Pak. j. life soc. Sci. (2024), 22(1): 4707-4722 E-ISSN: 2221-7630;P-ISSN: 1727-4915

Pakistan Journal of Life and Social Sciences
www.pjlss.edu.pk

https://doi.org/10.57239/PJLSS-2024-22.1.00347

RESEARCH ARTICLE

How to Increase Students' Global Diversity Character: Study of the Influence of Ethno-STEM-Integrated Project Learning Model on Indonesian Tea Aroma Volatile Compounds

Sudarmin[1], A. Tri Prasetya[2], A. Hanun Kusuma[3], B. Setiawan[4], Rr. S.E. Pujiastuti[5], H. Hanim Binti Mohd Zain[6], Winarto[7]

[1,2] Chemistry Education Study Program Faculty of Mathematics and Natural Sciences , Universitas Negeri Semarang, Indonesia
[3] Master of Public Health Student, Faculty of Medicine, Universitas Negeri Semarang, Indonesia
[4] Science Education Department, Faculty of Mathematics and Natural Sciences Universitas Negeri Surabaya,Indonesia
[5] Nursing Department, Politeknik Kesehatan Kemenkes Semarang, Indonesia
[6] Faculty of Science and Mathematics, Universty Pendidikan Sultan Idris Tanjung Malim 35900, Perak, Malaysia
[7] Science Education Departement, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

ARTICLE INFO

Received: May 22, 2024

Accepted: Jul 4, 2024

Keywords

Global Diversity Character
Project Learning Model
Ethno-STEM

***Corresponding Author:**

sudarmin@mail.unnes.ac.id

ABSTRACT

In the 21st century, strengthening students' global wisdom is essential as part of the Sustainable Development Goals (SDGs) and the vision of Universitas Negeri Semarang (UNNES). This study aims to preserve the drinking tea culture through Ethno-STEM-integrated project learning and equip global diversity characters. The research subjects were 27 chemistry education students at Universitas Negeri Semarang taking the mini research course. Data were collected through observation, interviews, and experiments identifying herbal tea aroma compounds using a coffee maker integrated with an Arduino gas sensor. The following are the conclusions of this study: (a) Global diversity characters increase in the context of knowledge, attitudes, and cognitive skills after implementing Ethno-STEM-integrated project learning, (b) Scientific knowledge products are reconstructed based on Indigenous knowledge regarding drinking tea culture, tea making, benefits and responses to tea as local wisdom, (c) 27 Indonesian and global tea aroma volatile compound identified by the Arduino gas sensor are carbon monoxide, ammonia gas, propane, LPG, acetone, and ether.

INTRODUCTION

Ngeteh, or drinking tea, is one of Indonesia's favorite and typical cultures. This Ngeteh culture is widespread throughout Indonesia (Meriza et al., 2016). Tea and drinking tea culture were first introduced during the Han Dynasty (206 BC – 220 AD) by Emperor Shen Nung as a royal drink. It became widely known by the public during the Tang Dynasty and developed into an industry during the Ming Dynasty (1368 – 1644 AD). More rapid development was triggered by the Portuguese and Dutch bringing tea to Europe, followed by its spread worldwide (Martina & Abdillah, 2020). In Indonesia, tea plants were discovered in 1686 by Andreas Cleyer, but at that time, it was only known as an ornamental plant in home gardens. Tea plants were successfully planted in the Bogor Botanical Gardens in 1826 and the Cisurupan

Experimental Gardens in 1827. In 1828, during the Dutch government under Governor Van Den Bosch, people were forced to plant tea.

Ngeteh, or drinking tea, is one of Indonesia's favorite and typical cultures. This Ngeteh culture is widespread throughout Indonesia (Meriza et al., 2016). Tea and drinking tea culture were first introduced during the Han Dynasty (206 BC – 220 AD) by Emperor Shen Nung as a royal drink. It became widely known by the public during the Tang Dynasty and developed into an industry during the Ming Dynasty (1368 – 1644 AD). More rapid development was triggered by the Portuguese and Dutch bringing tea to Europe, followed by its spread worldwide (Martina & Abdillah, 2020). In Indonesia, tea plants were discovered in 1686 by Andreas Cleyer, but at that time, it was only known as an ornamental plant in home gardens. Tea plants were successfully planted in the Bogor Botanical Gardens in 1826 and the Cisurupan Experimental Gardens in 1827. In 1828, during the Dutch government under Governor Van Den Bosch, people were forced to plant tea through a system of forced labor (Langgeng & Widiana, 2013). This study aims to preserve the drinking tea culture through Ethno-STEM-integrated project learning and equip global diversity characters.

Indonesia's population is the fourth largest in the world. The diversity of Indonesia is commensurate with the 723 tribes (Husni, 2020). With a large population in the 21st century, Indonesian people face many difficulties in preserving local culture because local wisdom clashes with extraordinary advances in science and technology. On the other hand, every nation must achieve and realize sustainable development goals (SDGs). In the 21st century, strengthening students' global wisdom is essential as part of the Sustainable Development Goals (SDGs) and the vision of Universitas Negeri Semarang (UNNES). Therefore, controversial and interesting local and global cultural topics, such as the drinking tea culture, can be used in the present learning as local wisdom. Indonesian people and other countries know this culture very well.

Indonesia has entered the era of global education. This era encourages conventional and traditional education in Indonesia to transform into global education based on technology, digital, and the introduction of information technology (Keengwe, 2010; Sudarmin et al., 2022). In the era of global education, students are challenged to collaborate with various cultures, nations, and individuals from various racial, ethnic, gender, and socio-economic backgrounds. Education in this era requires students to have global diversity characters, which are strengthened in this research.

The essence of global education in this research is an education and learning that requires students' ideas, reasoning, attitudes, and thoughts to be global, humanistic, and holistic yet maintain the culture, morality, and character of Indonesian values (Lee et al., 2012, Sudarmin et al., 2021).

In this research, emphasis is placed on strengthening students' global diversity characters and values as global community citizens. In the future, they will strengthen their sense of empathy, belonging, and love for Indonesia's cultural diversity and have the ability to make the right decisions regarding cultural issues through scientific approaches (Hosnan, 2016; Sumarni et al., 2020).

Research on drinking culture and tea aroma compounds is interesting. With this research, students are expected to love and preserve the drinking tea culture after learning about the benefits of tea, drinking tea, and tea aroma compounds. Yang et al. (2013), Xiao et al. (2022), and Zeng et al. (2022) used gas chromatography, FTIR, and mass spectrometry to identify tea aroma volatile compounds. Meanwhile, a coffee maker integrated with an Arduino gas sensor has never been used to analyze and identify the volatile compound profile of tea aroma, making it the novelty of this research. The urgency of this research is to update the knowledge about tea, drinking tea culture, scientific reasons for the benefits of tea, the role of tea aroma compounds for health, and the volatile aroma compounds of Indonesian and global herbal teas.

This research is essential. The literature analysis shows that science learning must strengthen scientific literacy, overcome societal issues, and strengthen global diversity characters in students (Choi et al., 2011; Sudarmin et al., 2022). Students' global diversity characters can be internalized and strengthened through metacognition and self-direction towards loving culture, instilling cultural characters and values through

thinking skills, integrating them into learning, and embedding science to preserve cultures. The framework of character dimensions and cultural values developed in students will develop the character and values of future generations as global citizens and strengthen empathy for Indonesian cultural diversity as global wisdom.

Character is how students' knowledge and understanding of good values in life from culture manifest in everyday attitudes and behavior (Parmiti et al., 2021). Currently, the younger generation's empathy for culture is decreasing, and one of the causes of the decline in the value of local Indonesian culture is the rapid flow of globalization. Integrating culture into ethnoscience-based learning is one way to build and strengthen cultural literacy (Sudarmin et al., 2023) because ethnoscience-based learning, in this case, tea and drinking tea culture, is appropriate to the students' situations in the learning environment.

This research applies Ethno-STEM-integrated project learning, which combines the project learning model with Ethnoscience and STEM. This research is relevant to science learning objectives, oriented towards mastering global wisdom's knowledge, skills, and attitudes to participate actively in the global era. This research is oriented towards integration between culture and science education. In this research, the Project Learning Model (PjLM) was applied, integrating Ethno-STEM in the context of tea, drinking tea culture, tea making, the benefits of tea, and tea aroma volatile compounds; this approach offers several benefits (Sinagatullin, 2016, Kusuma et al., 2022, Sudarmin et al., 2023).

This research is relevant to Sustainable Education Development (SED), one of the sustainable development goals (SDGs) and the approaches to strengthening global diversity characters. Strengthening students' global wisdom, information, abilities, attitudes, and values is needed to enable students to have cultural literacy (Chhokar, 2010). Reconstruction of Ethno-STEM-integrated project learning, which integrates the project learning model with the Ethno-STEM approach, is the focus of this research and has been developed by Sudarmin et al. (2018).

One of the benefits of project learning in this research is that it allows students to use the knowledge gained in creating project assignments to solve problems (Lucas & Goodman, 2015; Shpeizer, 2019; Sumarni et al., 2020). Ethno-STEM-integrated project learning links technology in analyzing volatile tea aroma compounds with Indigenous knowledge regarding tea, drinking tea culture, and its benefits (Morris et al., 2019; Khoiri et al., 2021; Sudarmin et al., 2023).

Local wisdom characters are global in the SDGs context, while in the Indonesian context, they are known as global diversity characters (Kemendibudristek, 2023). In this research, what is meant by the global diversity characters is the cognitive ability and attitude to maintain noble culture, locality, and identity and remain open-minded in interacting with other cultures, thereby fostering mutual respect and acceptance of the formation of new cultures (Bornet, 2013; Arshad et al., 2020; Ariyatun et al., 2023).

METHODOLOGY

This research is qualitative (Creswell, 2008) to reconstruct and design Ethno-STEM-integrated project learning on Indonesian tea aroma compounds to strengthen students' global diversity characters. The research subjects were 27 chemistry education students at Universitas Negeri Semarang taking the mini research course. The reconstruction and design of Ethno-STEM-integrated project learning refer to the reconstruction model by Fogarty (2019), Suastra (2006), and Sudarmin et al. (2022).

Ethno-STEM-integrated project learning is implemented with the topic of local wisdom, the theme of Indonesian drinking tea culture to strengthen students' global diversity characters. This research uses an ethnoscience approach, including data collection, verification and reduction, conceptualization and validation, reconstruction, and scientific explanation (Suastra, 2006; Sudarmin et al., 2016). Data were collected through observation, interviews, and experiments identifying herbal tea aroma compounds using a coffee maker integrated with an Arduino gas sensor. The research instruments are observation sheets and questionnaires to measure global diversity characters in the context of the SDGs.

Data in this research were analyzed descriptively, qualitatively, and quantitatively based on indigenous knowledge. Data on strengthening global diversity characters were analyzed from students' responses to Ethno-STEM-integrated project learning, while data on the diversity of tea aroma volatile compounds were analyzed from experiments. Data on students' responses to drinking tea culture, the diversity of tea, tea aroma, and its health benefits were analyzed based on the percentage of students responding with do not understand (disagree), understand (agree), and very understand (strongly agree). Data analysis includes reduction, display, and conclusion drawing/verification (Creswell, 2008).

This research analyzed the volatile compounds of tea aroma using a coffee maker integrated with an Arduino gas sensor. This tool is a coffee maker, and the lid was fitted with Arduino-type MX1, 2, and 3 gas sensors that detect and identify volatile aroma compounds from tea samples. In this research, the volatile aroma compounds detected were herbal tea. Five grams of powdered tea and 100 mL of water were added to the coffee maker. Sometime later, steam (gas) forms, and the Arduino sensor detects the aromatic gas. The sensor will change the concentration of volatile compounds into an electrical signal, which is then processed by Arduino so that volatile compounds are identified from the aroma of herbal tea. The series of volatile compound identification tools using a coffee maker combined with an Arduino sensor is presented in Figure 1.

Figure 1. Coffee Maker Integrated with Arduino Gas Sensor

The series of Arduino sensor devices are grouped into three parts: coffee maker (1-5), sensor (6), and Arduino sensors (7-8). The coffee maker functions as a bath to produce gas vapor from the sample. Then, the sensor functions to capture the gas vaporized by the coffee maker. The captured gas is converted into electricity and sent to the Arduino board for identification. The results of identifying volatile compounds (gas) are connected to a data cable as an interface that processes and identifies compounds identified by the Arduino sensor and displays them on the computer.

RESULT

Ethno-STEM-Integrated Project Learning Model on Tea Aroma Volatile Compound

This research found that the Ethno-STEM-integrated project learning model on tea aroma volatile compound strengthens students' global wisdom characters. This model is based on analyzing literature regarding the project learning model and its integration with Ethno-STEM. The research team and interpretation from various reference sources determined that the design of project learning and Ethno-STEM is an "Integrated" model referring to Forgarty et al. (2015). The integration model in this research is between project learning and Ethno-STEM (pedagogical knowledge), Content Knowledge (CK) of Indonesian herbal tea aroma compounds, and Technology Knowledge (TK) regarding experimental tools

for identifying herbal tea aroma compounds using an Arduino gas sensor. The reconstruction design between project learning and Ethno-STEM is presented in Figure 2.

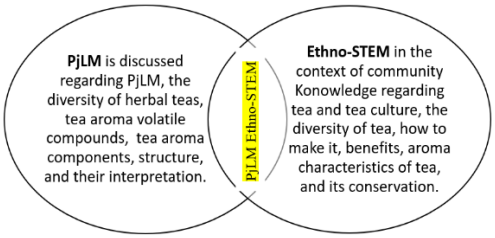


Figure 2: Integrated Model between Project Learning and Ethno-STEM on Tea Aroma Volatile Compound (Sudarmin et al., 2023).

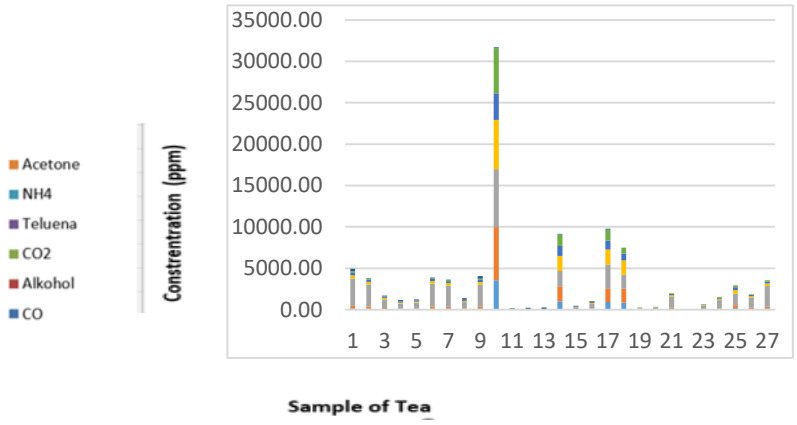
The research team discussed analyzing the content and context of drinking tea culture, diversity of tea, benefits, and aroma of tea and learning using Ethno-STEM-integrated project learning, as presented in Table 1.

Table 1. Design of Ethno-STEM-Integrated Project Learning Model on Tea Aroma Volatile Compound to Strengthen Students' Global Diversity Characters

No.	Components (sides)	Description of Content and Learning
1	Project Learning Model (left)	The scope of the project learning model consists of understanding, analyzing, and applying the model for discovery inquiry, class inquiry, and laboratory inquiry to identify the diversity of tea and test it as Indonesian global wisdom with the Arduino gas sensor tool.
2	Ethno-STEM (right)	It discusses indigenous knowledge about tea, drinking tea, making tea, the benefits of tea for health and the body, the different colors of teas, and the aroma and scent of various teas.
3.	Ethno-STEM-Integrated Project Learning Model (Middle)	It discusses the content and context of the following scientific reconstruction and explanation: (a) indigenous knowledge related to tea and drinking tea culture, (b) conventional and laboratory extraction processes for tea and its aroma, followed by laboratory inquiry experiments to identify various tea aromas using the Arduino gas sensor, (c) presenting the results of tea aroma experiments.
4.	Discussion results for Ethno-STEM-Integrated Project Learning Model with SUDARMIN syntax	In this research, reconstruction results were found for the PjLM Ethno-STEM stages with the SUDARMIN syntax: Serve problems, Utilize exploration and elaboration in work performance, Discuss work performance, Analyze project activities for research, Regulate implementation, Maximize project activities, Implement, Notably present and assess project results and global diversity characters.

Identification of Tea Aroma Volatile Compounds with the Arduino Gas Sensor

This research implemented the Ethno-STEM-integrated project learning model to strengthen students' global diversity characters. In this research, 27 tea samples were analyzed to identify their volatile aroma compounds: 22 Indonesian tea as global wisdom, 1 Thai tea, 1 Indian tea, 2 Korean teas, and 1 Malaysian tea. The tool to identify the tea aroma as global wisdom developed by Sudarmin et al. (2021) is presented in Figure 1. The research team and experts then analyzed the data from identifying the tea aroma volatile compounds. The analysis of the profile and identification of tea aroma volatile compounds using the Arduino sensor is presented in Figure 3.



Information: (1) Ansel Rose Tea, (2) Bajakah Tea, (3) Dilmah Ginger & Honey (Korea), (4) Green Tea, (5) Karo Wood (Malay), (6) Cinnamon, (7) Moringa, (8) Nutmeg Tea (Thailand), (9) Ant nest, (10) *Tambi Tea,* (11) Bidara leaves, (12) Insulin Leaves, (13) Chinese Teak Leaves, (14) Tea Delight, (15) Diet Tea, (16) Jasmine Fragrance Tea, (17) Green Tea, (18) Djenggot Green Tea, (19) Kabawetan Tea, (20) Lempaung Tea, (21) Origo Nigh, (22) Qustul Hindi Tea (India), (23) Salam Plus Tea, (24) Sea Dyke Tea (Jasmine), (25) Tan Ngan Lo Tea (China), (26) Twinings Tea, and (27) Wangi Jasmine Tea

Figure 3. The Profile and Identification of Tea Aroma Volatile Compounds Using Arduino Sensor (Sudarmin et al., 2023).

Data on Indonesian tea aroma compounds was obtained from the gas or steam of each tea sample and detected by an Arduino gas sensor installed on the lid of the coffee maker. In Figure 3, Tambi tea produces the most significant amounts of volatile aroma compounds compared to other types of tea.

Reconstruction of Drinking Tea Culture from Indigenous to Scientific Knowledge

Indigenous knowledge of drinking tea culture was reconstructed into scientific knowledge in the context of Ethno-STEM. This research occurred in Hargomulyo Village, Punen Hamlet, Ngrambe District, East Java (Sudarmin et al., 2023). This village is on Mount Lawu's slopes, meaning many tea plants grow scattered around the village. Data was collected by interviewing the owners of a Javanese tea production, Mbah Marsini (61 years old) and Lukiman (56 years old). The reconstruction activities are documented in Figure 4.

(1)

(2)

(3)

(4)

(5)

Figure 4. Interview Process (1,4), Ethnotechnology of Tea Making (2,5), and Javanese Tea Products (3).

This research carried out observations and interviews with sources. According to the stages of the Ethnoscience research by Suastra (2006) and Sudarmin et al. (2018), the interview data was reduced, validated, and reconstructed to be scientific. Its scienctific recontructionare presented in Table 3

Table 3. Reconstruction of Drinking Tea Culture from Indigenous to Scientific Knowledge in Ethno-STEM Context

No.	Question	Answer	Scientific Knowledge
1.	How is the process of making this local tea?	**(1)** Roasting the tea leaves until they are bendy	This process changes the chemical compounds in the leaves, reduces the water content (dehydration), and deactivates the peroxidase oxidase enzyme so the leaves become bendy (Lagawa et al., 2019).
		(2) Rolling the tea leaves to release the water When they are dried, "*godhong teh badhe malih*," or the color of the texture of the tea leaves changes.	In the rolling process, the catalyst will release the oxidant enzyme contained in the leaves. It reacts with polyphenols and oxygen to form polyphenols as catechin compounds, which will be oxidized into *teaflavin* and *teaubigin*, causing the tea leaves to change color (Azurianti et al., 2022).
		(3) The second roasting of the tea leaves to make them drier	The second roasting process aims to stop the enzymatic oxidation reaction in the tea leaves and kill micro-organisms that can pose health risks (Putri et al., 2021).
		(4) Drying tea leaves It can be done directly in the sun or the oven. During the rainy season, the leaves are sometimes put inside the house and covered with plastic.	The drying aims to reduce the water content of tea leaves and inactivate or inhibit the enzymes contained (Lagawa et al., 2019). After drying, the tea leaves are packaged in plastic for sale.
2.	What is *Ngeteh*? According to Mbah Marsini, it is brewing tea in hot water.	*Ngeteh* or drinking tea, is the Javanese people's local wisdom or culture. They usually drink tea in the morning by brewing dry tea in hot water. Sometimes, they also add sugar as a sweetener.	In making and drinking tea, the compounds in the tea are extracted and macerated into hot water. Meanwhile, tea water is a homogeneous mixture because the substances mixed in it cannot be distinguished (Hasbi et al., 2022).
3.	According to Mbah Marsini, what are the health benefits of tea?	Tea cures diabetes and high blood pressure. It can be used in a diet by adding lime or lemon.	Scientifically, tea's flavonoids, alkaloids, and saponins play an essential role in medicine and body health and fitness (Azurianti, 2022).

An interview was also conducted with an elementary school graduate, Mbah Marsini (61). The information from the sources and the explanation regarding Javanese tea and *ngeteh* culture was reconstructed and became scientific knowledge. The following is the reconstruction of *ngeteh* culture from indigenous to scientific knowledge.

Question 1: Why do the Lawu people call their tea Javanese tea?

People call it Javanese tea because it comes from Java, precisely on the slopes of Mount Lawu, East Java, where it is traditionally made. Meanwhile, the scientific explanation is that the height of the location of the tea plant is one of the factors that influence the growth and quality of tea. The higher the location, the slower the metabolic processes in tea plants will run (Azzurianti et al., 2022). Soil suitable for growing tea plants is the Andosol type.

Question 2: How do you determine which part of the tea plant is used as an ingredient for making Javanese tea?

Mbah Marsini uses the young tea leaves (peco in Javanese) and the stems. Scientifically, the part of the plant that is processed is the tea shoot. It consists of shoots, upper and lower stems, and first, second, and third leaves (Sudarmin et al., 2021).

Question 3: Why are only young tea leaves or shoots used and not the old ones?

Old tea leaves are stiff and have lost their taste. In science, the young tea leaves are rich in polyphenolic compounds, caffeine, and amino acids. Tannins and catechins in tea can affect the quality of color, aroma, and taste. The older the tea leaves, the fewer their catechins (Hasbi et al., 2022).

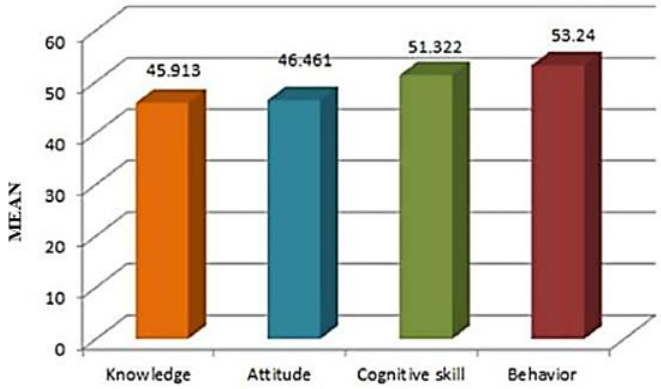
Question 4: How does Javanese tea taste without sugar or other ingredients?

It is bitter or slightly bitter and less stable. The scientific explanation is that tea is bitter or tart because it contains catechins, saponins, and alkaloids (Agca et al., 2018).

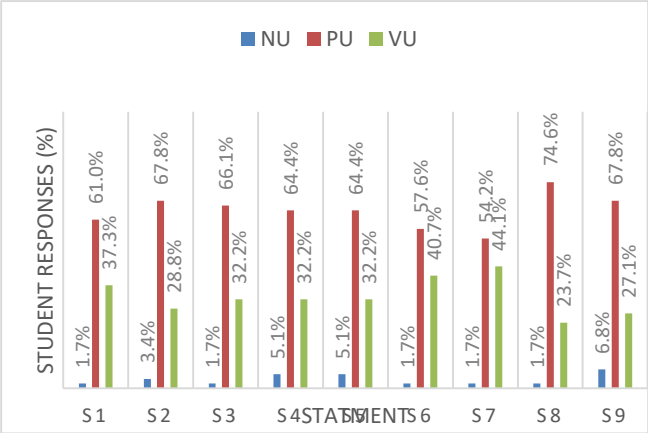
Implementation of Ethno-STEM-Integrated Project Learning to Strengthen Students' Global Diversity Character

Ethno-STEM-integrated project learning was implemented in study materials for tea aroma compounds to strengthen students' global diversity characters. After implementation, data on global diversity characters was collected from students in the Mini Research course. The results of measuring students' global diversity characters are presented in Figure 5.

Figure 5. Students' Global Diversity Characters in Knowledge, Attitudes, Cognitive Skills, and Behavior



In Figure 5, the average character for each domain is categorized as high. This result indicates that the developed Ethno-STEM-integrated project learning can equip students with global diversity characters. However, when viewed from a numerical perspective, the average results for each domain still need to be improved, especially in the knowledge and attitude domains. Meanwhile, the cognitive skills and behavior domains regarding numbers are closer to the high category. At the last meeting, a questionnaire was distributed to measure knowledge of tea (S1-S2), drinking tea culture (S3-S4), global diversity characters (S5-S6), and responses to learning (S7-S8). Students' responses are presented in Figure 6



NU: Not Understand, PU: Poor Understand, VU: Very Understand
Figure 6. Students' Responses to Ethno-STEM-Integrated Project Learning

Discussion

In the final part of this research, students respond to implementing Ethno-STEM-Integrated Project Learning in the mini research course to identify the volatile aroma compounds of Indonesian and global teas. The implementation involved a total of 2 credits and 27 chemistry education students. At the last meeting, a questionnaire was distributed to measure knowledge about tea, drinking tea culture, global diversity characters, and responses to learning. The responses are presented in Figure 6. It shows that the implementation of Ethno-STEM-Integrated Project Learning received a positive response from students.

Knowledge and attitude can be studied theoretically, while cognitive skills and behavior are practices and experiences (Aikowe & Mazancova, 2023; Chaudhry et al., 2022; Erazo, 2022). In this research, students may have sufficient knowledge about the environment, especially regarding volatile compounds. However, students do not yet have the skills to analyze problems related to environmental issues, especially in the context of SDGs, local wisdom, and environmental literacy (Kuruppuarachchi et al., 2021; Figueiredo et al., 2023; Husamah, 2023). In their research related to environmental literacy, Izzah et al. (2020) found that students have a positive attitude toward the environment but have not implemented it into their lives. The same research results were also obtained by Nasution (2016). According to him, two factors influence the level of environmental literacy: internal and external. The mismatch between knowledge and cognitive skills and attitude and behavior can change over time as students gain experience (Wang et al., 2023). Several activities that can be carried out to increase environmental literacy are through learning to apply knowledge and attitudes in daily life, such as environmental projects or volunteer activities (Fang et al., 2023; Figueiredo, M., 2023). The analysis of various articles related to efforts to promote environmental literacy, local wisdom, and the cultivation of positive environmental character has been carried out by (Juntunen et al., 2013; Goldman et al., 2018; Law, 2023; Marshall, 2023).

In this section, students' responses are presented regarding understanding herbal tea and its relationship to environmental literacy in the context of SDGs. It started at the second meeting for the mini research course. At the initial meeting, the learning outcomes of each meeting were explained, including regarding the aroma compounds of Indonesian tea as local wisdom (Sudarmin et al., 2023). The data analysis from the questionnaire presented in Figure 6 and Table 4 shows that the implementation of Ethno-STEM-Integrated Project Learning receives a positive response and is very well understood.

Sudarmin et al. (2021), Solheri et al. (2022), and Santiani et al. (2023) have also developed a learning model to develop conservation and environmental character using an ethnoscience and STEM approach. The same response was also generated from this research. The reconstruction of scientific knowledge in the Ethno-STEM context is conceptualized according to Suastra (2010) and Sudarmin et al (2022).

CONCLUSION

The following are the conclusions of this study: (a) Global diversity characters increase in the context of knowledge, attitudes, and cognitive skills after implementing Ethno-STEM-integrated project learning, (b) Scientific knowledge products are reconstructed based on Indigenous knowledge regarding drinking tea culture, tea making, benefits and responses to tea as local wisdom, (c) 27 Indonesian and global tea aroma volatile compound identified by the Arduino gas sensor are carbon monoxide, ammonia gas, propane, LPG, acetone, and ether.

Acknowledgements: We want to thank the Ministry of Education, Culture, Research, and Technology for funding this research through Regular Basic Research with Research Contract Agreement Letter No: 144/ES/ PG.02.00.PL/2023, dated June 20, 2023 and a budget of 186,700,00. (one hundred eighty-six million seven hundred thousand rupiah).

REFERENCES

Agca, A. C. , V. N. , and S. E. (2020). Penentuan Senyawa Volatil Pada Teh Hijau Dan Teh Hitam Asal Turki Dengan Menggunakan HS-SPME dan GC-MS. *Jurnal Farmasi Ÿstanbul*, 111–115.

Aikowe, L. D., & Mazancova, J. (2023). Pro-environmental awareness of university students–assessment through sustainability literacy test. *International Journal of Sustainability in Higher Education*, *24*(3), 719–741.

Anggraeni, D., Dahlan, D., & Sumardi, L. (2021). Pergeseran Nilai Gotong Royong pada Tradisi Perkawinan Masyarakat Dompu (Studi Kasus Di Dusun Fo'o Mpongi). *Jurnal Pendidikan Sosial Keberagaman*, *8*(2).

Ariyatun, S. S. W. & S. S. (2022). The Positions on the Level of Environmental Sustainability Awareness in Higher Education. *I-JiTEP (International Journal of Innovation in Education, Technology & Entrepreneurship)*, 1–20.

Arshad, H. M., Saleem, K., Shafi, S., Ahmad, T., & Kanwal, S. (2020). Environmental awareness, concern, attitude and behavior of university students: A comparison across academic disciplines. *Polish Journal of Environmental Studies*, *30*(1). https://doi.org/10.15244/pjoes/122617

Azurianti, R. W., Athallah, F. N. F., & Prijono, S. (2022). Kajian hubungan hara tanah terhadap produktivitas tanaman teh produktif di perkebunan teh Pagar Alam, Sumatera Selatan. *Jurnal Tanah Dan Sumberdaya Lahan*, *9*(1), 153–161.

Badelwaer, Y., Aji, S. D., Pratiwi, H. Y., Hudha, M. N., & Hakim, A. R. (2022). Pengembangan E–Modul IPA Terintegrasi Substainable Devolepment Goals (SDGs) untuk Meningkatkan Literasi Lingkungan Siswa pada Topik Tata Surya. *RAINSTEK: Jurnal Terapan Sains & Teknologi*, *4*(4), 216–224.

Banga Chhokar, K. (2010). Higher education and curriculum innovation for sustainable development in India. *International Journal of Sustainability in Higher Education*, *11*(2), 141–152.

Bartels, S. L., Rupe, K. M., & Lederman, J. S. (2019). Shaping Preservice Teachers' Understandings of STEM: A Collaborative Math and Science Methods Approach. *Journal of Science Teacher Education*, *30*(6). https://doi.org/10.1080/1046560X.2019.1602803

Creswell, J. W. (2008). Educational research: planning, conducting and evaluating quantitative and qualitative research. Upper Saddle River, NJ: Merril. Creswell, JW (2009). *Research Design. Qualitative, and Mixed Methods Approaches*.

Erman, & Suyatno. (2022). *Pembelajaran Sains Berbasis Kearifan Lokal*. JDS.

Fang, W.-T., Hassan, A., & LePage, B. A. (2023). *The living environmental education: Sound science toward a cleaner, safer, and healthier future*. Springer Nature.

Fetiana, N., Permanasari, A., & Permana, I. (2022). Environmental Literacy of Junior High School Students in Bogor: Contribution of Knowledge to Environmental Attitudes and Behaviors. *Jurnal Penelitian Pendidikan IPA*, *8*(5), 2423–2429.

Figueiredo, M., Dias, A., Neves, J., & Vicente, H. (2023). Assessment of Literacy to Biotechnological Solutions for Environmental Sustainability in Portugal. *Sustainability (Switzerland)*, *15*(13). https://doi.org/10.3390/su151310056

Goldman, D., Ayalon, O., Baum, D., & Weiss, B. (2018). Influence of 'green school certification' on students' environmental literacy and adoption of sustainable practice by schools. *Journal of Cleaner Production*, *183*. https://doi.org/10.1016/j.jclepro.2018.02.176

Günbatar, M. S., & Bakırcı, H. (2019). STEM teaching intention and computational thinking skills of pre-service teachers. *Education and Information Technologies*, *24*(2). https://doi.org/10.1007/s10639-018-9849-5

Hosnan, M. (2014). Pendekatan Saintifik dan Konstektual Dalam Pembelajaran Abad 21 Kunci Sukses Implementasi Kurikulum 2013. *Bogor: Ghalia Indonesia*, *242*.

Husamah, H., Suwono, H., Nur, H., & Dharmawan, A. (2022). Sustainable development research in Eurasia Journal of Mathematics, Science and Technology Education: A systematic literature review. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(5). https://doi.org/10.29333/ejmste/11965

Husni, H. (2020). Character education in Indonesia: a historical outlook. *Educational Review: International Journal*, *17*(1), 147–162.

Iskandar, H., Sudarmin, S., & Aji, M. P. (2022). Reconstruction of Indigenous Science of Tegal's unique Moci and Tofu Aci Culture as a Source of Learning Science, Data Literacy and Technology for Students. *Journal of Pharmaceutical Negative Results*, *13*(4), 1819–1829.

Izzah, S. N., Sudarmin, S., & Prasetyo, A. P. B. (2020). Identification of the indigenous science concepts in the batik-manufacturing process to develop STEM integrated ethnoscience learning. *Journal of Physics: Conference Series*, *1567*(4), 042032.

Jillani, H., Chaudhry, M. N., & Zahid, H. (2022). Assessing sustainability cognizance in higher education institutions. *Current Research in Environmental Sustainability*, *4*, 100190.

Juntunen, M., & Aksela, M. (2013). Life-Cycle Thinking in Inquiry-Based Sustainability Education – Effects on Students' Attitudes towards Chemistry and Environmental Literacy. *Center for Educational Policy Studies Journal*, *3*(2). https://doi.org/10.26529/cepsj.244

Keengwe, J. (2010). Fostering Cross Cultural Competence in Preservice Teachers Through Multicultural Education Experiences. *Early Childhood Education Journal*, *38*(3). https://doi.org/10.1007/s10643-010-0401-5

Kemendibudristek. (2023). *Profil Pelajar Pancasila*. Https:// Ditpsd. Kemdikbud.Go.Id/ Hal/ Profil-Pelajar-Pancasila.

Khoiri, A., Sunarno, W., Sajidan, S., & Sukarmin, S. (2021). Analysing students' environmental awareness profile using strategic environmental assessment. *F1000Research*, *10*. https://doi.org/10.12688/f1000research.51523.2

Kuruppuarachchi, J., Sayakkarage, V., & Madurapperuma, B. (2021). Environmental literacy level comparison of undergraduates in the conventional and ODLs universities in Sri Lanka. *Sustainability*, *13*(3), 1056.

Kusumandaru, A. D., & Rahmawati, F. P. (2022). Implementasi Media Sosial Aplikasi Tik Tok sebagai Media Menguatkan Literasi Sastra dalam Pembelajaran Tematik di Sekolah Dasar. *Jurnal Basicedu*, *6*(3), 4876–4886. https://doi.org/10.31004/basicedu.v6i3.2972

Lagawa, I. N. C., Kencana, P. K. D., & Aviantara, I. (2020a). Pengaruh waktu pelayuan dan suhu pengeringan terhadap karakteristik teh herbal daun bambu Tabah (Gigantochloa nigrociliata BUSE-KURZ). *Jurnal Biosistem Dan Teknik Pertanian*, *8*(2), 223–230.

Lagawa, I. N. C., Kencana, P. K. D., & Aviantara, I. (2020b). Pengaruh waktu pelayuan dan suhu pengeringan terhadap karakteristik teh herbal daun bambu Tabah (Gigantochloa nigrociliata BUSE-KURZ). *Jurnal Biosistem Dan Teknik Pertanian*, *8*(2), 223–230.

Langgeng, D. Y., & Widiana, H. S. (2013). Pengaruh Warna Cangkir Terhadap Persepsi Cita Rasa Teh. *EMPATHY, Jurnal Fakultas Psikologi*, *1*(2).

Law, J. W., Lye, C. T., & Ng, T. H. (2023). Can environmental literacy and integrated behavioral factors encourage green practices at home? Evidence from Malaysia. *Cleaner and Responsible Consumption*, *10*. https://doi.org/10.1016/j.clrc.2023.100134

Lee, H., Chang, H., Choi, K., Kim, S. W., & Zeidler, D. L. (2012). Developing Character and Values for Global Citizens: Analysis of pre-service science teachers' moral reasoning on socioscientific issues. *International Journal of Science Education*, *34*(6). https://doi.org/10.1080/09500693.2011.625505

Lin, K. Y., Wu, Y. T., Hsu, Y. T., & Williams, P. J. (2021). Effects of infusing the engineering design process into STEM project-based learning to develop preservice technology teachers' engineering design thinking. *International Journal of STEM Education*, *8*(1). https://doi.org/10.1186/s40594-020-00258-9

Lucas, N., & Goodman, F. R. (2015). Well-being, leadership,andpositive organizationalscholarship: A case study of project-based learning in higher education. *Journal of Leadership Education*, *14*(4). https://doi.org/10.12806/v14/i4/t2

Meriza, F., Lestari, D. A. H., & Soelaiman, A. (2016). Sikap dan kepuasan rumah tangga konsumen teh celup sariwangi dan sosro di Bandar Lampung. *Jurnal Ilmu-Ilmu Agribisnis*, *4*(1).

Moody-Marshall, R. (2023). An investigation of environmental awareness and practice among a sample of undergraduate students in Belize. *Environmental Education Research*, *29*(7). https://doi.org/10.1080/13504622.2022.2079613

Morris, J., Slater, E., Fitzgerald, M. T., Lummis, G. W., & van Etten, E. (2021). Using Local Rural Knowledge to Enhance STEM Learning for Gifted and Talented Students in Australia. *Research in Science Education*, *51*. https://doi.org/10.1007/s11165-019-9823-2

Nasution, R. (2016). Analisis Kemampuan Literasi Lingkungan Siswa SMA Kelas X di Samboja dalam Pembelajaran Biologi. *Proceeding Biology Education Conference*, *13*(1).

Parmiti, D. P., Rediani, N. N., Antara, I. G. W. S., & Jayadiningrat, M. G. (2021). The effectiveness of local culture-integrated science learning through project-based assessment on scientific attitudes and science process skills of elementary school students. *Jurnal Pendidikan IPA Indonesia*, *10*(3). https://doi.org/10.15294/JPII.V10I3.31301

Putri, K. D., Yusasrini, N. L. A., & Nocianitri, K. A. (2021). Pengaruh metode pengolahan terhadap aktivitas antioksidan dan karakteristik teh herbal bubuk daun Afrika (Vernonia amygdalina Delile). *Jurnal Ilmu Dan Teknologi Pangan*, *10*(1), 77.

Santiani, S., Rusilowati, A., Sudarmin, S., & Ngabekti, S. (2023). Fit-Model Sustainable Competencies of Palangka Raya Indonesia Peat Lands in the Environmental Literacy (P-PSEL) Questionnaire for Teacher-Candidates. *Polish Journal of Environmental Studies*, *32*(2). https://doi.org/10.15244/pjoes/157496

Shpeizer, R. (2019). Towards a successful integration of project-based learning in higher education: Challenges, technologies and methods of implementation. *Universal Journal of Educational Research*, *7*(8). https://doi.org/10.13189/ujer.2019.070815

Sinagatullin, I. M. (2016). Natisk globalizaysii: Perekhod ot traditsionnoy k infomatsionnoy paradigme [The impact of globalization: Transition from a traditional to information paradigm]. *Pedagogical Journal of Bashkortostan*, *1*, 36–39.

Solheri, S., Azhar, M., & Yohandri, Y. (2022). Analysis of ethnoscience integrated environmental literacy for junior high school. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *8*(2), 178–188.

Suastra, I. W. (2006). *Merekontruksi Sains Asli (Indegenous Science) Dalam Rangka Mengembangkan Pendidikan Sains Berbasis Budaya Lokal di sekolah (Studi Etnosains pada Masyarakat Panglipuran Bali).* . UPI.

Sudarmin, A.T Prasetya, & W. Sumarni. (2022). *Rekontruksi Integrasi Model Pembelajaran Proyek dan Etno-STEM Bahan Kajian Volatil Organic Compound (VOC) Teh Lokal Indonesia dan Malaysia Untuk Penguatan Karakter Kearifan Lokal Global Mahasiswa*.

Sudarmin, Hartono, & Sumarni. (2018). *Rekontruksi Sains Asli Masyarakat Budaya Jawa Menjadi Sains Ilmiah sebagai Sumber Pembelajaran Sains*.

Sudarmin, Hartono, & W. Sumarni. (2018). *Rekontruksi Sains Asli Masyarakat Budaya Jawa Menjadi Sains Ilmiah sebagai Sumber Pembelajaran Sains*.

Sudarmin, Mursiti, S., Sarwi, S., & Listiaji, P. (2021). Secondary metabolite learning model from Taxus sumatrana with ethnoscience integrated inquiry using online system and google form application. *Journal of Physics: Conference Series*, *1918*(3). https://doi.org/10.1088/1742-6596/1918/3/032025

Sudarmin, S., Kasmui, K., Endang, Rr. S., Mohd Zaim, H. H., & Ariyatun, A. (2023). Analysis of Student Responses to Downstream of the Inquiry Learning Model Integrated Ethno-STEM for Aroma Compounds from Indonesian Herbal Tea to Give a Conservation Character. *Asian Journal of Vocational Education and Humanities*, *4*(2). https://doi.org/10.53797/ajvah.v4i2.6.2023

Sudarmin, S., Pujiastuti, R. S. E., Asyhar, R., Prasetya, A. T., Diliarosta, S., & Ariyatun, A. (2023). Chemistry project-based learning for secondary metabolite course with ethno-STEM approach to improve students' conservation and entrepreneurial character in the 21st century. *JOTSE*, *13*(1), 393–409.

Sumarni, W., Sudarmin, S., Sumarti, S. S., & Kadarwati, S. (2022). Indigenous knowledge of Indonesian traditional medicines in science teaching and learning using a science–technology–engineering–

mathematics (STEM) approach. *Cultural Studies of Science Education*, *17*(2). https://doi.org/10.1007/s11422-021-10067-3

Tharasook, K., Rawang, W., & Srijuntrapun, P. (2020). Environmental literacy indicators: Development for communities in the ranong UNESCO biosphere reserve. *GMSARN International Journal*, *14*(4), 212 – 219. https:// bit.ly/3O5GssL

Vásquez, C., Alsina, Á., Seckel, M. J., & García-Alonso, I. (2023). Integrating sustainability in mathematics education and statistics education: A systematic review. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(11), Article em2357. https://doi.org/10.29333/EJMSTE/13809

UNNES. (2023). *Rencana Strategis dan rencana Bisnis tahun 2023- 2028*. Universitas Negeri Semarang.

Wang, J., Shan, X., Xue, Q., Liu, Y., Liu, Z., He, L., Wang, X., & Zhu, C. (2023). Wang, 2023.pdf. In *Inorganic Chemistry Communications* (Vol. 152).

Wardani, R. A. K., Karyanto, P., & Ramli, M. (2018). Analysis of high school students' environmental literacy. *Journal of Physics: Conference Series*, *1022*(1). https://doi.org/10.1088/1742-6596/1022/1/012057

Witoszek, N. (2018). Teaching sustainability in Norway, China and Ghana: challenges to the UN programme. *Environmental Education Research*, *24*(6). https://doi.org/10.1080/13504622.2017.1307944

Wei-Ta Fang., Ben A. LePage., Arba'at Hassan. (2023). The Living Environmental Education Sound Science Toward a Cleaner, Safer, and Healthier Future. Philadelphia, PA, USA : Academy of Natural Sciences. Retrieved from https://library.oapen.org/ handle/20.500.12657/58658