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RECONSTRUCTION OF ETHNO-STEM INTEGRATED PROJECT LEARNING MODELS FOR EXPLANATION OF SCIENTIFIC KNOWLEDGE REGARDING AROMA COMPOUNDS OF INDONESIAN AND WORLD HERBAL TEAS

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ABSTRACT

The background to this research is the importance of finding an integration pattern between the project learning model and Ethno-STEM based inquiry to explain scientific knowledge regarding the aroma of herbal tea. The fundamental research objective is to design an integration pattern for the project and Ethno-STEM learning model and reconstruct scientific knowledge based on public knowledge of the aromatic volatile compounds of Indonesian and world herbal teas. This research method and approach is mixed research. This qualitative approach is to find the integration of the project learning model and Ethno-STEM (Ethno-STEM PjLM) and its syntax. A quantitative approach regarding analyzing tea aroma volatile compounds using an Arduino gas sensor: research data from literature studies, interviews, reconstruction, and data on identifying volatile compounds in the aroma of herbal tea analyzed descriptively, qualitatively, and quantitatively. The results of the research concluded: (1) the reconstruction and integration pattern between PjLM Ethno-STEM is an integrated pattern with SUDARMIN syntax, (2) the reconstruction of scientific knowledge based on public knowledge regarding the process of isolation, extraction, and bioactivity of secondary metabolites, (3) herbal tea aroma volatiles compounds are identified by Arduino sensor: carbon dioxide, methane, propane, butane, acetone, alcohol, and ester, (4) the implementation of Ethno-STEM PjLM received a positive response from students.

Keywords: aroma compound; ethno-STEM; project learning model; reconstruction

INTRODUCTION

The background to this research is the importance of finding an integration pattern between the project learning model and Ethno-STEM based inquiry to explain scientific knowledge regarding the aroma of herbal tea. Thus, the aim of this research is to design an integration pattern of the project and Ethno-STEM learning model, as well as reconstructing scientific knowledge based on community knowledge of the aroma volatile compounds of Indonesian and world

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herbal teas. The state of the art that underlies this research is that as a result of article searches, it is known that project and inquiry learning research, as well as ethno-STEM approaches have been found, but research related to the integration of project and inquiry models with Ethno-STEM to plan the volatile compounds of tea aroma has not yet been discovered. found.

The urgency of this research is related to the extinction of the drinking tea culture as a legacy of the Indonesian ancestors. Ngeteh, or drinking tea, has many health benefits (Sudarmin et al., 2020; Azizah et al., 2022; Yanagimoto et al., 2023). The younger generation and students lack understanding and literacy about the health benefits of tea. Thus, urgent research is needed to reconstruct and downstream an innovative learning model that can scientifically explain the benefits of tea for health and the aroma volatile compounds of tea for fitness (Sudarmin et al., 2022).

The research aims to reconstruct Ethno-STEM PjLM to scientifically explain tea, drinking tea culture, its benefits, and the volatile compounds of herbal tea aroma. Reconstruction research from Ethno-STEM PjLM was chosen because the analysis of previous articles and research found that Ethno-STEM PjLM provides significantly improved problem-solving (Purwaningsih et al., 2020). The implementation of Ethno-STEM PjLM also impacts students' positive character values, learning outcomes, and social and emotional outcomes (Chang & Chen, 2022; Schneider et al., 2022). However, research that uses the Ethno-STEM PjLM reconstruction to scientifically explain the aroma volatile compounds of Indonesian and global herbal teas has not been found, which is the novelty of this research.

However, there has not been much research that addresses the reconstruction of the Project Learning Model with Ethno-STEM (Ethno-STEM PjLM). Thus, there is a need for research to examine the integration patterns, content and context of Ethno-STEM PjLM related to the volatile compounds of herbal tea aromas and their learning syntax, thereby emphasizing and clarifying that this Ethno-STEM-PjLM reconstruction research will have a positive impact on learning (Afriana et al., 2016; Utami et al., 2017 ; Purwaningsih et al., 2020; Reffiane et al., 2021). Apart from that, this research also aims to explain public knowledge into scientific knowledge scientifically. The importance of this research is reinforced by previous research, which involves interviews with several chemistry education students from Universitas Negeri Semarang (UNNES). It turns out that the drinking tea culture, its benefits, and volatile aroma compounds are not widely understood by students (Sudarmin et al., 2022).

The analysis of volatile and flavor compounds of tea using gas chromatography and spectrometry was carried out by Lin et al. (2012), Guo et al. (2019), and Chen et al. (2020). The analysis of articles and literature did not find any research that discusses the integration pattern between the Inquiry Project Learning Model with Ethnoscience and Science, Technology, Engineering, and Mathematics (Ethno-STEM PjLM) for scientific explanation of the volatile compound components of herbal tea aroma using an Arduino gas sensor.

Research related to tea aroma volatile compounds using gas chromatography, FTIR, and mass spectrometry has been carried out by Yang et al. (2013), Xiao et al. (2022), and Zeng et al. (2022). Meanwhile, the use of the Arduino gas sensor to trap and analyze the profile of herbal tea aroma volatile compounds has not yet been discovered, so this is the novelty of the research. This research can contribute to correct knowledge about the culture of drinking tea, scientific reasons regarding the role of bioactive compounds in tea for health, and a correct understanding of the volatile aroma compounds of Indonesian and global herbal teas.

The main objectives of this research are (a) reconstructing public knowledge regarding drinking tea culture in an Ethno-STEM context, (b) finding integration patterns between the Project Learning Model and Ethno-STEM and its learning syntax, (c) finding and explaining profiles of volatile aroma compounds of several herbal teas using an Arduino gas sensor and a gas chromatography-mass spectrometry. The research object is samples of Indonesian and global herbal tea. This research is interesting because no analysis of volatile compounds in the aroma of herbal tea using an Arduino sensor has been found; so far, it has been carried out using a gas chromatography-mass spectrometry tool (Apel et al., 2017). The Arduino sensor analyzes carbon dioxide gas in seawater and measures objects' detection distance (Binson et al., 2021).

This research is a continuation of several previous research, for example, research on the reconstruction of ethnoscience learning models and learning tools in science and chemistry, basic research on the reconstruction of Javanese public knowledge into scientific science and its implementation, and research on the development of

an Ethno-STEM integrated ethnoscience approach to equip conservation and scientific literacy characters and entrepreneurship by Sudarmin et al. (2019-2022). Meanwhile, Sudarmin et al. (2023) reconstructed the Ethno-STEM integrated inquiry learning model to scientifically explain and explain tropical forest plants as anticancer, antibacterial, and antioxidant drugs. Meanwhile, research on reconstructing the Ethno-STEM integrated project learning model to analyze the volatile compounds of Indonesian and global herbal tea aromas has not been carried out.

The background of this research refers to the vision and mission of Universitas Negeri Semarang (UNNES) to become a university with a conservation perspective. Therefore, this research contributes to preserving tea drinking culture and scientifically explaining the volatile compounds of tea aroma that are beneficial for health (Pratiwi & Rasmawan, 2014). Besides, Indonesia has the potential for extensive tropical forests and a factory for secondary metabolite compounds that benefit health. However, that potential is on the brink of extinction due to forest fires and illegal logging (Albuquerque et al., 2012).

This research is essential because there is a gap in public and scientific knowledge regarding scientific explanations of drinking tea culture and its benefits in an Ethno-STEM context. Therefore, this research reconstructs the Ethno-STEM-integrated project learning model to reduce the public and scientific knowledge gap regarding drinking tea culture, its benefits, and tea aroma compounds.

The Ethno-STEM-integrated project learning model is innovative in research and has not been widely developed (Sudarmin et al., 2022; Maryanti et al., 2023). According to the reference analysis, the project learning model has many advantages, including developing creative thinking, conservation, and problem-solving skills (Sumarni & Kadarwati, 2020).

This research is necessary because, in the globalization era in the 21st century, students need to have a sense of concern for the Indonesian culture, including drinking tea, its health benefits, and the volatile compounds of tea aroma (Yang et al., 2013). Cultural literacy of drinking tea can be provided through education and learning on campus (Sudarmin et al., 2023).

Therefore, it is necessary to reconstruct an innovative learning model to instill a conservation character regarding the importance of drinking tea culture, its health benefits, and the volatile compounds of tea aroma. Thus, the output of this research is (1) the integration pattern of the Project Learning Model with Ethno-STEM, (2) the reconstruction and scientific exploration of public knowledge about drinking tea culture, its health benefits, and the volatile compounds of tea aroma, (c) the scientific explanations regarding volatile compounds of tea aroma using a Volatile Organic Compound (VOC) tracking device with an Arduino sensor connected to a computer processing tool, as developed by Tonacci et al. (2015), Rodriguez-Vasquez et al. (2020), and Binson et al. (2021).

The novelty and advantage of this research is that gas sensors used for tracers and analysis of volatile tea aroma compounds have not been found and registered at the Pangkalan Data Kekayaan Intelektual. Currently, the tracer and identification tool for volatile tea aroma compounds developed in this research is in the application stage to obtain simple patent recognition at the Ministry of Law and Human Rights of the Republic of Indonesia.

Arduino gas sensor devices applied in this research include Arduino AT Mega 328, TGS 2602, TGS 2620, TGS 2611, TGS 2610, TGS 822, Mics-6814,3 and Nebulizer (Sudarmin et al., 2022). This research begins with an ethnoscience study to reconstruct scientific knowledge based on public knowledge about tea in an Ethno-STEM context, followed by reconstruction of the integration between the Project Learning Model and Ethno-STEM in Ethno-STEM content and context, and continued with project learning to analyze profiles of volatile compound of herbal tea aroma. The results of the reconstruction and downstream of Ethno-STEM PjLM will contribute to fostering a sense of care and conservation character in students towards the local wisdom of Indonesian and global herbal teas.

METHODS

This research focuses on (1) finding patterns of integration of the project learning model (PjLM) with Ethno-STEM to find a conceptual framework that describes the relationship between the PjLM and Ethno-STEM models, (2) reconstructing scientific knowledge based on public knowledge related to drinking tea culture in the context of Ethno-STEM, (3) explaining volatile compounds of herbal tea aroma with an Arduino gas sensor.

This type of research is descriptive qualitative to find the results of integration from the reconstruction of the project learning model with Ethno-STEM and its syntax through in-depth analysis of reference studies regarding PjLM and

Etnho-STEM. The next stage is to find the results of the knowledge-based scientific reconstruction of tea and drinking tea culture in the content and context of Ethno-STEM, a scientific reconstruction based on public knowledge with stages of observation, reduction and verification, conceptualization, and validation. This research is descriptive qualitative for data from scientific reconstruction results and quantitative for project experimental data for analysis of herbal tea aroma using the volatile compound tracer tool designed by Sudarmin et al. (2022).

The research instruments are interview sheets and observation sheets related to tea and drinking tea culture in Ethno-STEM studies, as well as instruments for project performance assessment related to the aroma volatile compound profiles of Indonesian and global herbal teas.

This research was carried out by modifying a coffee maker, in which 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. Some of the equipment and materials needed in this method are Arduino gas sensor, jumper cables, power supply, sample, solvent, and bath. 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 Circuit 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 (Rahmat, 2021).

The implementation of Ethno-STEM PjLM begins with preparation through coordination and collaboration with partners to equalize perceptions between the research team, students, and student assistants. Furthermore, program strengthening was carried out through consolidation through Focus group discussion (FGD) and questions-and-answers to find agreement in designing schedules, learning tools, and implementation of Ethno-STEM PjLM for Arduino gas sensor devices for analyzing volatile compounds of herbal tea aroma. The final stage is implementation and downstream through the application of Ethno-STEM PjLM and a tea aroma volatile compound gas sensor device for chemistry students from Universitas Negeri Semarang.

RESULTS AND DISCUSSION

According to the analysis of several literatures and FGD, the basis for the integration model between the project learning model (PjLM) and Ethno-STEM is an integrated model that refers to the theoretical and procedural framework of Fogarty (1991). Conceptually, an integrated model is an approach that combines various elements or disciplines to achieve an understanding or provide a more comprehensive solution (Tytler, 2022).

Thus, the Ethno-STEM integrated project learning model means combining project learning models (Sudarmin et al., 2019) as a pedagogical element with an inquiry learning model to analyze and identify volatile compounds of tea aroma in Indonesia using an Arduino gas sensor as an element of knowledge content (CK) and an element of technological knowledge (TK) in the context of pedagogical content knowledge (PCK) (Bahriah et al., 2017; Rivaldo et al., 2022). The project learning model with STEM reconstructed in this research is presented in Figure 2.

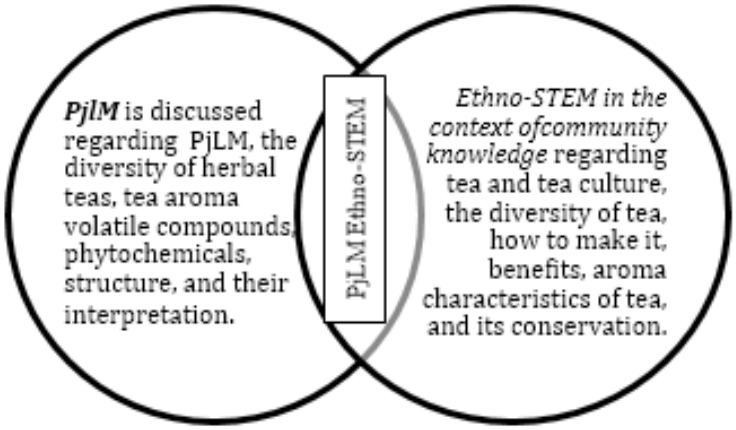


Figure 2. Integration Model Between PjLM with Ethno-STEM for Inquiry Experiment of Tea Aroma Volatile Compounds

This research has been carried out to explore the strengths and limitations of various project learning models, learning tools, and their integration with ethnoscience or ethno-STEM. The results of research findings related to this matter include (1) (Sudarmin et al., 2019, Rosita et al., 2019) which has developed green chemistry integrated project learning tools to develop conservation soft skills, (2) (Sumarni et al., 2016) analyze the strengths and limitations of project learning and their implications in chemistry learning, (3) (Sumarni et al., 2016; Sumarni, et al., 2019) developing a project learning model to equip students with psychomotor and critical thinking skills.

Meanwhile, Sudarmin et al (2019, 2020, and 2022) have designed and developed a project learning model with an ethnoscience or ethno-STEM approach to equip the character of entrepreneurship, conservation and literacy of natural dyes. The project and ethno-STEM learning model has also been designed by Afriana et al. (2023) to develop students' scientific literacy, only the conceptual and procedural framework for the integration between the project and ethno-STEM learning model has not been discussed comprehensively. Thus, this research is a continuation of various previous research and content related to volatile compounds in tea aroma, tea and tea drinking culture in an Ethno-STEM context has never been carried out.

The results of the analysis of various references and articles (Sumarni et al., 2020, 2023), the project learning model (PjLM) applied in research includes the following stages (1) planning which includes selecting a topic or project problem, formulating outcomes, and planning steps to achieve learning, (2) Information Gathering, where students carry out inquiry research and collect information relevant to projects related to the analysis and identification of tea aroma volatile compounds using an Arduino gas sensor, (3) Project design; at this stage, students make a detailed plan for implementing an inquiry project on the analysis of volatile tea aroma compounds, including designing activity schedules and division of tasks,

Stage (4) Project implementation, in this activity students carry out a laboratory-based inquiry experiment project in this research referring to the Wenning model' (2011, 2020), (5) Evaluation and Reflection, at this stage students interpret and analyze the volatile compounds of herbal tea aroma, followed by evaluation of the project results, and (6) Project Presentation, where students present the project results in class, which presents and explains the project objectives, methodology, results achieved, and discussion of experimental results, as well as conclusions obtained, (7) Assessment Stage, where the lecturer evaluates the project based on predetermined criteria, including aspects of creativity, collaboration, problem solving, and student communication skills.

Based on various analysis results and review of references, articles and previous research, the research team determined a conceptual and procedural framework for reconstructing the integration model between the project learning model and Ethno-STEM which is presented in Figure 1, where the content and context are presented in detail in Table 1.

Table 1. Reconstruction Pattern of Ethno-STEM PjLM Integration in Learning Herbal Tea Aroma.

No	Component (side)	Learning Description
1.	First side of the Project Learning Model (left)	In the component section of the Project-based Learning Model (PjLM) content. In the PjLM component, a description is presented of (a) the project learning model and its syntax, (b) the laboratory-based inquiry integrated project model, (c) the conceptual and procedural framework of the laboratory-based project model for isolation, phytochemical testing and volatile compounds of tea aroma, and (d) the experiment of analyzing volatile compounds of tea aroma with an Arduino sensor, as well as its profile analysis..
2.	Ethno-STEM (right)	In the ethno-STEM component section, the learning description concerns (a) observation and reconstruction of community knowledge (Indigenouse Science) regarding (a) the culture of tea and drinking tea, (b) the process of making tea, (c) knowledge about the benefits of tea for health and the body, (d) the diversity of types of various teas, (e) knowledge about the diversity of tea aromas.
3.	Ethno-STEM PjLM Integration (middle) and learning using **SUDARMIN** syntax	It discusses the content and context of the following scientific reconstruction and explanation: (a) public knowledge related to tea and drinking tea culture, (b) conventional and laboratory extraction processes for secondary metabolites and herbal tea aromas, followed by laboratory investigations for phytochemical tests, herbal extracts, (c) exploration and elaboration of volatile components of tea aroma from reference articles, experiments on trapping tea aromas with organic solvents, Arduino sensors, testing compounds with KGMS and FTIR, (d) presenting the results of herbal tea aroma inquiry experiments. In this section, Sudarmin's syntax is implemented in PjLM Ethno-STEM learning.

The product of the integration pattern between PjLM and Ethno-STEM, as well as its implementation in the learning applied in this research, has found an integration pattern between PjLM and Ethno-STEM with the Integrated Model pattern according to Forgaty (1991) and also refers to (Sahin, 2015; Rahim et al., 2019; Banks & Barlex, 2020). According to the developed Ethno-STEM PjLM reconstruction results, its contribution to future learning is a practical, innovative learning strategy for changing students' attitudes and behavior toward STEM content (Kelley & Knowles, 2016), SDGs literacy, and educational development literacy and sustainable development (Sudarmin et al., 2014). The results of literature searches with keywords support the results of this research. Literature searches were carried out using the keywords "Project-Based Learning" and "STEM" and 2018-2022 by Purwaningsih et al. (2020), and 72 articles were found. The distribution of articles with the keywords "PjBL" and "STEM" is presented in Figure 3.

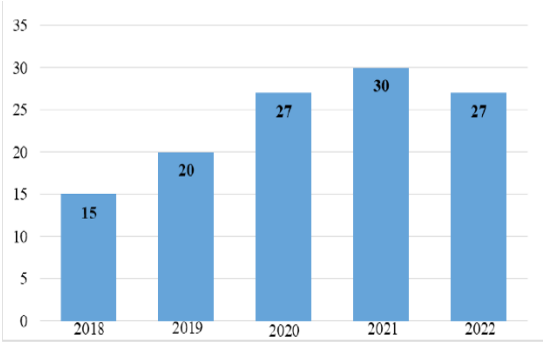


Figure 3. Distribution of Articles for the Keywords "PjBL" and "STEM" in 2018-2022

Figure 3 presents the distribution of articles with the keywords "PjBL" and "STEM" in 2018-2022. There were 15 articles published in 2018, 20 articles published in 2019, 27 articles published in 2020, 30 articles published in 2021, and 27 articles published in 2022. Thus, there are still many research categories related to PjLM and STEM.

This research also conducted content and context analysis of the integration model between Ethnoscience and STEM, known as Ethno-STEM. The conceptual and procedural framework of the integration model between Ethnoscience and STEM refers to Ariyatun et al. (2021), Maryanti et al. (2023), Bybee (2013), and various relevant previous research. Based on the analysis of various reference sources and research, this research applies an integration pattern between one field of Ethnoscience and four fields of STEM science so that it is known as Ethno-STEM as an abbreviation of Ethno-science, Ethnotechnology, Ethnoengineering, and Ethnomathematics (White, 1990; Bybee, 2013; Aulia, 2020; Schneider et al., 2022). In other contexts of Ethno-STEM, it is possible to integrate Ethnoscience with several disciplines in STEM, provided each Ethno-STEM approach allows someone to integrate Ethnoscience and STEM learning subjects and topics clearly (Samsudin et al., 2020). The content and context analysis of Ethno-STEM Integration in PjLM for volatile compounds of Indonesian and Global herbal tea aromas are presented in Table 2

Table 2. Content and Context Analysis of STEM and Ethno-STEM in the Ethno-STEM PjLM for Volatile Compounds of Indonesian and Global Herbal Tea Aromas

Science and Ethnoscience	Technology and Ethnotechnology
Factual science: Herbal tea is scientifically proven to contain sec-ondary metabolites, herbal tea has a distinctive smell or aroma, herbal tea plays an important role in health such as immunity, antioxidants and anti-cancer (Yang et al., 2013). Conceptual Science Herbal tea is a term for a mixture of flowers, leaves, seeds, roots, or dried fruits to be made into a drink also called herbal tea. Although called "tea", this concoction or drink does not only con-sist of leaves from the tea plant, but can come from other plants (Ningrum et al., 2021). Herbal tea is usually brewed with hot water to get a fragrant drink and fitness, tea contains bioactive compounds, volatile compounds, and tannins, flavo-noids, and tannins (Dirgantara et al., 2018, Dai et al., 2020, and Jin et al., 2021). **Ethnoscience:** Community knowledge (Indigenous science) re-garding the culture of tea drinking, traditional tea making, knowledge of the benefits of tea and the aroma of tea (Poswal et al., 2019).	**Technology** 1) Using a herbal tea making tool consisting of a nanoparticle blender, a tea extract making reactor with an integrated lid for herbal tea aroma compound sensors, phytochemical tests, Kromatography Gas and Spectrocopy Mass tests, and FTIR, as well as their interpretation (Abo El-Ola & Kotb, 2021). 2) Using a computer to search for references, data processing and information on issues related to herbal tea, chemical components in herbal tea and tea aroma, as well as relevant articles (Anders Apel et al., 2017). 3) Using computer technology devices for reporting and data analysis. **Ethnotechnology** The traditional technology for making herbal teas is traditionally boiled, brewed, and filtered.
Engineering and Ethnoengineering **Engineering** Engineering to produce valid data and information on tea culture (Cardoso et al., 2020), phytochemi-cal tests of tea extracts, procedures for testing vola-tile compounds of herbal tea aroma, and analysis processes for the composition and profile of vola-tile compounds of tea aroma that are valid, effec-tive and efficient (Movahedi et al., 2014). **Ethnoengineering** Public knowledge about how herbal tea is more efficacious (Mpofu et al., 2014), long-lasting and delicious; flavorful and delicious (Sutisno & Afendi, 2018).	**Mathematics and Ethnomathematics** **Mathematics** Calculating the composition of volatile compounds in various brands of Indonesian herbal teas on the market and herbal teas of tropical forest plants, calculating the composition of each compound that makes up the aroma of each tea and presenting it in the form of tables and graphs. **Ethnomathematics** Calculations are traditionally related to the dose between water and local plant materials and tropical forests in the manufacture of herbal teas.

In this research, the reconstruction of Ethnoscience and STEM combines the approach of one field of Ethnoscience with four disciplines in STEM. This approach is very suitable for project or problem-based learning, and this approach can create a cohesive and active learning atmosphere by carrying out the four STEM disciplines simultaneously to solve problems (Mawarni & Sani, 2020).

Based on the FGDs, literature studies, and references, a syntax for Ethno-STEM PjLM was found with the name SUDARMIN Syntax in this research. The syntax has the following stages.

1. **S**erve problems

Lecturers ask questions or problems from exciting issues related to the drinking tea culture, including facts and myths that several herbal teas like Bajakah, Taxus Sumatrana, Sarang Semut, and Akar Kuning have anticancer properties and/or aroma components as herbal teas. How about information about the issue of herbal tea?

2. **U**tilize exploration and elaboration in work performance

Students carry out exploration and elaboration independently or in groups, looking for information and sources or references, and articles available on the Internet to answer questions from lecturers or formulate hypotheses related to the volatile compounds of herbal tea aroma

3. **D**iscuss work performance

Students, after exploring and elaborating as a "Work Performance," search for information, record, and analyze the findings of answers to the lecturer's questions. In the next stage, students carry out group discussion activities to decide on the correct answer to the problem.

4. **A**nalyze project activities for research

Students analyze the best solutions and propose to design an experimental project for analyzing volatile compounds of herbal tea aroma from herbal tea samples provided by the lecturer. This activity aims to prove public knowledge that herbal tea contains volatile compound components capable of producing certain aromas and properties.

5. **R**egulate implementation

At this stage, a group discussion was held again to regulate the time for laboratory experiments, preparation of material requirements, and experimental equipment for testing volatile aroma compounds of Indonesian and world herbal teas.

6. **M**aximize project activities

During the activity, the experimental project planning and experimental schedule were maximized. The lecturer provided input from the students' experimental design and suggestions on whether the project design was excellent and specific to be implemented.

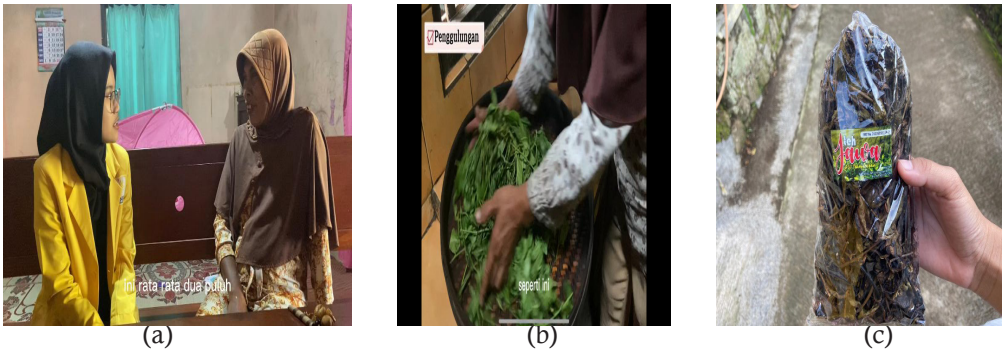
7. **I**mplement

At this stage, students in groups implement an inquiry experimental design regarding testing and analysis of volatile herbal tea aroma compounds from various Indonesian and global herbal teas.

8. **N**otably conclude and present

Students analyze data on volatile compounds of herbal tea aroma identified by the Arduino gas sensor, then conclude and present a project report in poster form.

In this research, the conceptual basis applied to determine project learning with the SUDARMIN syntax refers to the theory and concept of project learning from Fadzilah et al. (2016) and Sumarni et al. (2022). The STEM approach in Ethnoscience aims to equip students' skills to connect science with everyday problems so that learning becomes interesting (Gonzalez et al., 2012; Kelley & Knowles, 2016; Utami et al., 2017; York et al., 2019; Suja et al., 2023).
Observations and interviews were conducted with resource persons regarding their knowledge of the culture of drinking tea and drinking coffee, the manufacturing process, benefits, aroma, and which is better. The interviews with the resource person are presented in Figure 4.



(a) (b) (c)

Figure 4. Interview Process Regarding the Tea Making Process and Examples of Javanese Herbal Tea Products

As a result of the knowledge of the sources (Indigenous Science), a process of reconstructing scientific science based on community knowledge (Indegenous Science) is then carried out by referring to the patterns of exploration, elaboration, reconstruction and scientific conceptualization according to Mpofu, et al (2013a, 2013b), the results of which are presented in Table 3.

Table 3. Reconstruction and Explanation Regarding Indonesian Herbal Tea

Question Focus	Public Knowledge	Scientific Knowledge
What is public knowledge about tea and drinking tea?	Tea is a typical Indonesian drink.	The tea plant has another name, *Camellia sinensis*.
Why do you like coffee over tea?	Coffee has a better aroma than tea. Drinking coffee makes me feel fresher and less sleepy.	Caffeine in coffee can stimulate the nervous system's performance, making the mind calmer and less sleepy.
Why do you like to inhale the aroma of tea when drinking it?	I think tea has a calming aroma, and it tastes delicious.	The caffeine and tannins in tea are useful for increasing one's focus and concentration. Tannins are found in tea leaves and promote relaxation.
What are the health benefits of drinking tea and coffee?	I think coffee relieves drowsiness and calms the mind, while tea refreshes the body.	Tea is often consumed for fitness because tea leaves are high in antioxidant compounds, which help prevent the growth of cancer cells and free radicals and eliminate thirst.
What benefits do you get after drinking herbal tea?	I think *kawo* powder water relieves soreness after work, and kayu aro black tea increases endurance.	Black tea contains more caffeine than other teas. The caffeine and amino acid L-theanine in kayu aro black tea are useful for increasing concentration and brain activity.
Why is there an aroma from tea or coffee when we drink it?	It is caused by the water vapor from coffee and tea when brewed with hot water.	In coffee or tea, volatile compounds evaporate easily, giving a fragrant aroma when the coffee or tea is brewed or drunk while it is still hot.
Which one has better aroma, taste, and color? Tea bags or regular powdered tea?	I think the powdered tea is better. The aroma is also more fragrant than tea bags.	Powdered tea has better nutritional content than tea bags because the catechins in tea bags can decrease if stored for a long time and reduce the aroma of the tea.
What do you feel when you smell tea or coffee?	I think the aroma of coffee is fresher when I inhale it, while tea calms you.	Caffeine in tea and coffee has a calming effect when inhaled. It improves focus and concentration, so when you drink coffee and tea in the morning, your body will feel more energized.
What if you brew tea and coffee using cold water? How can tea or coffee taste, aroma, and color be brewed with cold water?	The taste, aroma, and color are not as delicious and thick as when brewed in hot water. Tea or coffee brewed in cold water produces minimal, even no aroma.	Cold water (low temperature) will slow the reaction rate of tea and coffee. The higher the temperature, the faster a reaction will occur, and vice versa. The aroma also does not come out because there is no steam from the hot water, so the volatile aroma does not form (does not evaporate).
Which tea has a stronger aroma, single-use or double-use tea bags?	The aroma is sharper if using single-use tea bags.	Single-use tea bags have more concentration than those used many times.

This research indirectly investigates the ethnobotany of how humans and plants interact indirectly. It is important to understand the scientific components of herbal teas, such as the aroma compounds, and the cultural and traditional knowledge associated with these plants. These studies can advance sustainable practices, preserve indigenous knowledge, and expand our understanding of the cultural value of herbal teas. The sensory experience and possible health benefits of herbal tea are greatly influenced by the aroma components of the herbal tea (Poswal et al., 2019). By studying these compounds, we can better understand various teas' therapeutic properties, taste, and quality (Dai et al., 2020; Zhai et al., 2022). This knowledge could increase tea production, which is especially important given the global popularity of herbal teas.

STEM education in this research is seen from students' ability to connect science with everyday problems, so learning becomes interesting (Kelley & Knowles, 2016; Tytler, 2022). Students analyze data, understand scientific methods, and appreciate the cultural context of research. STEM-based learning enhances critical thinking skills. It also encourages inclusivity by recognizing indigenous knowledge and using modern science (Utami et al., 2017; Suja et al., 2023). Students can study science, culture, and trekking simultaneously, thanks to the comprehensive approach provided by the ethno-STEM learning paradigm (Andrianie et al., 2018; Izzah et al., 2020; Ariyatun, 2021). The development of the Ethno-STEM PjLM model is interdisciplinary learning that combines practical experiments, field visits to nearby herbal tea farmers, and talks about the cultural significance of tea in Indonesia and around the world developed as a result of research. Local communities can obtain many benefits. First, researchers provide tools to communicate their knowledge and traditions by involving them in the research process. Second, this research can present business prospects, such as supporting regional companies or preserving ancient farming practices. Lastly, this research fosters a sense of pride and identification in community members who consider their traditions and culture valuable.

In this fundamental research, the reconstruction results of Ethno-STEM PjLM based on inquiry have been implemented. In this research, the samples of Indonesian herbal tea as global-local wisdom for identifying volatile aroma compounds of herbal tea were twelve (12) tea samples.

The research team and experts then analyzed the data from identifying the detected herbal tea aroma volatile compounds. The analysis of the identification and profile of herbal tea aroma volatile compounds are presented in Table 4 and Figure 5.

Table 4. Tea samples, Code, and Concentration of Volatile Compounds (ppm) of Tea Aroma Identified by the Arduino Gas Sensor

No	Tea Name	Code of Tea	The concentration of volatile compound (ppm) by The Arduino gas					
			CO	Alcohol	CO_2	Toluena	NH_4	Acetone
1	Kepala Jenggot	ST_1	20,42	4,35	7,60	2,12	8,88	1,72
2	Gopek (Tea bag)	ST_2	16,79	3,66	6,47	1,77	7,64	1,44
3	Tong Tji (Tabur Tea)	ST_3	15,91	3,51	6,21	1,69	7,37	1,38
4	Dilmah (Green Tea)	ST_4	33,24	6,70	11,47	3,34	13,05	2,69
5	Dilmah (Strawberry Tea)	ST_5	56,23	10,36	17,11	5,31	18,67	4,25
6	Dilmah (Blackcurrant)	ST_6	45,00	8,72	14,69	4,40	16,39	3,54
7	Rumah Kelor (Mori Te)	ST_7	15,29	3,36	5,96	1,62	7,06	1,32
8	Hikmah Herbal (Insulin Tea)	ST_8	61,76	11,44	18,93	5,86	20,67	4,69
9	Superindo (Black Tea)	ST_9	79,92	14,12	22,92	7,35	24,51	5,86
10	Sariwangi (Jahe Kunyit Tea)	ST_10	73,48	13,26	21,70	6,85	23,40	5,47
11	Sariwangi Tea	ST_11	88,86	15,55	25,15	8,13	26,73	6,47
12	Melati Tea	ST_12	192,97	29,55	45,31	16,16	45,24	12,69

The data in Figure 5 as resulting from identifying Indonesian herbal tea aroma compounds was obtained from the gas or steam from each tea sample and detected by a gas sensor installed on the coffee maker.

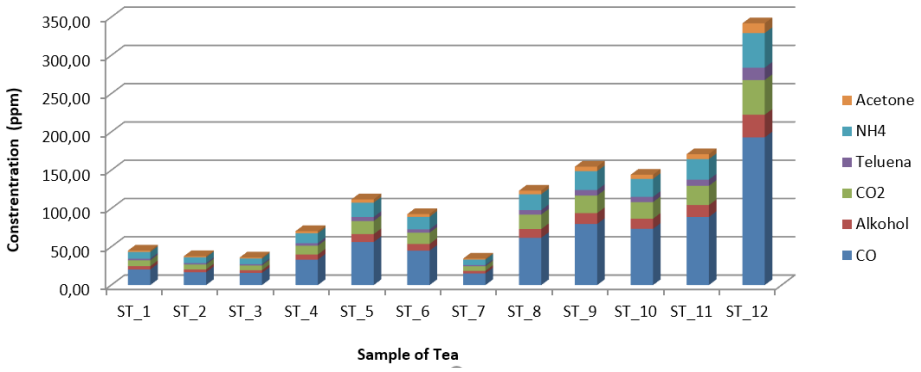


Figure 5. Results of Identification of Volatile Tea Aroma Compounds from Twelve Tea Samples Using an Arduino Sensor (Sudarmin et al., 2023)

In the final part of this research, students respond to implementing Ethno-STEM PjLM in Research Mini Courses to analyze the volatile aroma compounds of Indonesian and global herbal teas. Ethno-STEM PjLM is implemented in the Mini Research course with a total of 2 credits, and the number of students involved is 28 from the Chemistry education study program, Universitas Negeri Semarang. At the last meeting, a questionnaire was distributed to measure knowledge about herbal tea (P1), tea culture (2), the character of global local wisdom (3, 4), and responses to learning (5). The responses are presented in Figure 6.

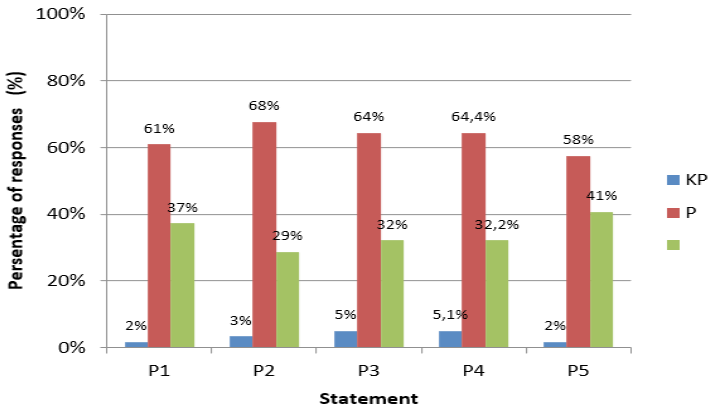


Figure 6. Student Responses to the Content and Learning Process of Ethno-STEM PjBL

The results of the data analysis of the questionnaire questions presented in Figure 6 show that the implementation of PjML integrated Ethno-STEM received a positive response from students.

CONCLUSION

The results of the research concluded: (1) the reconstruction and integration pattern between PjLM Ethno-STEM is an integrated pattern with SUDARMIN syntax, (2) the reconstruction of scientific knowledge based on public knowledge regarding the process of isolation, extraction, and bioactivity of secondary metabolites, (3) herbal tea aroma volatiles compounds are identified by Arduino sensor: carbon dioxide, methane, propane, butane, acetone, alcohol, and ester, (4) the implementation of Ethno-STEM PjLM received a positive response from students.

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