflects the progression from simpler to more complex scientific learning, such as discovery learning, interactive demonstration, inquiry lesson, inquiry labs, real-world application, and hypothetical inquiry.

The inquiry model has several advantages that make it an effective learning model. The inquiry model encourages students to actively participate in learning (Perdana et al., 2019). It fosters exploration and in-depth investi-

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

gation of biological concepts (Rodrigues, 2014), promoting the development of critical thinking skills (Nagarajan & Overton, 2019). Students engage in independent research, including experiment design, data collection, and result analysis. The inquiry model facilitates firsthand experiences in experiments and observations (Al-Balushi & Al-Abdali, 2015), stimulating student interest and motivation (Rodrigues, 2014). Additionally, students practice communication and public speaking skills by sharing research results with their peers or class (Setyawan et al., 2020). It exposes students to problem-solving scenarios (Kowaltowski et al., 2010) and prioritizes the learning process over results (O'Neil et al., 2020). Furthermore, the inquiry model can be directed to establish connections between biology concepts and the natural world (Perdana et al., 2019), helping students recognize the relevance and application of biology in real-life situations.

The inquiry model has various advantages, but it also has some disadvantages that need to be considered in the context of biology learning. Inquiry models often require more time than conventional learning models (Yusup et al., 2021). Effective teachers in inquiry learning need to have skills in facilitating students' learning process, designing triggering questions, and providing appropriate guidance (Tuenter et al., 2012). Some biological concepts are difficult to teach using the inquiry model, especially if the concepts are abstract or require deep understanding (Liu et al., 2021). The inquiry model gives students the freedom to explore learning topics, so learning outcomes could vary (Dmoshinskaia et al., 2021). Implementation of the inquiry model requires access to certain resources and equipment (Suárez et al., 2018). Evaluation of inquiry models is more difficult than conventional models (Bollen et al., 2018). The inquiry model provides students with the freedom to develop their own understanding, but it also means that teachers have less control over what students learn, which could pose challenges in covering all planned material (Costes-Onishi & Kwek, 2023). Furthermore, some students feel awkward with open and flexible learning models such as inquiry, so students with more structured learning styles or different learning preferences experience difficulties (Nzomo et al., 2023). Students need extra guidance from teachers when going through the inquiry process, especially when facing difficulties in formulating questions or interpreting experimental results (de Jong et al., 2023).

Ethnobotany in the Perspective of Medicinal Plants

Ethnobotany is a discipline that combines ethnology (the science of human culture) and botany (the science of plants) to understand how traditional societies or certain cultures utilize plants in various aspects of daily life (Van Wyk & Gorelik, 2017). Ethnobotany explores traditional knowledge passed down from generation to generation about plants in the neighborhood (Hossain et al., 2021). Ethnobotany includes knowledge of how plants are collected and processed (Rahman et al., 2019), utilized in daily practices (Nanjala et al., 2022) (religious rituals, traditional medicine), and how medicinal plants are linked to cultural stories and myths (Xiong et al., 2020).

The natural medicinal plants known in Indonesia include *daun sirih* (*Piper betle*), *kunyit* (*Curcuma longa*), *Jahe* (*Zingiber officinale*), *sambiloto* (*Andrographis paniculata*), and *temulawak* (*Curcuma xanthorrhiza*) (Gaoue et al., 2021). Every medicinal plant has specific properties and is recognized in traditional medicine to treat various health problems. While modernization and developments in medical science bring changes in medicinal practices, the practice of using natural medicinal plants persists in many communities in Indonesia (Axiotis et al., 2018; Bunalema et al., 2014). Scientific research efforts on medicinal plants link traditional knowledge with modern medical knowledge so communities can utilize natural medicinal plants more mindfully and effectively.

Medicinal plants have a variety of chemical compounds that may exhibit pharmacological or therapeutic effects on the human body (Gaoue et al., 2021). Several medicinal plants contain active compounds that have *antibacterial, anti-inflammatory, antioxidant*, and *analgesic* properties or could even boost the immune system (Alsarhan et al., 2021). Medicinal plant treatments include various forms, such as infusions, decoctions, extracts, essential oils, capsules, and ointments (Hossain et al., 2021). Moreover, some medicinal plants can also be processed into health products or natural supplements available in the market. Although medicinal plants are recognized in traditional medicine practices, their effectiveness and safety must be supported by strong scientific evidence (Hossain et al., 2021).

More than 2,039 species of medicinal plants are an integral part of traditional medicine practices in various ethnic groups living in and around forests (Gaoue et al., 2021) . People living near forests or in natural environments often have a deep understanding of the environment, including the plants that grow around them (Rahman et al., 2019). Knowledge of medicinal plants includes identification of medicinal plants, how to process them, and the correct dosage. Medicinal plants are medicinal tools with deep cultural and spiritual meanings for specific communities (Zaidi et al., 2022). The custom of rural communities, especially those living near forests, using natural plants to treat several ailments is a centuries-old practice passed down from generation to generation (Arumugam, 2019).

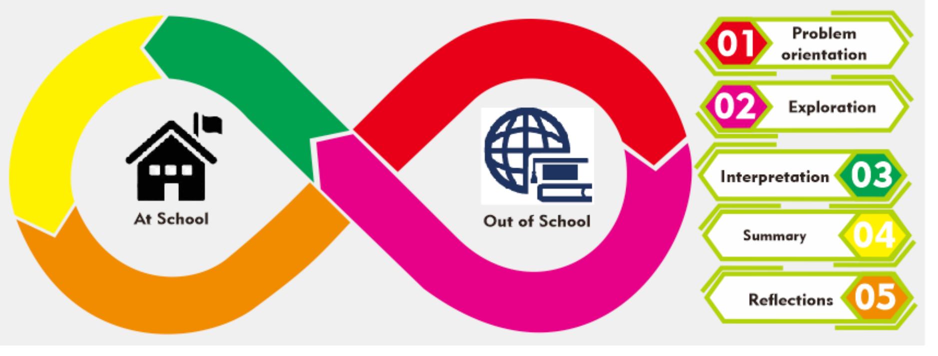
https://doi.org/10.33225/jbse/24.23.377

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

The Inquiry-Etnobotany (IEb) Model

The IEb model is a learning model that combines the concepts of inquiry and discovery learning model in the context of ethnobotany, which results in the syntax of IEb (Figure 1). The inquiry model provides a foundation for students to lead the learning process through exploration and discovery (Ng & Fergusson, 2019; Rodrigues, 2014; Wenning, 2005), while the discovery learning model enriches students' experience through direct observation, exploration, and an active role in understanding biological concepts (Adriyawati et al., 2020; Bicknell-Holmes & Seth Hoffman, 2000; Muhammad et al., 2023). Ethnobotanical elements were added to the conceptual framework to align learning with plant knowledge, cultural use of plants, and sustainability practices (Peticca-Harris et al., 2016; Van Wyk & Gorelik, 2017).

Figure 1
Visual Syntax of The Inquiry-Ethnobotany (IEb) Model



The positive contribution of developing the IEb model towards a deeper understanding of human interaction with plants and enhanced environmental literacy. The IEb model is expected to stimulate students' curiosity and encourage them to ask questions, investigate, and discover knowledge independently. Additionally, hands-on experience and exploration in the IEb model could give students a deeper understanding of biological concepts in a natural context, strengthening the connection between theory and practical application. The primary objectives of the IEb model are to (1) explore traditional knowledge about plants and understand their role and meaning in human culture, (2) invite students to engage in the inquiry process, triggering curiosity, creativity, and student activeness in learning, and (3) develop a deeper understanding of the interrelationships between humans and the plant environment and the diversity of ethnobotanical knowledge.

Learning activities in the IEb model are carried out by encouraging students to conduct research or exploration related to the use of plants by humans, including the utility of plants in traditional medicine, food, jewelry, or other cultural needs. Students formulate research questions, collect data through direct observation, interviews with experts or the community, and analyze information. The syntax linkage with student learning activities in the IEb model is presented in Table 1.

Table 1
Syntax and Student Learning Activities in The IEb Model

Syntax IEb Model	Student Learning Activities
Problem orientation	Observe and understand phenomena or occurrences presented by the teacher.
Exploration	Discuss and distribute tasks to find data needed to solve problems (search for data/references/ sources)
Interpretation	Clarify, interpret, and analyze the same/different exploration findings.

https://doi.org/10.33225/jbse/24.23.377

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Syntax IEb Model	Student Learning Activities
Concluding	Summarize the results of the investigation, then relate them to other concepts and possibly compare the same/different exploration findings.
Reflection	Express all forms of feelings and impressions (both strengths and weaknesses) after learning and provide what is desired and expected in the next learning activity.

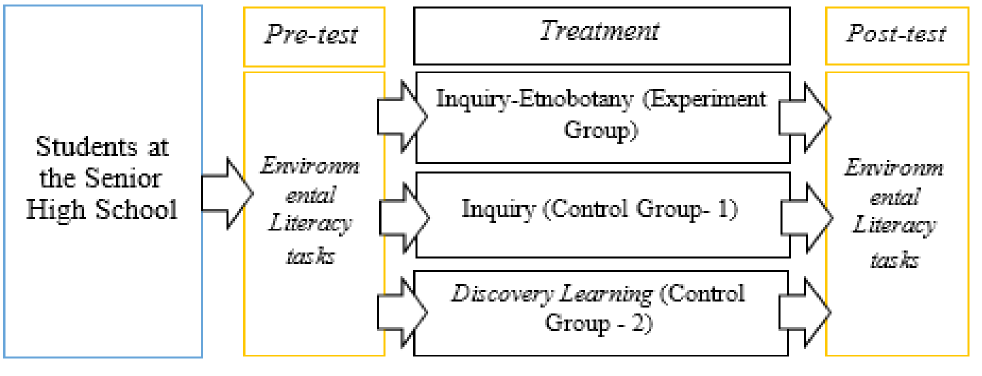
Research Methodology

Design & Procedure

The study design involved a pretest-posttest control group design (Figure 2) to evaluate the effectiveness of the intervention, in this instance, the IEb model, by comparing it directly with the existing inquiry and discovery learning models. The initial stage of the research involved collecting pre-test data to assess students' baseline understanding before exposure to the three predefined models. Three groups of students were divided into three classes according to the learning models: one experimental class with the IEb model and two control classes with inquiry and discovery learning models, respectively.

The experimental class applied the IEb model. The first stage of learning with the IEb model involves students understanding the basics of biology and the relationship between humans and plants through an inquiry model. It provides the necessary knowledge base to proceed to the discovery learning stage, where students engage in hands-on experience and exploration to develop an understanding of biological concepts in the context of plants. Elements of ethnobotany become integral to the inquiry and discovery learning models as students discuss plant utilization in culture, understand the diversity of ethnobotanical practices, and reflect on the sustainability implications of plant utilization. Integrating the inquiry model, discovery learning, and ethnobotanical elements provided a contextual and cultural dimension to education, motivating students to explore and investigate deeper.

Figure 2
Research Design



Implementation of lessons in control class 1 applied the Inquiry model. Learning was conducted with a focus on the inquiry process involving exploration, inquiry, and discovery. The students in the control class engaged in a series of structurally designed activities but needed to integrate the ethnobotanical context specifically, as in the experimental class. Although a structured inquiry process occurred in the control class of the Inquiry model, the focus was more on exploring concepts without any specific integration with the ethnobotanical context. Learning activities were centered more on applying the principles of inquiry in understanding concepts in general without explicitly considering the cultural aspects associated with using plants.

The implementation of learning in control class 2 implemented the discovery learning model. The discovery learning model focuses on students' exploration, experimentation, and discovery. The discovery learning model allowed students to lead their learning by providing situations or problems that enabled them to find solutions or understanding. Moreover, in the control class with the discovery learning model, students were given more autonomy to determine the steps in learning a topic.

https://doi.org/10.33225/jbse/24.23.377

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

However, the posttest data were collected to assess the students' environmental literacy level after the different learning models. Posttest data from each class (IEb, inquiry, and discovery learning) was analyzed to compare the enhancement of students' understanding in each group. Accordingly, the study's results provide empirical evidence related to the effectiveness of the IEb model in achieving learning objectives compared to existing models, which were inquiry, discovery, and learning models.

The current research, conducted in Karanganyar, Central Java, Indonesia, aimed to assess the effectiveness of the IEb model in enhancing students' environmental literacy. The research was conducted from July to September 2023 in three senior high schools under the Department of Education of Karanganyar Regency, Central Java, Indonesia. During this time, data collection activities, including pre-test assessments, implementation of the IEb model, inquiry model, and discovery learning model, as well as post-test evaluations, were carried out across the three selected secondary schools in Karanganyar, Central Java, Indonesia. July marked the commencement of the research, with preparatory activities such as obtaining ethical approvals, securing research permissions from school authorities, and refining research instruments. Subsequently, August saw the implementation phase, where lessons based on the IEb model, inquiry model, and discovery learning model were delivered to students in the respective schools. Throughout this period, meticulous records were maintained to document the teaching process, student engagement, and any unforeseen challenges encountered. Finally, in September, post-test assessments were administered to measure the effectiveness of the different learning models in enhancing students' environmental literacy. The conclusion of data collection in September marked the conclusion of the research period, paving the way for subsequent data analysis and interpretation.

Research Sample

The population of the study comprised secondary school students from three specific institutions: Senior High School (in Indonesian; *Sekolah Menengah Atas*, SMA) SMA 1 Karanganyar, SMA 2 Karanganyar, and SMA Muhammadiyah Karanganyar. The selection of SMA 1 Karanganyar, SMA 2 Karanganyar, and SMA Muhammadiyah Karanganyar as research locations has several reasons: (1) The three schools are educational institutions under the Department of Education of Karanganyar Regency, so they are representative of evaluating educational policies and programs implemented at the district level; (2) The selection of schools based on the uniformity of pre-test scores in the environmental literacy test ensured that the research sample came from a similar background in terms of understanding environmental literacy; (3) The selection of the three schools also aimed to reduce demographic differences among the research sample, ensuring a broader representation of the student population in the Karanganyar district. Accordingly, the selection of this research site was based on strategic considerations that enabled the researcher to gain a more holistic and relevant insight into environmental literacy in the local educational environment.

The study population consisted of 792 students who were in grade 10. The 3 schools were selected based on the uniformity of the pre-test scores in the environmental literacy test obtained by the students. The selection of the three schools also aimed to reduce demographic differences among the study sample. The purposive sampling method was used to select the sample, which resulted in the participation of 297 students, with 99 students selected from each school. This sample selection process was conducted with the approval of the Department of Education of Karanganyar Regency, school principals, and classroom teachers. The 297 students involved in the study included 169 students (59.90%) who were female, while 128 students (43.09%) were male, with an average age of 15 years. Prior to the start of the study, important steps were taken to ensure students' voluntary participation and comprehension. Each student involved was asked to read and sign an informed consent form affirming their willingness to participate in the study. Furthermore, each participant was given a pseudonym to maintain confidentiality and hide their identity. The importance of this confidentiality was emphasized to the students, along with stressing that they had the right to withdraw from the study at any time without facing any sanctions or negative consequences.

Data Collection Tools

Environmental literacy tests were in the form of essays for ethnobotanical topics. They were prepared based on the following activities of the IEb model. The assessment tool calibration of environmental literacy uses the Rasch Model, which consists of test reliability analysis, item difficulty level, item suitability level, construct validity, and construct reliability. The reliability value of the test is .89, so the reliability of both items and students is in the

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

high category. The MNSQ outfit value ranges from .77 to 1.33 in the good category. Boone et al., (2014) provided a limitation that the range of recognized values for MNSQ is .5 to 1.5. The ZSTD outfit value ranges from -2.4 to +3.0, which is good enough. The Pt Mean Corr value ranges from .64 to .77 in the good category. Boone et al., (2014) provided a limitation that the range of values considered appropriate for Pt Mean Corr is .4 to .85. If the Pt Mean Corr value is outside this range, the item does not support a well-measured range of student performance (Affandy et al., 2021). The environmental literacy variable produces items based on theoretical synthesis and biology learning outcomes, so the analysis of environmental literacy test kits uses confirmatory factor analysis (CFA). The results of the study of the environmental literacy test device produced items that were constructively valid through the parameters df = 48; Root Mean Square Error of Approximation (RMSEA) = .061; Normed Fit Index (NFI) = .90; Comparative Fit Index (CFI) = .91; and Goodness of Fit Index (GFI) = .81.

Data Analysis

The analyses included statistical tests such as the dependent sample t-test to assess whether there was a significant difference between the pre-test and post-test scores. Moreover, the IBM SPSS Statistics program could also be utilized to conduct data distribution tests, such as the Shapiro-Wilk test, to ensure the data had a normal distribution before further analysis. The normality test results confirmed that the data obtained were normally distributed. The IBM SPSS Statistics 26/PC statistical program was used as an analytical tool to process quantitative data. The IBM SPSS Statistics program could perform various statistical analyses relevant to the collected dataset.

However, the results of the Shapiro-Wilk test confirmed that the students' environmental literacy score data in the study fulfilled the normal distribution assumption with a 95% confidence interval ($Pretest_{IEb}$ = .882 > .05; $Posttest_{IEb}$ = .871 > .05; $Pretest_{Inkuiri}$ = .861 > .05; $Posttest_{Inkuiri}$ = .593 > .05; $Pretest_{DL}$ = .531 > .05; $Posttest_{DL}$ = .592 > .05; $Pretest_{SA}$ = .515 > .05; $Posttest_{SA}$ = .768 > .05; $Pretest_{SB}$ = .401 > .05; $Posttest_{SB}$ = .670 > .05; $Pretest_{SC}$ = .277 > .05; $Posttest_{SC}$ = .970 > .05). The results of the normality test which confirmed that the data had a normal distribution at the 95% significance level validated the use of the dependent sample t-test to more accurately evaluate the difference between students' environmental literacy pre-test and post-test scores. The significance level in statistics is a threshold value used to determine whether differences or relationships between variables are the result of chance or actually exist significantly in the wider population. The value for significance level is p < .05.

Research Results

Enhancing Environmental Literacy Based on Learning Models

The results found significant differences between pre-test and post-test scores regarding environmental literacy across the three models (IEb, Inquiry, and discovery learning models). The results of the analysis of environmental literacy enhancement based on each learning model provided a detailed overview of the effectiveness and effects of the three models in enhancing students' understanding and awareness of environmental issues.

Table 2
Results of Independent Sample T-Test Based on Learning Model

Learning Models	Test	*n*	*M*	*SD*	*t*	*p*
IEb	Pre-test	99	71.14	4.35	-59.25	.0001
	Post-test	99	78.10	4.69		
Inquiry	Pre-test	99	69.53	4.35	-18.53	.0001
	Post-test	99	71.82	4.45		
Discovery Learning	Pre-test	99	70.75	5.18	-12.57	.0001
	Post-test	99	72.78	5.20		

The results in Table 2 represent a significant difference between students' environmental literacy levels before and after applying different learning models. The difference between the pre-test and post-test results with the IEb model represents -6.96 (*SD* = 1.16; *p* < .05). However, in the context of environmental literacy, it indicates a

https://doi.org/10.33225/jbse/24.23.377

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

significant increase in understanding after learning using the IEb model. Meanwhile, in the Inquiry model, there is an increase in students' environmental literacy with a difference in results of -2.29 (SD = 1.23; $p < .05$). Even though there is an increase, the difference between the pre-test and post-test results is not as vast as that shown in the IEb model. However, the difference in the results is lower, with a value of -1.52 (SD = 1.20; $p < .05$) compared to the Inquiry and IEb models. Furthermore, the IEb model has a more significant effect in enhancing students' environmental literacy than the inquiry and discovery learning models.

Enhancing Environmental Literacy in School Settings

The current research evaluated the improvement of environmental literacy in each school by applying three different learning models: IEb, inquiry, and discovery learning. The study results provided a more detailed overview of the effectiveness of the learning models in each school in enhancing students' understanding of environmental issues. However, each school had a distinctive learning environment and students with different backgrounds. Therefore, presenting the results of improving environmental literacy in other schools considered these differences in context. The presented information provided greater insight into how the learning models interacted with the characteristics of each school and the extent to which they were effective in enhancing students' awareness of environmental issues in each learning environment.

Table 3
Results of Dependent Sample T-Test in Each School

School	Test	*n*	*M*	*SD*	*t*	*p*
SMA 1 Karanganyar	Pre-test	99	73.09	4.11	-13.49	.0001
	Post-test	99	76.93	5.03		
SMA 2 Karanganyar	Pre-test	99	70.94	4.03	-12.37	.0001
	Post-test	99	74.34	4.93		
SMA Muhammadiyah Karanganyar	Pre-test	99	67.39	4.04	-14.11	.0001
	Post-test	99	70.92	5.07		

The results in Table 3 illustrate the significant difference between the pre-test and post-test scores in terms of environmental literacy in the three schools involved in the study, which are SMA 1 Karanganyar, SMA 2 Karanganyar, and SMA Muhammadiyah Karanganyar. According to SMA 1 Karanganyar, the difference between the pre-test and post-test results in environmental literacy is -3.84 (SD = 2.83; $p < .05$). The negative number in the difference indicates a decrease in post-test scores from pre-test scores. Still, in the context of environmental literacy, it suggests an increase in students' understanding of environmental issues after participating in learning at SMA 1 Karanganyar. Meanwhile, at SMA 2 Karanganyar, the difference between the pre-test and post-test results on environmental literacy is -3.39 (SD = 2.72; $p < .05$). It also indicates a significant increase in students' understanding of environmental literacy after the SMA 2 Karanganyar learning process. Meanwhile, at SMA Muhammadiyah Karanganyar, there is a difference in the pre-test and post-test results of environmental literacy of -3.53 (SD = 2.49; $p < .05$). However, the negative number indicates an increase in students' understanding and awareness of environmental issues after participating in learning at SMA Muhammadiyah Karanganyar. Furthermore, all three schools display a significant difference between the pre-test and post-test scores of environmental literacy. However, the difference between the post-test and pre-test results is negative. It indicates a positive increase in students' understanding of environmental literacy after the learning process.

Discussion

Enhancing Environmental Literacy Based on Learning Model

The current research focuses on the utilization of the IEb model as a means to enhance students' environmental literacy. The IEb model explores students' understanding of the environment in depth by integrating aspects of inquiry, discovery learning, and ethnobotanical knowledge. The study's findings confirmed that applying the IEb

https://doi.org/10.33225/jbse/24.23.377

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

model can effectively improve students' understanding of environmental issues. The IEb model provides an approach that allows students to holistically understand the linkages between environmental aspects and ethnobotanical knowledge, thus enhancing environmental literacy in a more in-depth and integrated way.

The IEb model is constructed based on the Inquiry model integrated with ethnobotany. Previous research in many literatures reports that learning with an inquiry model enhances literacy (Calcagni et al., 2023; Chu et al., 2011; O'Neil et al., 2020), while the discovery learning model enriches students' experiences through direct observation, exploration, and active roles in enhancing literacy (Adriyawati et al., 2020; Bicknell-Holmes & Seth Hoffman, 2000; Muhammad et al., 2023). Furthermore, other research results also report that learning based on ethnoscience studies improves literacy (Abonyi et al., 2014; Fasasi, 2017; Rusilowatil et al., 2021), which is the expected impact of ethnoscience-based learning. Nonetheless, in this study, the IEb model's effect significantly enhances environmental literacy. The significant results indicate that the IEb model successfully enhances students' understanding of environmental issues and ways to address environmental challenges using ethnobotanical knowledge.

Furthermore, the improvement could have been in the IEb model, indicating a more minor impact on enhancing students' understanding of environmental literacy. However, applying the discovery learning model represents a significant enhancement of environmental literacy. Nonetheless, this difference is minor compared to the inquiry and IEb models. The three learning models indicated an enhancement in environmental literacy, but the enhancement level was different. However, the IEb model proves to have a more significant effect on enhancing students' understanding of the environment than the inquiry and discovery learning models.

Previous research has suggested a significant enhancement in students' understanding of environmental issues and their ability to respond to environmental challenges by utilizing ethnobotanical knowledge (Rusilowatil et al., 2021). According to the study, it has been found that the application of ethnobotanical knowledge in an environmental context has helped students better understand the interaction between humans and the natural environment. The cultivation of student comprehension has been achieved through an inquiry-ethnobotany approach, encouraging active questioning, investigation, and application of knowledge regarding plants and their everyday use. Students have learned not only about the traditional benefits of plants but also how traditional knowledge could be applied to deal with environmental challenges encountered by modern society.

The utilization of the IEb model provides opportunities for students to engage in deeper research and exploration of natural resources, local wisdom, and efforts to protect the environment. Each student gains a more holistic understanding of the complex relationship between humans and nature, as well as the importance of maintaining ecosystem balance (Zerbo et al., 2022). Accordingly, the results of previous studies (Abonyi et al., 2014; Rusilowatil et al., 2021) illustrate that the use of the inquiry-ethnobotany model can be an effective approach in enhancing students' understanding of environmental issues and how the application of ethnobotanical knowledge could provide solutions in addressing current environmental challenges.

Enhanced Environmental Literacy in School Settings

The results at SMA 1 Karanganyar, SMA 2 Karanganyar, and SMA Muhammadiyah Karanganyar provide an exciting insight into the effectiveness of learning approaches in enhancing students' understanding of environmental issues. However, while all three schools demonstrate enhancement in environmental literacy, the different enhancement levels reflect the other effects of each learning model. The three schools indicated that each learning model further enhanced students' understanding of environmental issues. Each learning model, IEb, inquiry, and discovery learning, presented different learning activities. The effects of the three learning models in enhancing students' understanding of environmental issues are based on learning activities and encouraging students to interact with environmental information.

Previous studies have reported that each learning model has varying effects on enhancing student understanding (Calcagni et al., 2023; Cheng & Carolyn Yang, 2023; Yue et al., 2023), including environmental issues. Combining multiple learning models could provide a holistic and in-depth approach to educating students about protecting and preserving the environment (Calcagni et al., 2023). The IEb model, emphasizing evidence-based learning, has assisted students in analyzing and structuring their understanding of environmental issues based on existing facts and evidence. Meanwhile, the inquiry model has emphasized active exploration and knowledge discovery by students. Furthermore, the discovery learning model has emphasized learning through experimentation and observation. Therefore, the difference in the enhancement of environmental literacy in each school reflects how each learning model provides different learning experiences for students.

https://doi.org/10.33225/jbse/24.23.377

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Limitations of This Study

While the primary aim of the research is to introduce the IEb model as a means to enhance students' environmental literacy, it is important to acknowledge several limitations. Firstly, the findings of the study may have limited generalizability due to the specific context in which the IEb model was implemented. Variations in cultural backgrounds, educational systems, and geographical locations could influence the effectiveness of the model in different settings. Secondly, limitations related to sample size and diversity may impact the study's applicability to a broader population. A small or homogeneous sample may constrain the ability to draw widespread conclusions. Additionally, the inclusion of diverse student demographics could provide a more comprehensive understanding of the IEb model's effectiveness. Thirdly, the duration of the IEb model's implementation could be a limiting factor. Longer-term studies would offer insights into the sustained impact of the model on students' environmental literacy over time. Fourthly, the validity and reliability of the measurement tools used to assess students' environmental literacy could pose limitations. Ensuring the adequacy and appropriateness of assessment instruments is crucial for accurately capturing the effects of the IEb model. Finally, external factors such as socioeconomic status, family influence, and community support may also influence students' environmental literacy. While the IEb model may contribute to enhancing environmental awareness, these external influences should be considered in interpreting the findings. Despite these limitations, the research findings are anticipated to provide valuable insights into the potential of the IEb model in promoting environmental literacy and bridging the gap between modern scientific knowledge and local wisdom.

Conclusions and Implications

The current research highlights how the IEb model exhibited a significant effect in enhancing students' environmental literacy. Although the difference in post-test scores from the pre-test is negative, it indicated an enhanced and deeper understanding of environmental issues post-learning. The inquiry model also contributes to enhancing environmental literacy, although not as much as IEb. While the discovery learning model, although providing a significant enhancement, provides less impact compared to the other models. However, from the results of the research in each of the schools involved, all indicated a significant enhancement of environmental literacy. Although the difference between post-test and pre-test results is negative, it also indicated a positive enhancement in students' understanding of environmental issues after the learning process. While each school has different characteristics and responses to the learning models, in general, they all indicated a positive impact in enhancing students' understanding of environmental issues.

Furthermore, while the inquiry model also contributes to improving environmental literacy, its impact is not as significant as that of the IEb model. Similarly, the discovery learning model, while yielding significant enhancements, demonstrates a lesser impact compared to the other models. However, the results across all schools involved in the study uniformly indicate a substantial enhancement of environmental literacy. Despite the negative difference between post-test and pre-test results, there is a clear positive enhancement in students' comprehension of environmental issues following the learning process. In summary, this research confirms that all three learning models positively influence students' understanding of environmental issues. Moving forward, future studies could delve into specific aspects of environmental literacy, such as ecosystem comprehension, engagement in environmental conservation efforts, or awareness of global environmental issues. This approach may yield deeper insights into the nuanced effects of each learning model on distinct facets of environmental literacy. Moreover, expanding the scope of studies to include more schools or diverse geographical regions could provide a broader understanding of how learning models interact within specific educational or community contexts. Further studies could focus on specific aspects of environmental literacy, such as understanding of ecosystems, environmental conservation actions, or awareness of global issues. It might provide deeper insights into how each learning model influences specific aspects of environmental literacy.

Declaration of Interest

The authors declare no competing interest.

https://doi.org/10.33225/jbse/24.23.377

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

References

Abonyi, O. S., Achimugu, L., & Njoku, M. (2014). Innovations in science and technology education: A case for ethnoscience based science classrooms. *International Journal of Scientific and Engineering Research*, *5*(1), 52–56. https://www.ijser.org/researchpaper/Innovations-in-Science-and-Technology-Education.pdf

Adriyawati, Utomo, E., Rahmawati, Y., & Mardiah, A. (2020). Steam-project-based learning integration to improve elementary school students' scientific literacy on alternative energy learning. *Universal Journal of Educational Research*, *8*(5), 1863–1873. https://doi.org/10.13189/ujer.2020.080523

Affandy, H., Aminah, N. S., & Supriyanto, A. (2019). The correlation of character education with critical thinking skills as an important attribute to success in the 21st century. *Journal of Physics: Conference Series*, *1153*(1). https://doi.org/10.1088/1742-6596/1153/1/012132

Affandy, H., Nugraha, D. A., Pratiwi, S. N., & Cari, C. (2021). Calibration for instrument argumentation skills on the subject of fluid statics using item response theory. *Journal of Physics: Conference Series*, *1842*(1), 1–10. https://doi.org/10.1088/1742-6596/1842/1/012032

Al-Balushi, S. M., & Al-Abdali, N. S. (2015). Using a moodle-based professional development program to train science teachers to teach for creativity and its effectiveness on their teaching practices. *Journal of Science Education and Technology*, *24*(4), 461–475. https://doi.org/10.1007/s10956-014-9530-8

Alsarhan, A., Al-Khatib, A., Sultana, N., & Kadir, M. R. A. (2021). Review on some Malaysian traditional medicinal plants with therapeutic properties. *Journal of Basic & Applied Sciences*, *10*, 149–159. https://doi.org/10.6000/1927-5129.2014.10.20

Arumugam, N. (2019). Knowledge, attitudes and practices (KAP) towards medicinal plants among Malaysian consumers. *Medicinal & Aromatic Plants*, *8*(6), 1–6. https://doi.org/10.35248/2167-0412.19.8.341

Axiotis, E., Halabalaki, M., & Skaltsounis, L. A. (2018). An ethnobotanical study of medicinal plants in the Greek islands of the north Aegean region. *Frontiers in Pharmacology*, *9*(May), 1–6. https://doi.org/10.3389/fphar.2018.00409

Bicknell-Holmes, T., & Seth Hoffman, P. (2000). Elicit, engage, experience, explore: Discovery learning in library instruction. *Reference Services Review*, *28*(4), 313–322. https://doi.org/10.1108/00907320010359632

Bollen, L., Van Kampen, P., & De Cock, M. (2018). Development, implementation, and assessment of a guided-inquiry teaching-learning sequence on vector calculus in electrodynamics. *Physical Review Physics Education Research*, *14*(2), 20115. https://doi.org/10.1103/PhysRevPhysEducRes.14.020115

Boone, W. J., Staver, J. R., & Yale, M. S. (2014). *Rasch analysis in the human sciences*. Springer.

Bruschi, P., Fico, G., Sugni, M., Moretti, A., & Signorini, M. A. (2019). Children's versus adult's knowledge of medicinal plants: An ethnobotanical study in Tremezzina (Como, Lombardy, Italy). *Revista Brasileira de Farmacognosia*, *29*(5), 644–655. https://doi.org/10.1016/j.bjp.2019.04.009

Bunalema, L., Obakiro, S., Tabuti, J. R. S., & Waako, P. (2014). Knowledge on plants used traditionally in the treatment of tuberculosis in Uganda. *Journal of Ethnopharmacology*, *151*(2), 999–1004. https://doi.org/10.1016/j.jep.2013.12.020

Calcagni, E., Ahmed, F., Trigo-Clapés, A. L., Kershner, R., & Hennessy, S. (2023). Developing dialogic classroom practices through supporting professional agency: Teachers' experiences of using the T-SEDA practitioner-led inquiry approach. *Teaching and Teacher Education*, *126*. https://doi.org/10.1016/j.tate.2023.104067

Chen, C. M., Li, M. C., & Chen, Y. T. (2022). The effects of web-based inquiry learning mode with the support of collaborative digital reading annotation system on information literacy instruction. *Computers and Education*, *179*, 104428. https://doi.org/10.1016/j.compedu.2021.104428

Cheng, C.-C., & Carolyn Yang, Y.-T. (2023). Impact of smart classrooms combined with student-centered pedagogies on rural students' learning outcomes: Pedagogy and duration as moderator variables. *Computers & Education*, *207*(September), 104911. https://doi.org/10.1016/j.compedu.2023.104911

Chu, S. K. W., Tse, S. K., Loh, E. K. Y., & Chow, K. (2011). Collaborative inquiry project-based learning: Effects on reading ability and interests. *Library and Information Science Research*, *33*(3), 236–243. https://doi.org/10.1016/j.lisr.2010.09.008

Costes-Onishi, P., & Kwek, D. (2023). Technical skills vs meaning-making: Teacher competencies and strength of inquiry-based learning in aesthetic inquiry. *Teaching and Teacher Education*, *130*, 104152. https://doi.org/10.1016/j.tate.2023.104152

Dabaghian, F., Hasanpour, M., Maroufizadeh, S., Joulani, M. H., & Khanavi, M. (2023). Use of medicinal plants and its association with health literacy in the general population of Iran during the COVID-19 Pandemy: a Web-Based Cross-Sectional Survey. *Research Journal of Pharmacognosy*, *10*(1), 31–40. https://doi.org/10.22127/RJP.2022.366963.1997

de Jong, T., Lazonder, A. W., Chinn, C. A., Fischer, F., Gobert, J., Hmelo-Silver, C. E., Koedinger, K. R., Krajcik, J. S., Kyza, E. A., Linn, M. C., Pedaste, M., Scheiter, K., & Zacharia, Z. C. (2023). Let's talk evidence – The case for combining inquiry-based and direct instruction. *Educational Research Review*, *39*(November 2022). https://doi.org/10.1016/j.edurev.2023.100536

Dmoshinskaia, N., Gijlers, H., & de Jong, T. (2021). Learning from reviewing peers' concept maps in an inquiry context: Commenting or grading, which is better? *Studies in Educational Evaluation*, *68*(May 2020), 100959. https://doi.org/10.1016/j.stueduc.2020.100959

Fasasi, R. A. (2017). Effects of ethnoscience instruction, school location, and parental educational status on learners' attitude towards science. *International Journal of Science Education*, *39*(5), 548–564.

Food and Agriculture Organization. (2020). *The State of The World's Forests: Forests, Biodiversity, and People*. https://doi.org/https://doi.org/10.4060/ca8642en

Gaoue, O. G., Moutouama, J. K., Coe, M. A., Bond, M. O., Green, E., Sero, N. B., Bezeng, B. S., & Yessoufou, K. (2021). Methodological advances for hypothesis-driven ethnobiology. *Biological Reviews*, *96*(5), 2281–2303. https://doi.org/10.1111/brv.12752

https://doi.org/10.33225/jbse/24.23.377

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Global Partnership for Education. (2020). *21st Century Skills: What Potential Role for the Global Partnership for Education? - A Landscape Review*. Global Partnership for Education.

Harfouche, A. L., Petousi, V., Meilan, R., Sweet, J., Twardowski, T., & Altman, A. (2021). Promoting ethically responsible use of agricultural biotechnology. *Trends in Plant Science*, *26*(6), 546–559. https://doi.org/10.1016/j.tplants.2020.12.015

Hossain, M. S., Sharfaraz, A., Dutta, A., Ahsan, A., Masud, M. A., Ahmed, I. A., Goh, B. H., Urbi, Z., Sarker, M. M. R., & Ming, L. C. (2021). A review of ethnobotany, phytochemistry, antimicrobial pharmacology and toxicology of Nigella sativa L. *Biomedicine and Pharmacotherapy*, *143*, 112182. https://doi.org/10.1016/j.biopha.2021.112182

Kamaraj, C., Vimal, S., Ragavendran, C., Priyadharsan, A., Marimuthu, K., & Malafaia, G. (2023). Traditionally used medicinal plants mediate the biosynthesis of silver nanoparticles: Methodological, larvicidal, and ecotoxicological approach. *Science of the Total Environment*, *873*(February), Article 162402. https://doi.org/10.1016/j.scitotenv.2023.162402

Kowaltowski, D. C. C. K., Bianchi, G., & De Paiva, V. T. (2010). Methods that may stimulate creativity and their use in architectural design education. *International Journal of Technology and Design Education*, *20*(4), 453–476. https://doi.org/10.1007/s10798-009-9102-z

Linger, R. S. (2017). Design and implementation of an elective on the ethnopharmacology of appalachia for the PharmD curriculum. *American Journal of Pharmaceutical Education*, *81*(10), 47–55. https://doi.org/10.5688/ajpe6100

Liu, C., Bano, M., Zowghi, D., & Kearney, M. (2021). Analysing user reviews of inquiry-based learning apps in science education. *Computers and Education*, *164*(January), Article 104119. https://doi.org/10.1016/j.compedu.2020.104119

Martín, J. L. (2015). *Social perceptions of single-use plastic consumption of the Balinese population*, 41. https://www.theseus.fi/bitstream/handle/10024/93403/Lopez_Javier.pdf?sequence=1

Muhammad, I., Darmayanti, R., Arif, V. R., & Afolaranmi, A. O. (2023). Discovery learning research in mathematics learning: A bibliometric review. *Delta-Phi: Jurnal Pendidikan Matematika*, *1*(1), 26–33. https://doi.org/10.61650/dpjpm.v1i1.77

Nagarajan, S., & Overton, T. (2019). Promoting Systems Thinking Using Project- And Problem-Based Learning. *Journal of Chemical Education*. https://doi.org/10.1021/acs.jchemed.9b00358

Nanjala, C., Odago, W. O., Rono, P. C., Waswa, E. N., Mutinda, E. S., Oulo, M. A., Muema, F. W., Wanga, V. O., Mkala, E. M., Kuja, J., Njire, M. M., & Hu, G. W. (2022). A review on ethnobotany, phytochemistry, and pharmacology of the genus Didymocarpus wall. (Gesneriaceae). *Journal of Ethnopharmacology*, *295*(May), 115404. https://doi.org/10.1016/j.jep.2022.115404

Ng, W., & Fergusson, J. (2019). Technology-Enhanced Science Partnership Initiative: Impact on Secondary Science Teachers. *Research in Science Education*, *49*(1), 219–242. https://doi.org/10.1007/s11165-017-9619-1

Nzomo, C., Rugano, P., Njoroge Mungai, J., & Gitonga Muriithi, C. (2023). Inquiry-based learning and students' self-efficacy in chemistry among secondary schools in Kenya. *Heliyon*, *9*(1), 0–9. https://doi.org/10.1016/j.heliyon.2022.e12672

O'Neil, J. M., Newton, R. J., Bone, E. K., Birney, L. B., Green, A. E., Merrick, B., Goodwin-Segal, T., Moore, G., & Fraioli, A. (2020). Using urban harbors for experiential, environmental literacy: Case studies of New York and Chesapeake Bay. *Regional Studies in Marine Science*, *33*, Article 100886. https://doi.org/10.1016/j.rsma.2019.100886

Ojalehto, bethany l., Medin, D. L., & García, S. G. (2017). Conceptualizing agency: Folkpsychological and folkcommunicative perspectives on plants. *Cognition*, *162*, 103–123. https://doi.org/10.1016/j.cognition.2017.01.023

Perdana, R., Budiyono, Sajidan, Sukarmin, & Atmojo, I. R. W. (2019). A conceptual of teaching models inquiry-based social constructivism (IbSC). *IOP Conference Series: Earth and Environmental Science*, *243*(1).

Peticca-Harris, A., deGama, N., & Elias, S. R. S. T. A. (2016). A dynamic process model for finding informants and gaining access in qualitative research. *Organizational Research Methods*, *19*(3), 376–401. https://doi.org/10.1177/1094428116629218

Pratiwi, S. N., Cari, C., Aminah, N. S., & Affandy, H. (2019). Problem-Based learning with argumentation skills to improve students' concept understanding. *Journal of Physics: Conference Series*, *1155*(1). https://doi.org/10.1088/1742-6596/1155/1/012065

Rahman, I. U., Afzal, A., Iqbal, Z., Ijaz, F., Ali, N., Shah, M., Ullah, S., & Bussmann, R. W. (2019). Historical perspectives of ethnobotany. *Clinics in Dermatology*, *37*(4), 382–388. https://doi.org/10.1016/j.clindermatol.2018.03.018

Rahmawaty, R. (2020). Environmental education for early childhood through planting activities in khansa kindergarten (TK Khansa) Medan. *Journal of Saintech Transfer*, *3*(1), 21–32. https://doi.org/10.32734/jst.v3i1.3916

Rodrigues, S. J. (2014). Environmental education: a propose of high school. *Procedia - Social and Behavioral Sciences*, *116*, 231–234. https://doi.org/10.1016/j.sbspro.2014.01.199

Rusilowatil, A., Sundari, & Marwoto, P. (2021). Development of integrated teaching materials vibration, wave and sound with ethnoscience of bundengan for optimization of students' scientific literation. *Journal of Physics: Conference Series*, *1918*(5). https://doi.org/10.1088/1742-6596/1918/5/052057

Setyawan, A., Aznam, N., Paidi, P., & Citrawati, T. (2020). Influence of the use of technology through problem based learning and Inkuiri models are leading to scientific communication students class VII. *Journal of Technology and Science Education*, *10*(2), 190–198. https://doi.org/10.3926/jotse.962

Suárez, Á., Specht, M., Prinsen, F., Kalz, M., & Ternier, S. (2018). A review of the types of mobile activities in mobile inquiry-based learning. *Computers and Education*, *118*(March 2017), 38–55. https://doi.org/10.1016/j.compedu.2017.11.004

Templeman, K., Robinson, A., & McKenna, L. (2018). Complementary medicine teaching in Australian medical curricula: The student perspective. *Collegian*, *25*(4), 421–427. https://doi.org/10.1016/j.colegn.2017.10.010

Trilling, B., & Fadel, C. (2009). 21st Century Skills. *Jossey-Bass*, 256. https://doi.org/10.1145/1719292.1730970

Tuenter, E. A., Biemans, H. J. A., Tobi, H., Wals, A. E. J., Oosterheert, I., & Mulder, M. (2012). Inquiry-Based science education competencies of primary school teachers: a literature study and critical review of the American national science education standards. *International Journal of Science Education*, *34*(17), 2609–2640. https://doi.org/10.1080/09500693.2012.669076

Van Wyk, B. E., & Gorelik, B. (2017). The history and ethnobotany of Cape herbal teas. *South African Journal of Botany*, *110*, 18–38. https://doi.org/10.1016/j.sajb.2016.11.011

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Wenning, C. J. (2005). Levels of inquiry: Hierarchies of pedagogical practices and inquiry processes. *Journal of Physics Teacher Education Online*, *2*(3), 3–11.

Wenning, C. J. (2011). The levels of inquiry model of science teaching. *Journal of Physics Teacher Education Online*, *6*(2), 9–16.

Wenning, C. J., & Khan, M. A. (2011). Levels of inquiry model of science teaching : learning sequences to lesson plans. *Journal of Physics Teacher Education Online*, *6*(2), 17–20.

Xiong, Y., Sui, X., Ahmed, S., Wang, Z., & Long, C. (2020). Ethnobotany and diversity of medicinal plants used by the Buyi in eastern Yunnan, China. *Plant Diversity*, *42*(6), 401–414. https://doi.org/10.1016/j.pld.2020.09.004

Yue, S., Wei, J., Aziz, H., & Liew, K. (2023). A study on the effectiveness of self-assessment learning system of ideological and political education for college students. *Learning and Motivation*, *84*(June), 101929. https://doi.org/10.1016/j.lmot.2023.101929

Yusup, F., Istiqamah, I., & Khairunnisa, K. (2021). Learning methods on environmental education to improve pre-service teachers' environmental literacy. *Journal of Biology Education Research (JBER)*, *2*(2), 50–55. https://doi.org/10.55215/jber.v2i2.4137

Zaidi, S. F., Saeed, S. A., Khan, M. A., Khan, A., Hazazi, Y., Otayn, M., Rabah, M., & Daniyal, M. (2022). Public knowledge, attitudes, and practices towards herbal medicines; a cross-sectional study in Western Saudi Arabia. *BMC Complementary Medicine and Therapies*, *22*(1), 1–15. https://doi.org/10.1186/s12906-022-03783-y

Zerbo, I., Salako, K. V., Hounkpèvi, A., Zozoda, D., Kakaï, R. G., & Thiombiano, A. (2022). Ethnobotanical knowledge and conservation of Bombax costatum Pellegr. and Vuillet: an overexploited savanna tree species. *Trees, Forests and People*, *10*(August). https://doi.org/10.1016/j.tfp.2022.100356

Received: *January 28, 2024* | Revised: *February 18, 2024* | Accepted: *April 02, 2024*

Cite as: Sri Lestari, E., Sajidan, S., Rahmawati, F., & Indrowati, M. (2024). The inquiry ethnobotany learning model: An instructional design model to enhance student environmental literacy. *Journal of Baltic Science Education*, *23*(2), 377–389. https://doi.org/10.33225/jbse/24.23.377

Endang Sri Lestari
(Corresponding author)
PhD Student, Doctorate Program of Natural Science Education, Sebelas Maret University (Universitas Sebelas Maret), Jl. Ir. Sutami 36A, Surakarta Postcode 57126, Central Java, Indonesia.
E-mail: srilestariendang99@gmail.com

Sajidan Sajidan
Professor, Lecturer, Biology Education Program, Sebelas Maret University (Universitas Sebelas Maret), Jl. Ir. Sutami 36A, Surakarta Postcode 57126, Central Java, Indonesia.
E-mail: sajidan_fkip@staff.uns.ac.id
Website: https://iris1103.uns.ac.id/profil-0015046603.asm
ORCID: https://orcid.org/0000-0001-6306-6849

Fitria Rahmawati
Professor, Lecturer, Chemistry Department, Sebelas Maret University (Universitas Sebelas Maret), Jl. Ir. Sutami 36A, Surakarta Postcode 57126, Central Java, Indonesia.
E-mail: fi_rahmawati@staff.uns.ac.id
Website: https://iris1103.uns.ac.id/profil-0010107504.asm
ORCID: https://orcid.org/0000-0002-3145-9063

Meti Indrowati
PhD, Lecturer, Biology Education Program, Sebelas Maret University (Universitas Sebelas Maret), Jl. Ir. Sutami 36A, Surakarta Postcode 57126, Central Java, Indonesia.
E-mail: metiindrowati@staff.uns.ac.id
Website: https://iris1103.uns.ac.id/profil-0001107804.asm
ORCID: https://orcid.org/0000-0003-2000-671X