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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

Sudarmin[1], Kasmui[1], Pujiastuti, Rr. Sri Endang[2], Mohd Zaim, Haniza Hanim[3], Ariyatun[4]

[1]*Chemistry Education Study Program, Universitas Negeri Semarang
Sekaran, Gunung Pati, Semarang City, Central Java 50229, INDONESIA

[2]Nursing Departmen, Poltekkes Kemenkes Semarang
Jalan Tirtoagung Pedalangan Banyumanik, Semarang 50329, INDONESIA

[3]Faculty of Science and Mathematics, Universty Pendidikan Sultan Idris
Tanjung Malim 35900, Perak, MALAYSIA

[4]Doctoral Science Education, Universitas Negeri Semarang
Sekaran, Gunung Pati, Semarang City, Central Java 50229, INDONESIA

*Corresponding author email: sudarmin@mail.unnes.ac.id

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Abstract: This research is related to downstream research from an innovative learning model. This research aims to (a) downstream the Ethno-STEM integrated inquiry learning model, (b) analyze the profile of aroma compounds from herbal tea extracts in Indonesia, and (c) analyze student responses to the downstream of the Ethnoscience and STEM (Ethno-STEM) integrated inquiry learning model. STEM). Research was conducted at the Faculty of Mathematics and Natural Sciences. The research subjects were students of chemistry education at UNNES for the 2022/2023 academic year. The research instruments consisted of questionnaires, questionnaires, and observation sheets from the test results of Indonesian herbal tea aroma compounds. In this research the trapping of tea aroma compounds uses Arduino sensors. Data obtained from questionnaires and data on Indonesian herbal tea aroma compounds were analyzed descriptively qualitatively and quantitatively. The results of the research concluded that (a) the integrated Ethno-STEM inquiry learning model that was down streamed was the Sudarmin syntactic model, (b) Indonesian herbal tea aroma compounds consisted of hydrogen compounds, propane, carbon monoxide (CO), alcohol, carbon dioxide (CO2), toluene, ammonia, acetone, heptane, and sulfuric acid gas, and (c). students respond well to the integrated Ethno-STEM inquiry learning model that was developed, and this model is able to increase the Conservation character.

Keywords: Inquiry, Ethno-STEM, Aroma Tea, Conservation character

1. Introduction

This research is a contribution to realizing the vision of Universitas Negeri Semarang (UNNES) as a university with a conservation perspective. Therefore an innovative learning design that is able to equip students with conservation characteristics is important to develop and discover. In this research, it is important to develop an Inquiry Learning Model integrated with ethno-science and STEM (MPI Ethno-STEM) for the analysis of aroma compounds of Indonesian herbal teas. In addition, this research is rooted in UNNES Renstra related to conservation and innovative learning (LPPM, 2020). This research is part of the output targets of the 2023 Regular Basic Research (Sudarmin et al., 2023). In this basic

*Corresponding author: sudarmin@mail.unnes.ac.id

research, it was carried out in conjunction with Indonesia, which had just been hit by the Covid-19 pandemic outbreak, so the research team decided to carry it out online and offline or hybrid learning.

This research, during the Covid 19 pandemic, was an activity to reconstruct public knowledge about the aroma of herbal tea, so learning was done online. Meanwhile, the explanation process to scientific knowledge to explain the diversity of aroma compounds from herbal teas is carried out through inquiry project activities at the UNNES Chemistry Laboratory. Herbal teas as research samples are herbal teas circulating in the market. In project activities through inquiry experiments in the laboratory, the experimental activities apply the Occupational Health and Safety protocol. The application of project learning with integrated Ethno-STEM inquiry experiments is expected to be able to encourage students to be literate in technology, information and data, be able to equip conservation characters, and preserve the culture of drinking tea as local Indonesian and global wisdom (Sudarmin et al., 2019; Sumarni & Kadarwati, 2020). Thus the project learning model through MPI-Ethno-STEM can equip the local wisdom conservation character of the Indonesian people and MPI Ethno-STEM learning according to the demands of this global era.

The urgency of importance of conducting MPI Ethno-STEM research, because the herbal tea aroma compound test is an interesting experiment and is able to prove the diversity of volatile secondary metabolites and as a distinctive aroma of local herbal teas in Indonesia (Sudarmin et al., 2023). MPI Ethno-STEM research regarding the aroma of this herbal tea has not been carried out much, so this research can explain the diversity of aromas in herbal teas that are known to the Indonesian and global community. In research with this project approach, the components of the tea aroma compound were traced using an Arduino-type electronic flavor sensor designed by Sudarmin et al., (2020). This research refers to the successful use of the Genoses electronic sensor for the detection of Covid-19 patients which was developed at UGM by Kuwat & Grehenson, (2020). As for the results of the analysis of several articles related to volatile compound sensor devices, it was found that theoretically and procedurally this tool could be used as a detector for various aromas and flavors of various natural ingredients and the quality of herbal teas in the future (Setyopratomo, 2014; Sitohang, 2018; Urquiza et al., 2019). With this research, in addition to down streaming the Ethno-STEM MPI, it is also expected to find component data for herbal tea aroma compounds, as well as to find out student responses to the developed MPI Ethno-STEM.

This basic research was initiated by Sudarmin et al., (2020) regarding the reconstruction of scientific knowledge based on community knowledge around tropical forests regarding the tea plant as an anticancer agent. Data collection was carried out through observation, interviews, and or online with an ethnoscience approach. While the focus of questions related to community knowledge regarding ethnobotany, ethnomedicine, ethnopharmacology, and ethnoecology of tropical forest plants from Bajakah, Akar Kuning, Taxus Sumatrana, and Sarang Semut. The results of data and information obtained from observation, interviews and/or interviews are then reconstructed into scientific knowledge (Sudarmin et al., 2020). This scientific knowledge is integrated as a topic in (a) Natural Material Organic Chemistry (KOBA) Course, (b) Ethnoscience and Local Wisdom approach courses, and (c) Ethno-STEM and Chemical Literacy approach courses in the Undergraduate and Masters program in Chemistry Education Post-graduate at Universitas Negeri Semarang..

2. Literature Review

The conceptual framework for the STEM learning approach developed in this research refers to the National Science Teacher Association (NSTA) in 1996 for science lecturer education and is still considered a very innovative learning model in the 21st century (Gonzalez & Kuenzi, 2012; Torlakson & Bonilla, 2014; Kelley & Knowles, 2016). The scientific aspect of the STEM approach is the ability to use scientific knowledge and processes to understand and manipulate natural phenomena to address real symptoms or problems in society. The technological aspects of the STEM approach include students' ability to know how to develop new technologies, the skills to use them, and how to use them to promote the human workforce. The technological aspect of the STEM approach is people's ability to manipulate or assemble things. Mathematical aspects are skills used to analyze, reason, convey ideas effectively, solve problems, and interpret computational and data-based mathematical solutions (Kapila & Iskander, 2014; Utami et al., 2017; Khoiriyah et al., 2018). All of these aspects can make knowledge more meaningful when integrated into the science/chemistry learning process (Sumarni & Mahatmanti, 2018; Izzah et al., 2020; Sumarni et al., 2022).

The approach and integration between Ethnoscience and STEM or known as Ethno-STEM is an interesting and innovative learning approach, because the results of the analysis of several articles show that the Ethno-STEM approach is able to facilitate students in conserving local wisdom, entrepreneurial character, higher order thinking, and chemical literacy (Sudarmin et al., 2019; Sumarni & Kadarwati, 2020; Ma & Ma, 2014). With reference to this research, it is conceptually known that the contribution of this research is (a) obtaining a design prototype of an Inquiry Learning Model (MPI) integrated with Ethno-STEM, (b) finding an innovative model of MPI Ethno-STEM as a form of model learning to realize the conservation vision of UNNES, (c) contributing to conceptual and procedural development regarding the field of study regarding how to analyze the components of Indonesian tea aroma compounds, (c) helping chemistry students involved in scientific research to scientifically reconstruct and explain public knowledge about the constituent compounds aroma of herbal teas in Indonesia.

3. Methodology

3.1 Type of research, sample, and research location

This type of research is basic research to seek and downstream from MPI Ethno-STEM for study materials for the analysis of aroma compounds from extracts of various Indonesian herbal teas. The research was carried out in the 2022/2023 academic year with research subjects being students majoring in Chemistry and Sciences Education at FMIPA UNNES. In the early stages of this research, focus group discussions were conducted between the research team to discuss and find design patterns for combining Inquiry Learning Models (MPI) and Ethno-STEM with reference to the Inquiry learning model from Wenning, (2016) and Fogarty, (1991). In the next stage, FGD activities were carried out to discuss patterns of integration between Ethnoscience and STEM, which analyzed various studies from Sudarmin et al (2019). In subsequent research, project work was carried out to design computer programs and design a series of Arduino sensor devices, as well as trials of trapping components for Indonesian herbal tea aroma compounds. The resulting profiles of aroma compounds for herbal teas are in the form of display patterns for the components of aroma compounds for various herbal teas in Indonesia. The location of the research on the identification of herbal tea aroma compounds was carried out at the UNNES FMIPA Chemistry Laboratory.

3.2 Tracer experiment for the aroma components of Indonesian herbal teas with Arduino sensors

Experiments on trapping the components of aroma compounds of various herbal teas with a tea aroma trap using an Arduino sensor are (a) determining the correct sensor design, (b) making sure the sensor circuit and the display results on the computer screen from the Arduino application are correct, (c) building the Arduino application script to run the herbal tea aroma sensor circuit and read the data it outputs, (d) Arduino application script to connect the sensor to the Arduino board and computer, (e) Sensor calibration in measuring the actual amount of gas content.

3.3 Data collection Student response to the developed MPI Ethno-STEM

In this research, to collect data regarding student response data to MPI Ethno-STEM which was developed for the topic Aroma Compounds of Indonesian herbal teas, it was carried out through a questionnaire. The questionnaire was developed by the research team and validated by experts, then packaged in the Google Form application. In this research, data collection was carried out at the end of the lesson by filling out a questionnaire in the Google Form application, and the results were analyzed and interpreted.

4. Result and Discussions

4.1 Results of the Ethno-STEM MPI Design that will be down streamed

In the research, Focus Group Discussion (FGD) activities were carried out by fellow research teams to determine and design an Ethno-STEM integrated MPI design. The inquiry learning model was developed referring to Wenning, (2016), in which this model is able to encourage students to produce insights and creative ideas, and can develop students' potential cognitively, emotionally, and conservation literacy (Sudarmin, et al., 2019) and (Sumarni & Kadarwati, 2020). Sudarmin et al., (2022) creatively designed an Ethno-STEM integrated inquiry learning model using the SUDARMIN syntax, namely:

1) Serve. The lecturer asks questions or problems from interesting issues related to herbal tea, its benefits, how to make it, as well as the taste and aroma of Indonesian herbal teas.
2) Performance. Students independently and or in groups carry out exploration, observation, and information seeking from sources or references, books, and articles from various digital-based sources to answer questions from lecturers or develop hypotheses. In this research activity, students are challenged to find temporary answers, why do some Indonesian tea extracts have different tastes, smells or aromas, as well as different activities? In this research students are required to find information based on various literature regarding the components of tea aroma compounds or organic volatile compounds found in herbal tea extracts in Indonesia.
3) Discuss. In the next stage, students carry out discussion activities in groups to convey performance results independently and collaboratively design inquiry experimental activities, to answer and prove the aroma compounds in herbal tea extracts. In this activity students designed an experimental project to test the components of Indonesian herbal tea aroma compounds.
4) Analysis. At this stage, students are required to re-analyze whether the proposed project design and aroma trap device with Arduino sensors have been supported by a strong literature review and supporting references, so that conceptually and procedurally convincing experimental designs can be carried out properly. In this activity an analysis was also carried out regarding project implementation or inquiry trials to prove public knowledge about the uniqueness of the aroma of Indonesian herbal teas.
5) Design a project for an herbal tea aroma inquiry experiment. At this stage, group discussions were carried out to determine the time for research implementation, preparation of experimental tools and materials, as well as various

data collection instruments related to herbal tea aroma compounds and student responses, as well as preparing for presentations.

6) Steady. Lecturers provide input from the results of student presentations. In this activity, the lecturer communicatively provided suggestions for improvement to strengthen the experimental project for the analysis of the components of Indonesian herbal tea aroma compounds. Thus this step is to improve or perfect the design of the experimental design of the component analysis of Indonesian herbal tea aroma compounds using Arduino sensors.
7) Implement. At this stage, students in groups apply an inquiry experimental design regarding the analysis of the components of Indonesian herbal tea aroma compounds. Each group is required to collect data and information, analyze and explain the community's knowledge regarding the components of the aroma compounds of Indonesian herbal teas that have been determined.
8) Assess, evaluate, and conclude. In research activities after each group carried out a pilot project to analyze the components of Indonesian herbal tea aroma compounds, each group discussed to draw conclusions about the herbal tea aroma compounds and at the same time to present the results of their experiments.

4.2 Ethno-STEM Integrated Inquiry Learning Model Design

In this research, the implementation and downstream activities of MPI Ethno-STEM are designed through online and offline learning. As for the learning process activities, study materials, and learning outcomes as follows students are able to (a) understand the nature of inquiry learning and SUDARMIN syntax, (b) recognize and understand the diversity of secondary metabolites as herbal tea aroma compounds and their characteristics, (c) understand the design MPI Ethno-STEM activities and their application, and (d) understand the diversity of herbal teas, herbal tea aroma compounds and Volatile Organic Compounds based on reference data, (e) and be able to work scientifically on herbal tea aroma tracer experiments with sensors. In this research, offline learning activities, students carry out experiments on the extraction and maceration of the main components of herbal teas using an Arduino sensor designed by Sudarmin et al., (2020). While the learning activities refer to Wenning's Inquiry which includes activities as presented in Fig 1.

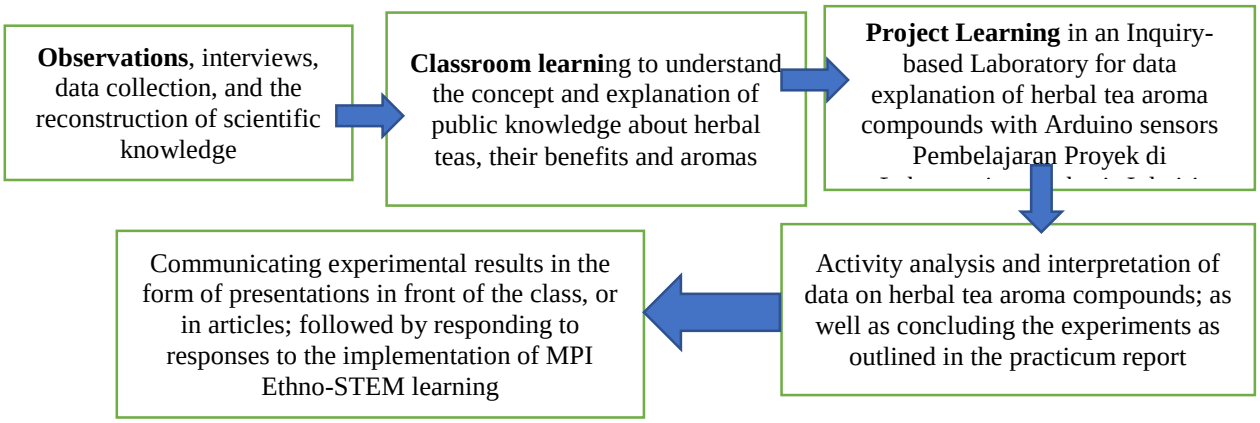

Fig 1. Activities for Down streaming and Implementation of MPI Ethno-STEM

In this research, data on herbal tea aroma compounds captured from Arduino sensors and successfully captured by computer monitor screen sensors are stored first in the Docx document format, where the processed data from components for each herbal tea is presented in Table 1.

Table 1: Mean Measurement Results for Herbal Tea Aroma compounds with Arduino Senso Type MQ135 (in ppm)

No	Types and Brands of Tea	CO	Alcohol	CO2	Toluena	NH_4	Acetone
1	Kepala Jenggot - Teh Hijau Tabur	5.631704	1.35736	2.494284	0.635038	3.090015	0.520045
2	Kepala Jenggot - Teh Melati celup	20.41978	4.347809	7.603903	2.12367	8.876324	1.723339
3	Gopek - Teh Tabur	14.20837	3.144718	5.586221	1.516125	6.644279	1.235203

4	Gopek - Teh Celup	16.79055	3.662763	6.467767	1.773988	7.637188	1.44243
5	Tong Tji - Teh Tabur	15.90778	3.5054	6.214176	1.692625	7.372597	1.378339
6	Poci - Teh Celup	14.83078	3.269082	5.798131	1.578261	6.881733	1.284657
7	Dilmah - Tea Pure Camomile Celup	5.774781	1.390672	2.552403	0.650443	3.159688	0.53343
8	Dilmah - Green Tea Celup	33.24169	6.703445	11.47349	3.335079	13.04541	2.694294
9	Dilmah - Peach Tea Celup	6.597949	1.561026	2.845732	0.733816	3.494404	0.602398
10	Dilmah - Strawberry Celup	56.23274	10.35654	17.10899	5.314852	18.66837	4.252839
11	Dilmah - Blackcurrant Celup	44.99796	8.721536	14.68631	4.397534	16.38732	3.539612
12	Korean One - Ginseng Tea Celup	6.757903	1.592383	2.898763	0.749472	3.552775	0.615339
13	Twinning of London - Peach Tea Celup	9.005777	2.088763	3.781026	0.989698	4.601825	0.811403
14	Walini - Teh Hijau Celup	10.67951	2.446763	4.403403	1.164534	5.320915	0.951476
15	Rumah Kelor - Teh Mori Daun Kelor Celup	15.28883	3.363354	5.958676	1.624625	7.064597	1.32193
16	Hikmah Herbal - Teh Daun Insulin celup	61.76049	11.43968	18.92804	5.859779	20.66776	4.693558
17	Superindo - Teh Hitam Celup	79.91674	14.11522	22.92422	7.34917	24.50782	5.856112
18	Sariwangi - Teh Hitam Jahe Kunyit celup	73.47501	13.25604	21.69727	6.854716	23.40064	5.473066
19	*Sariwangi - Teh Sariwangi celup*	***88.95515***	*15.55301*	*25.14603*	*8.129048*	*26.72625*	*6.469723*
20	*2 Tang - Teh Melati celup*	*192.9725*	***29.55036***	***45.3085***	***16.16192***	***45.24406***	***12.69328***
21	2 Tang - Teh Jasmine celup	17.11151	3.709991	6.534903	1.800125	7.695642	1.463521

Herbal teas from Indonesia contain aroma compounds consisting of hydrogen compounds, propane, carbon monoxide (CO), alcohol, carbon dioxide (CO2), toluene, ammonia, acetone, heptane, and sulfuric acid gas, after being trapped with an Arduino sensor.

4.3 Analysis of Student Responses to Downstream from developed MPI Ethno-STEM

At the end of the down streaming and implementation of MPI Ethno-STEM, data were collected on student responses to the process of implementing and down streaming MPI Ethno-STEM for the topic of Indonesian herbal tea aroma compounds, the results of which are presented in Table 2.

Table 2: Results of MPI Ethno-STEM Implementation Responses

No	Statement	Percentage		
		Very Understanding	Understanding	Not Really Understand
1	I understand the purpose of the lecture regarding MPI Ethno-STEM for Indonesian herbal tea aroma compounds.	37,3	61	1,7
2	I understand the meaning of inquiry, ethnoscience, and Ethno-STEM MPI, and the character of conservation.	28,8	67,8	3,4
3	I understand about downstream, the level of inquiry in its application in MPI Ethno-STEM in Indonesian herbal tea aroma lectures..	32,2	66,1	1,7
4	I understand the components and indicators of conservation and the meaning of the university as a university with a conservation perspective.	32,2	64,4	5,1
5	I understand various forms of Indonesian local wisdom as research objects and sources related to the Ethno-STEM approach.	32,2	64,4	5,1
6	I agree that the MPI Ethno-STEM topic of Indonesian herbal tea aroma compounds is able to equip students with a conservation character.	40,7	57,6	1,7
7	I agree that lectures with MPI Ethno-STEM volatile compounds in the aroma of herbal teas can provide information about books and references related to inquiry, ethno-STEM learning models and their integration.	44,1	54,2	1,7

8	I understand well the diversity of integration models, the characteristics of Ethno-STEM MPI, and their application in Ethno-STEM integrated science inquiry learning.	23,7	74,6	1,7
9	I have a good understanding of the working procedures for aroma compound tracers in Indonesian herbal teas that have been developed.	27,1	67,8	6,8

Table 2. explained that students really understand that by lecturing with MPI Ethno-STEM in the context of volatile compounds in the aroma of herbal tea, they are able to provide information about books and references, investigations, learning models and their integration. However, there are some students who have a little good understanding of the work procedures for tracking aroma compounds in Indonesian herbal teas that have been carried out. Not a few students also lack understanding of conservation components and indicators, as well as various forms of Indonesian local wisdom that can be used as research objects.

In addition to these statements, there are several other statements regarding the implementation of MPI Ethno-STEM, which are explained in Table 3

Tabel 3: Results of analysis of student responses to MPI Ethno-STEM

No	Statement	Percentage		
		Strongly Agree	Agree	Disagree
1	I agree that environmental literacy and conservation character are important for the younger generation	78	22	0
2	I agree that lectures with MPI-Ethno-STEM on herbal tea aroma compounds require me to find various relevant research articles.	40,7	57,6	1,7
3	I understand the meaning of Ethno-STEM in learning the aroma of Indonesian herbal tea, contained in the meaning in the fields of study of Ethnoscience, Ethnotechnology, Ethnoengineering, and Ethnomathematics.	47,5	64,4	3,4
4	I agree that science/chemistry lessons can explain scientifically the public's knowledge regarding the aroma of Indonesian herbal teas.	54,2	44,1	1,7
5	I agree that the downstreaming of MPI Ethno-STEM for herbal tea aroma compounds will encourage lecturers to be more creative and innovative.	49,2	47,5	3,4

The results of the analysis of student responses showed that all students strongly agreed that environmental literacy and conservation character are very important for the lives of young people. In addition, 57.6% of students agreed and 40.7% of students agreed that the MPI Ethno-STEM model was able to explore relevant research-related information. Overall, students responded positively to the application of the MPI Etho-STEM model because it was able to encourage students to think actively, creatively and innovatively in interpreting indigenous knowledge of society (indigeneos science) into the meaning of scientific science. This is in line with the results of the study (Sudarmin et al., 2019) which states that learning with ethnoscience integration is able to develop students' creative thinking skills in the context of green chemistry.

5. Conclusion

The results of the research concluded that (a) the integrated Ethno-STEM inquiry learning model that was down streamed was the Sudarmin syntactic model, (b) Indonesian herbal tea aroma compounds consisted of hydrogen compounds, propane, carbon monoxide (CO), alcohol, carbon dioxide (CO2), toluene, ammonia, acetone, heptane, and sulfuric acid gas, and (c). students respond well to the integrated Ethno-STEM inquiry learning model that was developed, and this model is able to increase the Conservation character.

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