OmniaScience

Journal of Technology and Science Education
JOTSE, 2023 – 13(1): 393-409 – Online ISSN: 2013-6374 – Print ISSN: 2014-5349
https://doi.org/10.3926/jotse.1792

CHEMISTRY PROJECT-BASED LEARNING FOR SECONDARY METABOLITE COURSE WITH ETHNO-STEM APPROACH TO IMPROVE STUDENTS' CONSERVATION AND ENTREPRENEURIAL CHARACTER IN THE 21ST CENTURY

Sudarmin[1], Rr. Sri Endang Pujiastuti[2], Rayandra Asyhar[3], Agung Tri Prasetya[1], Skunda Diliarosta[4], Ariyatun[5]

[1]Chemistry Education Study Program, Universitas Negeri Semarang (Indonesia)
[2]Ministry of Health Polytechnic Semarang (Indonesia)
[3]Chemistry Education Study Program, Jambi University (Indonesia)
[4]Science Department, Universitas Negeri Padang (Indonesia)
[5]Doctoral Students, Science Education, Universitas Negeri Semarang (Indonesia)

sudarmin@mail.unnes.ac.id, rarastuti@yahoo.com, r.asyhar@unja.ac.id, agungchem@mail.unnes.ac.id, skunda@fmipa.unp.ac.id, ariyatun@students.unnes.ac.id

Received June 2022
Accepted August 2022

Abstract

This research aims to develop chemistry project-based learning with an Integrated Ethnoscience Approach in Science, Technology, Engineering, and Mathematics (Ethno-STEM) to improve students' conservation and entrepreneurial character. The research method refers to the Research and Development (R&D) model with the Four D. The research samples are chemistry education students from Universitas Negeri Semarang. The model effectiveness test was conducted in secondary metabolite lectures at the Department of Chemistry, Faculty of Mathematics and Natural Science, Universitas Negeri Semarang, Indonesia. Data collection techniques used expert validation sheets to assess the feasibility of the model and observation sheets and questionnaires to measure students' conservation and entrepreneurial character. Based on the results of research, it was concluded that a chemical project-based learning model for the secondary metabolites course on essential oils and terpenes and learning tools with an Ethno-STEM approach was feasible and effective for improving students' conservation and entrepreneurial character with moderate and high criteria based on the N-gain score. Entrepreneurial characters, which include persistence, discipline, and creativity, have been developed so that students can produce attractive and worthy chemical batik products for sale.

Keywords – Ethno-STEM, Character, Conservation, Entrepreneur.

To cite this article:

Sudarmin, Pujiastuti, R.S.E., Asyhar, R., Prasetya, A.T., Diliarosta, S., & Ariyatun (2023). Chemistry project-based learning for secondary metabolite course with Ethno-STEM approach to improve students' conservation and entrepreneurial character in the 21st century. *Journal of Technology and Science Education,* 13(1), 393-409. https://doi.org/10.3926/jotse.1792

----

1. Introduction

Higher education policies in Indonesia are implementing the *Merdeka Belajar-Kampus Merdeka* (MBKM) program to face the 21st century, which emphasizes several competencies and higher-order thinking skills, such as creative, critical, collaborative, and communicative thinking. 21st-century competencies and skills can be developed through Ethno-STEM integrated project learning (Sudarmin, Sumarni, Endang & Susilogati, 2019; Sumarni, Sudarmin, Sumarti & Kadarwati, 2022). On the other hand, the vision of higher education in Indonesia is not only to make graduates of international reputation but also to be oriented towards cultural conservation, local wisdom, and the nation's cultural values. This research aims to develop Ethno-STEM integrated project learning as an innovative product from research that will contribute to the development of 21st-century education science and technology.

The problem is that higher education in Indonesia has not fully prepared graduates to face the challenges of the 21st century and realize the Sustainable Development Goals (SDGs). This research is also in line with the vision of higher education to realize quality education and increase learning opportunities for everyone (Lisa, Rusmiati & Kesuma, 2021). Quality education is essential to produce quality human resources, so good conservation and entrepreneurial character education can realize quality education according to the SDGs. Sustainable development also means the protection of the contents of the environment and social life to preserve culture as a treasure trove of local wisdom (Anggorowati, Shinta, Nafi'ah & Lathif, 2020; Fakhriyah, Yeyendra & Marianti, 2021). Conservational and entrepreneurial character in the 21st century is a critical concern for education in Indonesia because quality education is essential to produce quality human resources, and good character education can realize quality education under the SDGs.

Based on the policy and vision of higher education in Indonesia, Universitas Negeri Semarang has a vision as a conservation-oriented university with an international reputation and aspires to become an entrepreneurial university (Renstra, 2019). To realize its vision and mission, challenging and actual work is needed for the academic community at UNNES. The problem is that the concern and commitment to realizing the vision and mission of UNNES have not been formed (Sudarmin, 2015). This problem was found when an assessor of the National Accreditation Board for Higher Education (BAN-PT) was conducting accreditation activities in a study program at UNNES. Not all lecturers have developed conservation and entrepreneurial characters in their learning (Sudarmin, Sumarni & Susilogati, 2018). The results of interviews with several chemistry-education students found that most lecturers are still oriented toward mastering concepts (Sudarmin, Sumarni & Mursiti, 2019). From these findings, it was identified that, for now, a facility is needed by lecturers to develop students' conservation and entrepreneurial character.

A solution for developing students' conservation and entrepreneurial character is the importance of implementing learning policies for each subject that integrates conservation character for all lecturers and downstream of research results to develop students' entrepreneurial character (Renstra, 2019; Sudarmin et al., 2018). In addition, at this time, learning at UNNES must follow the needs of 21st-century education and learning. In this research, the meaning of conservation character includes the character of loving the environment, caring for the environment, being responsible, and preserving the environment while still upholding the established cultural values to develop in the community (Hardati, Setyowati, Wilonoyudho, Martuti & Utomo, 2016). Meanwhile, the value of entrepreneurial character includes being persistent, creative, innovative, disciplined, and ready to face 21st-century challenges (Nancy, 2007; Sudarmin et al., 2018). Both characters will be trained and developed through chemistry project-based learning (PjBL) using the Ethno-STEM approach.

This study applies a project-based learning model because this model is under the decision of the Minister of Education, Culture, Research and Technology number 56 of 2022 concerning guidelines for implementing the curriculum in the context of learning recovery, including developing independent, creative, collaborative, and critical characters per 21st-century skills and entrepreneurial character. The ethnoscience approach was chosen for this research because Indonesia has various cultures with local wisdom as a science learning source (Suastra, 2010; Winarto, Sarwi, Cahyono & Sumarni, 2022; Winarto, Cahyono, Sumarni, Sulhadi, Wahyuni & Sarwi, 2022). The ethnoscience approach has developed a conservation carácter (Patton & Robin, 2012; Zakiyah & Sudarmin, 2022). The ethnoscience approach can also develop students' scientific and chemical literacy, thinking skills, and entrepreneurial nature (Sudarmin, Mastur & Parmin, 2017; Sumarni 2018; Tresnawati 2018).

One suitable local wisdom for instilling students' conservation and entrepreneurial character in secondary metabolite lectures is the traditional technology of essential oil distillation by essential oil artisans in Cepogo, Boyolali, Central Java. This critical oil industry has been going on for generations and uses traditional technology. The situations are exciting to introduce to students. In the traditional essential oil refining process, apart from containing valuable scientific knowledge as a source of learning for secondary metabolites, students can also teach entrepreneurship to artisans about how the distillation technology is carried out, how the engineering is carried out to obtain essential oils with good yields, and how the artisans estimate the results of the oil yield mathematically. Thus, in this study, students can examine aspects of Science, Technology, Engineering, and Mathematics based on Ethnoscience (Sudarmin, Diliarosta, Pujiastuti, Jumini & Prasetya, 2020).

The research problem is how to develop and produce learning chemistry projects with an appropriate and effective Ethno-STEM approach to improve students' conservation and entrepreneurial character. The Ethno-STEM approach developed in this research refers to the theoretical framework from Sudarmin, Sumarni, Endang and Susilogati (2019). The Ethno-STEM approach was patented by the Ministry of Law and Human Rights of the Republic of Indonesia. The STEM approach was chosen because it has been developed in several countries globally (Bybee, 2013; Reeve, 2013; Li, 2018), including Indonesia, and has been able to create human resources and thinking skills for students (Lam, Doverspike, Zhao, Zhe & Menzemer, 2008; Urban & Falvo, 2015; Firman, 2015; National STEM Education Center, 2014). In this research, chemistry project-based learning is applied to secondary metabolite courses.

It is integrated with Ethnoscience and STEM, called Ethno-STEM integrated chemistry project-based learning. A scientific study of culture in science learning is called Ethnoscience (Werner & Fenton 1970). Thus, the essence of ethnoscience is a study of community science related to cultural activities in daily life, which is passed down from generation to generation as local wisdom and contains scientific knowledge (Ahimsa-Putra, 1985; Suastra, 2010; Sumarni, Sudarmin, Wiyanto & Supartono, 2016). The Ethno-STEM approach has been proven to suit the needs of the 21st century and can develop critical, creative, innovative, and collaborative thinking skills (Reeve, 2013; National STEM Education Center, 2014; Zakiyah & Sudarmin, 2022).

In this research, the scientific study material that is the focus of research is the study of secondary metabolites for Essential Oils and Terpenes according to the books by Satrohamidjojo (2004) and Saifudin (2012). The main study's analysis results, the essential oil material in STEM and Ethnoscience, then Sudarmin et al., (2018) reconstructed the study material. The following are results of the reconstruction of the content: the nature of essential oils and terpene chemistry, traditional essential oil refining techniques and laboratories, various structures of important oil secondary metabolites, conventional essential oil production techniques and processes, ways to produce high yields essential oils, transformation components of terpene compounds into their derivatives so that they are more valuable, and a project to create a chemical motif batik design with a component structure of essential oils and other secondary metabolites. Thus, in this study, in addition to students taking secondary metabolites lectures, they were also given a project to conduct observations in the local batik industry, Zie Batik, in Malongan, Semarang, to practice making batik products with chemical structure motifs of secondary metabolites on canvas.

1.1. Ethno-STEM Integrated Project-Based Learning

Project-based learning models can equip 21st-century learning and develop conservational and entrepreneurial characters (Sudarmin, Sumarni, & Mursiti, 2019; Sumarni, Sudarmin, Sumarti &

Kadarwati, 2022). In PjBL with the STEM approach (PjBL-STEM), students are given a project to solve problems based on STEM aspects (Science, Technology, Engineering, Mathematics) (Patton & Robin, 2012; Uziak, 2016; Murphy, MacDonald, Danaia & Wang, 2019). Through the Ethno-STEM project learning, students can develop the conservation and entrepreneurial character needed in this 21st-century era (Baran, Karakoyun & Maskan, 2021). PjBL is widely applied in learning science and organic chemistry with natural materials, which is innovative and can develop critical, creative, and innovative thinking skills to solve projects or problems.

Stanley (2021) states that project learning requires students to be responsible, creative, and collaboratively involved in preparing and implementing project designs to solve problems given by the teacher. Students are required to think creatively in solving problems in everyday life. PjBL is an innovative learning practice that builds learning based on challenges in tasks or problems that lead students to design, investigate, conclude, and finally make decisions with a product. (Stanley, 2021). Based on the literature review, the PjBL learning model can be integrated with SETS (Sudarmin, Sumarni, & Mursiti, 2019; Sumarni, Sudarmin, Sumarti & Kadarwati, 2022), STEM (Baran et al., 2021), and Ethno-STEM (Ariyatun, 2021; Reffiane, Sudarmin, Wiyanto & Saptono, 2021) to equip students with 21st-century skills. This research applies secondary metabolite learning with the Ethno-STEM PjBL approach because it can equip students with skills needed in the 21st century and conservational character.

People are required to master several skills due to the demands of the 21st century, and so are students. Learning with a STEM approach has improved 21st-century skills (Triana, Anggraito & Ridlo, 2020; Reffiane et al., 2021). While STEM education, which includes courses that examine teaching and knowledge transfer between two or more subject matters, is a set of connected disciplines that involve mathematics for data processing and technology and engineering as science applications (Afriana, Permanasari & Fitriani, 2016; Bahrum, Wahid & Ibrahim, 2017). STEM education is being applied in a variety of methods around the world, especially in Asia. Various learning methodologies or models are blended and contrasted with STEM applications (Chung, Lin & Lou, 2018; Kuo, Tseng & Yang, 2019; Wahono, Lin & Chang, 2020). In many countries around the world, improving student skills in Science, Technology, Engineering, and Mathematics (STEM) is crucial for future economic and technological growth (Morrison, Frost, Gotch, McDuffie, Austin & French, 2021; Wilson, 2021; Bahrum et al., 2017).

In this research, PjBL is integrated with Ethno-STEM because ethnoscience can increase students' awareness by presenting local knowledge values and incorporating them into the learning process. It has become one of Indonesia's most important learning disciplines today (Dewi, Erna, Martini, Haris & Kundera, 2021). Integrating the Ethno-STEM approach with synergistic learning models such as project-based learning (Ethno-STEM PjBL) will solve existing problems. This model involves project-based learning combined with four STEM areas based on local culture to develop critical, creative, innovative, and collaborative thinking skills. In addition, community-specific knowledge (Ethnoscience) is also fundamental to developing student character (Sumarni & Kadarwati, 2020). The success of learning with the STEM approach is demonstrated by several research findings. Different innovative learning strategies can be employed to facilitate the adoption of STEM integration. The integration of Ethno-STEM with the PjBL model can develop entrepreneurial character (Sudarmin, Sumarni, Endang & Susilogati, 2019) and students' critical, creative, innovative, and collaborative thinking skills and understanding of concepts.

The Ethno-STEM integrated PjBL model contains integration between Science, Technology, Engineering, and Mathematics with ethnoscience. This Ethno-STEM integrated learning prepares to learn in the era of the industrial revolution 4.0, also known as the disruptive innovation phenomenon, which emphasizes that students must have technological literacy skills, are multicultural, learn and innovate, are skilled in social and cultural life, collaborate, think critically, and effective in communication (Sumarni & Kadarwati, 2020). The educational design framework for integrating Ethno-STEM in science learning is presented in Figure 1.

Ethno-STEM integrated project-based learning starts from exploring culture or local wisdom, which is proven related to the science material studied after being reconstructed. Studies related to technology and engineering as a form of science application and mathematics as data processing aids and the representation of symbols are also integrated into learning. So far, PjBL research has not been integrated with Ethno-STEM and has not been widely developed. The novelty of this research is between Ethnoscience with STEM and PjBL with Ethno-STEM so that three integrated models are formed.

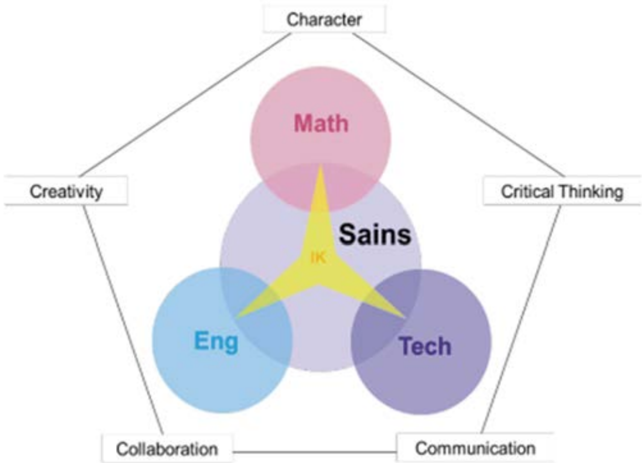

Figure 1. PjBL-Ethno-STEM Model

1.2. Conservation Character

Character education must be established as early as possible to prepare children for increasingly complex future issues, such as their lack of responsibility, attention to the world around them, and lack of confidence. Honesty, discipline, responsibility, patriotism, respect, and care are values taught in character education and meant to be embraced, lived, and used in daily life in the classroom, home, society, and the state. Character education coaches students to become fully human beings with character in heart, mind, body, taste, and intentions.

As a conservation-oriented university, Graduates from Universitas Negeri Semarang (UNNES) should possess conservation characters. The following are the conservation characters: inspirational, humanist, caring, innovative, creative, sporty, honest, and fair. In this study, the UNNES conservational characters provided to students are caring, innovative, and creative characters in conserving the environment, especially related to secondary metabolites. Caring character in this study is the ability to pay attention and a persistent attempt to stop environmental damage and ecological repair damage are qualities associated with caring value. Innovative character is the ability to apply thinking and imagination to create novel items (updates) defines innovative value, and creative character is an ability to reason through or take action to intelligently solve problems is what creativity value is.

This conservational character is realized through Ethno-STEM PjBL learning through the assignment of projects to make Ethno-STEM chemical batik motifs. These characters were assessed through observation and questionnaires. Caring, innovative, and creative conservation character raises conservational soft skills to love, care and be responsible for the environment (Hardati, Setyowati, Wilonoyudho & Martuti, 2015). Nevertheless, if we rely solely on secondary metabolites course to shape students' conservation characters, UNNES' vision and mission as a conservation-focused university will take ages to realize. Ecological beliefs present and the relationship between humans and the environment (Bilir & Özbas, 2017; Halilović, Mešić, Hasović & Vidak, 2022). Conservation is an endeavor to protect and maintain cultural values and human behavior when engaging with the environment. Future environmental stability can be preserved by a conservation carácter (Khusniati, Parmin & Sudarmin, 2017).

1.3. Entrepreneurial Character

An entrepreneur is someone who creates a business by making products in the form of goods or services by looking at the availability and utilization opportunities (Sampurnaningsih, Andriani, Zainudin, Sunarsi & Sunanto, 2020). An entrepreneur can perceive opportunities and create organizations to pursue them. Meanwhile, entrepreneurship education is focused on developing students' competencies and preparing them to be entrepreneurs. The competencies in question are skills or entrepreneurial character traits be mastered from the educational process. Therefore, entrepreneurship education aims to equip students in various activities with the skills, and even the entrepreneurial character, to be self-reliant and exceptional individuals.

The following is the entrepreneurial character assessed in this study which refers to Nancy (2007): (1) persistent, exhibited by their consistent efforts to produce essential oils despite limited facilities, finance, materials, and fluctuating prices; (2) discipline, evidenced by their production target and their diligence in watering and adding fuel; (3) creativity, indicated by their creative way to boost output and recycle waste as compost or fuel to sell it to local farmers. When learning organic chemistry with natural materials, the three main characters were conveyed to the students. In this study, local wisdom as an ethnoscience study material is a local plant that produces essential oils because essential oils contain secondary metabolites with interesting structures and can be used as Ethno-STEM chemical batik motifs.

2. Methods

2.1. Research Type

This research is Research and Development (R&D) type with 4D stages (Define, Design, Develop, Disseminate) (Thiagarajan, Semmel & Semmel, 1974). This research reaches the development stage. The results are in learning models and tools based on chemistry projects with an Ethno-STEM approach for secondary metabolites courses to improve students' conservation and entrepreneurial character.

2.2. Research Procedures

The procedures refer to the research objective of designing and producing learning models and tools based on chemistry projects for secondary metabolites with an Ethno-STEM approach. In the initial or Define stage, a needs analysis and determination process is carried out regarding learning outcomes for the secondary metabolites of essential oils and terpene chemistry, and the characteristics of chemistry project-based learning are determined. In the next stage, a chemistry project-based learning design was carried out for essential oils and terpene chemistry using the Ethno-STEM approach. Experts validated the draft, and the results are applied to test the feasibility and effectiveness of students' conservation and entrepreneurial character development. To develop students' conservation and entrepreneurial character, the chemistry project assigns students to observe batik products in the Zie Batik, traditional batik industry in Malongan, Semarang, Indonesia. In addition, students were also assigned a group project to design the motifs of secondary metabolites' chemical structure, followed by the practice of batik on canvas. The research team assesses the results of batik motif creations on canvas as a product of student entrepreneurship.

2.3. Location, Subjects, and Research Instruments

This research is located at the Faculty of Mathematics and Natural Science of Universitas Negeri Semarang (UNNES) and the Traditional Essential Oil Distillation Center in Cepogo, Central Java, Indonesia. The research subjects were chemistry students of Universitas Negeri Semarang who took secondary metabolites courses. The research instruments are observation sheets, questionnaires, and tests. The suitability between Semester Learning Plans (RPS) and their application in learning is determined using observation sheets. It also assesses various batik products on canvas and students' conservation and entrepreneurial character. This research refers to the criteria from UNNES to measure the conservation character (Hardati et al., 2016): love for the environment, care for the environment, and responsibility for handling waste. While students' entrepreneurial character refers to Nancy (2007): the ability to be creative, work hard, and never give up on producing chemical batik products with attractive motifs, creative in designing batik motifs and processes, as well as choosing contrasting batik colors, as well as originality.

2.4. Data Analysis

In this research, data on the feasibility of the resulting learning tools were analyzed descriptively and qualitatively. At the same time, the effectiveness of chemistry projects with the Ethno-STEM approach for the secondary metabolites was taken during the learning process and outcomes and the batik on the canvas production process. The data from research instruments are then analyzed to answer the formulated problems. Research data from aspects of conservation and entrepreneurial character use the N-gain formula (Hake, 1999) as follows:

$$N - gain = \frac{S_{posttest} - S_{pretest}}{S_{max} - S_{pretest}}$$

It is in the high category if the N-gain score is $\geq 0,7$. If the N-gain score is $0,7 > g \geq 0,3$, it is in the average category and a low category if the N-gain is $<0,3$.

3. Result

3.1. Results of Gap Analysis and Current Secondary Metabolite Learning Problems

Before carrying out a chemistry project-based learning design at the beginning of the study, the research team analyzed the syllabus, lesson plans, and learning tools. The results of the analysis found that secondary metabolites learning so far have not been contextual, and chemistry project-based learning has not linked community knowledge, uses the STEM approach, is still oriented to mastery of concepts, and has not developed students' conservation and entrepreneurial character (Sudarmin et al., 2018; Sudarmin et al., 2020). The analysis results are used to design and build chemistry project-based learning with the Ethno-STEM approach and link essential oil scientific knowledge and community knowledge in an Ethno-STEM context. To gain a public understanding of essential oils, the research team conducted observations in the Traditional Essential Oil Industry in Cepogo, Boyolali. The analysis results of the observational data were then carried out with a Scientific Knowledge Reconstruction through a Focus Group Discussion (FGD) between the research team and students, and the results are presented in Table 1.

The reconstruction of scientific knowledge in the Ethno-STEM context is conceptualized according to Suastra, (2010) by verification and reduction of community knowledge data, followed by conceptualization and integration in chemistry project-based learning tools and models. Experts validated chemistry project-based learning tools and models, and then documentation was made in teaching materials for Essential Oils and Terpenes. The topics refer to the secondary metabolites course syllabus and the textbooks of Satrohamidjojo (2004) and Achmad (1986). The validation of the device and the learning model related to the content, syntax, and stages of chemistry project-based learning and the lesson plans designed by the research team are excellent and feasible to be implemented.

In this research for the learning design and referring to the results of the analysis of several references and discussions with the research team, the following are the learning characters of chemistry projects with the Ethno-STEM approach for secondary metabolites courses:

1. The learning model developed makes reference to Patton & Robin (2012) which is learning aimed at students designing, planning, and making products (batik of chemical structures).

2. Students are required to make collaborative decisions and are in charge of handling information to select intriguing batik motifs. Students must create batik motifs of secondary metabolites structures for this study.

3. The process of making batik is continuously evaluated by the lecturer.
4. Lecturers and students periodically reflect on the activities in the batik project.
5. The lecturer assesses the final product of the batik project with the designed instruments qualitatively and quantitatively.
6. The chemistry project-based learning model with an Ethno-STEM approach is tolerant of change and increases students' creativity and innovation.

No.	Questions and Answers with the Interviewees	Chemical content of scientific knowledge
1	***Ethno-science question:*** *Where did you learn about refining essential oils?* ***Answer:*** My ancestors handed me these skills. My colleagues and I have recently attended training and toured various refineries. One of the refineries is a large factory in Kendal for essential clove leaf iols, with about 1.100 hectares of clove land.	The scientific questions are knowledge and experience about essential oil refinement (procedural knowledge).
2	***Ethno-technology question:*** *How do we distillate the essential oils?* ***Answer:*** The 8-9 quintals of ingredients are placed in a giant furnace. The furnace must be tightly closed and equipped with clamps. The ingredients are steamed. The water for steaming is adjusted to the signs on the furnace and refilled every three hours. The steam comes out from a long pipe on the stove. The pipe is inside a cooling spiral pipe. This pipe made from stainless steel does not affect the oil. The condensed oil vapor will be gathered in a container via a tap. Since the distillation results (betel, bay leaf, adas, and clove) are still a mixture of oil and water, they must be filtered to make a white layer. Because betel oil is light, this layer acts as a barrier between it and the wáter. The distillation yields clear, brown, scented, and relatively thick oils.	This question is about essential oil refinement techniques. Traditional essential oil distillation requires mixed ingredients with water or steam distillation. The distillation process made use of principles and knowledge about substance changes, isolation, and the identification of essential oils. Density and mixture separation are used in the technique. There is an essential oil that is less than water. The clove oil, on the other hand, contains more wáter.
3	***Ethno-Engineering Question:*** *How does refined waste engineering work? Is the essential oil processed using engineering?* ***Answer:*** Because most households utilize manure, which is generally dried for fuel, none have converted refined waste into compost. Betel leaf waste is composted and sold to local people. The dried waste is also sold for animal feed (cattle) at a profit of Rp. 1000/kg.	This section describes the conservation and entrepreneurial characters of recycling manure and the engineering aspects of essential oil waste management.
4	***Ethnomathematics question:*** *How much material is required to produce the essential oil?* ***Answer:*** Bay leaves have the highest output, with 2.5 quintals providing approximately 4.5 - 5 kg of essential oil or approximately 6 liters depending on quality. The best bay leaves are grown during the dry season since they are not prone to much water. By weight, the oil contains 2% of nutmeg seeds, 2.5% of Adas leaves, and 0,2% of betel leaves. During the wet season, The produced oil will decrease, and the ingredients will be hard to obtain. For instance, nine quintals of betel nut distillation only produce approximately 1.1 kg of oil when it usually produces 1.5 kg in the dry season.	The researchers aim to determine the mathematics aspects of essential oil production. It was revealed that the essential oil content varies depending on the season, water content, and age of the distilled materials.

Table 1. Community Knowledge-Based Scientific Knowledge Reconstruction Results related to Essential Oils with an Ethno-STEM Approach

Table 2. presents the design results from the implementation of the Ethno-STEM integrated PjBL with activities using the stages from Sudarmin et al., (2020). The syntax for implementing Ethno-STEM integrated PjBL is as follows: 1) Lecturer assigns a project to make Ethno-STEM chemical batik from secondary metabolites; 2) Students in groups conduct discussions to understand the secondary metabolite material and determine the secondary metabolite compounds that will be used as batik motifs; 3) Each group discusses the chemical batik design; 4) Each group submits a chemical batik design from discussion to the lecturer and or batik expert; 5) Students and lecturers arrange schedules, tools, materials, and project implementation; 6) Each group strengthens the design of the batik project through a visit to make batik in Zie Semarang; During the visit, students conduct interviews about the meaning, manufacturing process, tools and materials, and the practice of batik-making; 7) Each group implements the experience they have gained at the batik-making site in Zie Semarang; 8) Each group presented the results of the batik making project to be assessed by the lecturers and other groups from the aspect of color, originality, and creativity as an outcome of students' entrepreneurial character.

Phase	The Syntaxes of Project-Based Learning	The Learning Activities
1	Introducing Problem	The lecturer introduces the learning purpose, urges the students to learn actively, and introduces science ideas relevant to essential oils (definition, isolation, and component identification). The lecturer introduces the essential oil refinement technique, a question-answer session, and a profit-and-loss analysis for the production and business of essential oil.
2	Finding relevant questions	The lecturer provides the class with films and images about the refinement process for essential oils and addresses open-ended questions about essential oil and Ethno-STEM.
3	Arranging the class	The lecturer helps students find material that connects traditional essential oil refinement techniques with Ethno-STEM.
4.	Scheduling	The lecturer assists the class in creating a schedule to complete the project on time.
5	Planning the project	The lecturer encourages the students to cooperatively and rationally plan a chemical batik project.
6	Monitoring the project implementation	The lecturer guides the class while they carried out the planned Project.
7	Monitoring the project improvements	The lecturer and students check whether the project is suitably carried out following the plan. Only if required would the lecturer assist.

Table 2. Syntax of secondary metabolite learning model with Ethno-STEM approach on the topic of essential oils

3.2. Characteristics of Integrated Chemistry Project-Based Learning With Ethno-STEM Approach

The design and characteristics of chemical project-based learning for the secondary metabolite course on essential oils in this study, based on the results of discussions with the research team, an integrated pattern for the Ethno-STEM approach was designed as in Figure 2.

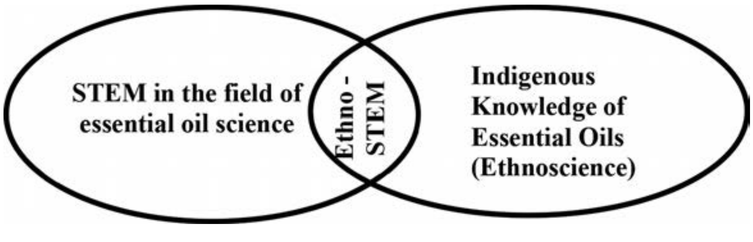

Figure 2. Ethno-STEM Approach Integrated Design Model for Essential Oil Topic

In this model, Ethnoscience and STEM are discussed separately based on the field of Ethnoscience about Indigenous Science and Secondary Metabolite Science, the topic of Essential Oils as scientific knowledge in STEM studies. Its application in the content and context of Ethnoscience and STEM is discussed together or integrated. Students have explained the meaning, types of principal components, and various essential oils in this approach. In the next lesson, we continued with isolation and identification techniques and transformation reactions of the main compounds in essential oils and assigned a chemistry project task in groups to design batik with a chemical structure motif and learn to make batik at Zie Batik Semarang. Students individually or in groups carry out projects by creating chemical batik motifs in the content and context of Ethno-STEM. Thus, the Ethno-STEM Integration section discusses projects related to observing the process and design of batik products with the main structure of various secondary metabolites, how to produce the best batik, understanding the character of the entrepreneurial spirit, conservation, and innovative and creative ideas from batik business people.

3.3. Results of Secondary Metabolite Learning Design with Ethno-STEM Approach to Develop Conservation and Entrepreneurial Character

In instilling conservation and entrepreneurial characters in students, the results of the interviews with the owners and workers were presented. It was found out that the conservation characters of the owners and workers are environmental lovers, caring, and conservation of local plants. Their conservation character is suitable for UNNES (LPPM UNNES, 2019). In this Entrepreneurship course, students were informed about the entrepreneurial nature of the owners and workers of the essential oil business in Boyolali based on the results of interviews. The following are entrepreneurial characters of the owners and workers: (1) persistent, exhibited by their consistent efforts to produce essential oils despite limited facilities, finance, materials, and fluctuating prices; (2) discipline, evidenced by their production target and their diligence in watering, adding fuel, and isolating essential oils; (3) creativity, indicated by their creative way to boost output and recycle waste as compost or fuel to sell it to local farmers. In other words, this research has taught students about the conservation character of love for the environment, care, and responsibility.

The assessment results of students' conservation character are presented in Table 3.

No	Soft skill in conservation	Pretest Score	Postest Score	N-Gain Score	Category
1	Environmental loving	78	89	0,50	Average
2	Environmental caring	75	93	0,72	High
3	Responsibility	79	93	0,67	Average

Table 3. N-Gain Score of Conservation Characters of Students

Conservation characters are evaluated through a test that includes concept mastery questions and questions related to environmental love, care, and responsibility about Ethno-STEM content and context.

3.4. Results of the Implementation of Chemistry Project-Based Learning on the Character of Conservation and Student Entrepreneurship

In this research, the application of chemistry project-based learning with the Ethno-STEM approach was carried out on 23 UNNES Chemistry students who took the secondary metabolites course. In this research, the research team taught the students how to make batik and showed them a tutorial video. After that, the research team facilitated the students to learn batik at Zie Batik Semarang to develop creativity and entrepreneurship. The research team and other student groups evaluated the students' batik results and products. The results are presented in Table 4.

Based on Table 4, the batik motif assessment by the research team found that the motif and originality indicators' average N-gain scores were considered high. Contrarily, creativity, attractiveness, and color choice fell into the average category.

No	Chemical Batik Motifs	Batik Description
1		*Type:* Contrast-colored Lurik *Motif:* The eugenol structures from clove oil, curcuminoid, and clove flower are depicted in the motif. The fabric was colored with synthetic and organic pigments derived from curcumin extract. This fabric holds the price of IDR 300.000 for one meter.
2		*Type:* Contrast-colored Lurik (yellow, red, and white) *Motif:* The motif shows the chemical compositions of curcuminoid, clove leaves, and flowers. A notable fabric that costs up to IDR 350.000/meter was produced by combining curcumin extract with synthetic batik colors.
3		*Type:* Contrast-colored Lurik (brown, yellow, blue, and white) *Motif:* It portrays the chemical structure of curcuminoid with clove flower as the highlight. Using a blend of synthetic coloring and curcuminoid extract, a meter of this batik costs IDR 350.000.
4		*Type:* Contrast-colored Lurik *Motif:* Clove flowers take most place in the fabric, encircling the eugenol, phenylpropanoid, and aromatic compound structures. The color was from teak leaves with artificial coloring. A meter of the batik cloth costs IDR 350.000.

Table 4. Results of Batik Motif Creativity by students and their descriptions in the Ethno-STEM context

4. Discussion

The following are characteristics of the Ethno-STEM-integrated project-based learning model: 1) The learning model developed refers to Patton and Robin (2012) and the Ministry of Education and Culture, which aims at students to design, plan, and create products which, in this case, are chemical structure batik; 2) Students are required to make collaborative decisions and are in charge of handling information to select intriguing batik motifs. Students must create batik motifs of secondary metabolites structures for this study; 3) The process of making batik is continuously evaluated by the lecturer; 4) Lecturers and students periodically reflect on the activities in the batik project; 5) The lecturer assesses the final product of the batik project with the designed instruments qualitatively and quantitatively; and 6) The chemistry project-based learning model with an Ethno-STEM approach is tolerant of change and increases students' creativity and innovation.

Students, teachers, classrooms, schools, and systemic problems are all related to factors contributing to high-quality teaching and learning and an effective educational system (Lee, Hung & Teh, 2014). Students must possess 21st-century skills beyond knowledge and encompass solid morals and character (Halilović et al., 2022). Qualified educators are essential for 21st-century learning (Ozsoy, Ozyer, Akdeniz & Alkoc, 2017; Lin, Tang, Lin, Liang & Tsai, 2019; So, Jong & Liu, 2020). Building, adjusting, and applying knowledge to real-world issues are all highlighted in classroom practice. Effective systems must continually adapt to change (Laar, van Deursen, van Dijk & de Haan, 2017). As it evolves from policy to implementation to produce quality learners, the system is cognizant of the context. This issue draws attention to creating policies and strategies to remain relevant today and uncharted territory in the future. This study examines how the education system is influenced by the school context, community demands, interrelated history, and local wisdom. Furthermore, try to understand how the reforms enacted have aligned the education system with the goals of 21st-century education.

Higher education is one of the institutions that can instill values and totality into the traditional order of society to function as a service institution in carrying out social control mechanisms (Liu & Low, 2015). In connection with the conservation process of regional cultural values, it functions as one of the community institutions in maintaining the traditional values of a society. Therefore, educational institutions play a critical role in developing and preserving local wisdom. Local wisdom acquired in the learning process is expected to shape students' conservation and entrepreneurial characters who think globally and act locally. Because cultural competency will determine the professional value of educational services, teachers must enhance cultural aspects to accommodate cultural diversity in the classroom (Ethnoscience) (Ariyatun, Sudarmin & Triastuti, 2020). As one of the cultural values that live and develop in society, environmental wisdom has made the natural environment sustainable and maintained.

New conservation challenges emerged from the cultural heritage preservation community from the mid-twentieth century to the present (Chalifoux, 2019). New conservation challenges have arisen when the cultural heritage preservation community from the mid-twentieth century to the present. The 21st century has seen global changes in science and technology (Sudarmin & Sumarni, 2018). The changes that take place have a good effect and an increasing effect on the emergence of new concerns linked to global issues that endanger the survival of the human race. Therefore, learning must go through various activities that show and perform/display their character during education. Through multiple activities in learning with the Ethno-STEM approach, students can actively work hard to unconsciously build positive characters within themselves during the learning process (Isnarto, Utami & Utomo, 2018; Chusna, Rokhman & Zulaeha, 2019).

Conservation character education is an educational effort to develop and sow the values of religion, honesty, intelligence, fairness, responsible, caring, tolerance, democratic, polite, loving the homeland, and challenging students to become healthy, superior, and competitive. The importance of conservation character in learning is also supported by research (Isnarto et al., 2018; Rukayah, Bharoto & Malik, 2018, Masrukhi, Priyanto, Supriyanto & Wahono, 2022). According to the study's findings, students can acquire conservation-based character qualities by doing basic tasks that take place within an efficient learning process. This is the rationale behind entrepreneurship education activities that prioritize or inspire and develop students' entrepreneurial characters (Rina, Murtini & Indriayu, 2019; Bakar & Ismail, 2020). Even in schools, it can help students develop the skills and characters necessary to succeed as entrepreneurs.

The success of implementing Ethno-STEM PjBL cannot be separated from the learning process, where the problems presented in PjBL are semi-open, which means that the answers are uncertain. Students are more motivated and interested in engaging in the problem-solving process when real problems are presented and integrated with the local culture. It is also simpler for students to engage with their groups to investigate social facts and phenomena connected to the concepts they study when Ethno-STEM PjBL learning is blended with the local culture (Sumarni, 2018; Sudarmin, Sumarni, & Mursiti, 2019; Ariyatun, 2021). It also encourages students to use higher order thinking skills, use direct experience methods, and involve various modes of communication to learn to find solutions to solve real problems by creating products.

5. Conclusion

The research concluded that a chemical project-based learning model for the secondary metabolites course on essential oils and terpenes and learning tools with an Ethno-STEM approach was feasible and effective for improving students' conservation and entrepreneurial character with moderate and high criteria based on the N-gain score. Entrepreneurial characters, which include persistence, discipline, and creativity, have been developed so that students can produce attractive and worthy chemical batik products for sale.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

Funding

This research was funded by the Directorate of Research and Community Service (DRPM) of the Ministry of Education, Culture, Research and Technology of Indonesia from the Basic Research Scheme for Higher Education Excellence in 2020/2021, with SPK No. 21.23.3/UN37/PPK.3.1/2020

References

Achmad, S.A. (1986). *Kimia Bahan Alam*. Jakarta: Karnunika.

Afriana, J., Permanasari, A., & Fitriani, A. (2016). Implementation Project-Based Learning Integrated STEM to Improve Scientific Literacy Based on Gender. *Jurnal Inovasi Pendidikan IPA*, 2(2), 202-212. http://journal.uny.ac.id/index.php/jipi Jurnal https://doi.org/10.21831/jipi.v2i2.8561

Ahimsa-Putra, H.S. (1985). Etnosains dan etnometodologi: Sebuah perbandingan. dalam Masyarakat Indonesia. *Jurnal Th. Ke-XII*, 2.

Anggorowati, E.L., Shinta, A.A.M., Nafi'ah, E.R., & Lathif, S. (2020). Peran Pendidikan Karakter Sebagai Wujud Pendidikan Berkualitas Sesuai Dengan Tujuan Sustainable Development Goals (Sdgs). *Prosiding Seminar Nasional Pendidikan Biologi V 2019*, 354-361.

Ariyatun, A. (2021b). Analysis of Ethno-STEM Integrated Project Based Learning on Students' Critical and Creative Thinking Skills. *Journal of Educational Chemistry (JEC)*, 3(1), 35-44. https://doi.org/10.21580/jec.2021.3.1.6574

Ariyatun, Sudarmin, & Triastuti, S. (2020). Analysis Science Literacy Competency of High School Student Through Chemistry Learning Based on Projects Integrated Ethnoscience. *Proceedings of the 5th International Conference on Science, Educational and Technology (ISET)*. https://doi.org/10.4108/eai.29-6-2019.2290321

Bahrum, S., Wahid, N., & Ibrahim, N. (2017). Integration of STEM Education in Malaysia and Why to STEAM. *International Journal of Academic Research in Business and Social Sciences*, 7(6). https://doi.org/10.6007/ijarbss/v7-i6/3027

Bakar, M.A.A., & Ismail, N. (2020). Implementation of enterpreneurship, buying and selling activities in mathematics learning to promote students interaction and metacognitive regulation skills. *Journal of Sustainability Science and Management*, 15(5), 151-164. https://doi.org/10.46754/JSSM.2020.07.013

Baran, M., Karakoyun, F., & Maskan, A. (2021). The influence of project-based STEM (PjbL-STEM) applications on the development of 21st century skills. *Journal of Turkish Science Education*, 18(4), 798-815. https://doi.org/10.36681/tused.2021.104

Bilir, A., & Özbas, S. (2017). Evaluation of values, beliefs and norms of high school students on the conservation of biodiversity. *Journal of Turkish Science Education*, 14(3), 26-39. https://doi.org/10.12973/tused.10203a

Bybee, R.W. (2013). *The case for STEM education: Challenges and opportunity*. National Science Teachers Association (NSTA) Press.

Chalifoux, M.S. (2019). Conservation of Character-Defining Engineered Building Systems. *APT Bulletin: The Journal of Preservation Technology*, 50(4), 33-41. https://widgets.ebscohost.com/prod/customerspecific/ns000545/custom proxy.php?url=https://search.ebscohost.com/login.aspx?direct=true&db=edsjsr&AN=edsjsr.26893536&amp%0Alang=pt-pt&site=eds-live&scope= site

Chung, C.C., Lin, C.L., & Lou, S.J. (2018). Analysis of the learning effectiveness of the STEAM-6E special course-a case study about the creative design of IoT assistant devices for the elderly. *Sustainability (Switzerland)*, 10(9), 1-16. https://doi.org/10.3390/su10093040

Chusna, N., Rokhman, F., & Zulaeha, I. (2019). Writing Essay with Conservation Contained in Elementary School to Build Positive Character Education About Environment Article Info. *Journal of Primary Education*, 8(3), 281-290. https://journal.unnes.ac.id/sju/index.php/jpe/article/view/27514

Dewi, C.A., Erna, M., Martini, Haris, I., & Kundera, I.N. (2021). Effect of Contextual Collaborative Learning Based Ethnoscience to Increase Student's Scientific Literacy Ability. *Journal of Turkish Science Education*, 18(3), 525-541. https://doi.org/10.36681/tused.2021.88

Fakhriyah, Yeyendra, & Marianti, A. (2021). Integrasi Smart Water Management Berbasis Kearifan Lokal Sebagai Upaya Konservasi Sumber Daya Air di Indonesia. *Indonesian Journal of Conservation*, 10(1), 67-41. https://doi.org/10.15294/ijc.v10i1.31036

Firman, H. (2015). Pendidikan sains berbasis STEM: Konsep, pengembangan, dan peranan riset Pascasarjana. *Seminar Nasional Pendidikan IPA Dan PLKH Universitas Pakuan, Agustus*.

Hake. (1999). *Analyzing Change/Gain Scorer*.

Halilović, A., Mešić, V., Hasović, E., & Vidak, A. (2022). The Post-Instruction Conceptions about Conservation of Mechanical Energy: Findings from a Survey research with High School and University Students. *Journal of Turkish Science Education*, 19(1), 144-162. https://doi.org/10.36681/tused.2022.115

Hardati, P., Setyowati, D.L., Wilonoyudho, S., & Martuti, N.K.T. (2015). *Pendidikan Konservasi*. Semarang: Magnum Pustaka Utama.

Hardati, P., Setyowati, D.L., Wilonoyudho, S., Martuti, N.K.T., & Utomo, A.P.Y. (2016). *Buku Ajar Pendidikan Konservasi*. Unnes Press.

Isnarto, I., Utami, N.R., & Utomo, A.P.Y. (2018). Identification of Learning Model Including Conservation Value in College As A Strength Of Students' Character. *Proceedings of the International Conference on Science and Education and Technology 2018 (ISET 2018)*, 263-267. https://doi.org/10.2991/iset-18.2018.56

Khusniati, M., Parmin, & Sudarmin (2017). Local wisdom-based science learning model through reconstruction of indigenous science to improve student's conservationist character. *Journal of Turkish Science Education*, 14(3), 16-23. https://doi.org/10.12973/tused.10202a

Kuo, H.C., Tseng, Y.C., & Yang, Y.T.C. (2019). Promoting college student's learning motivation and creativity through a STEM interdisciplinary PBL human-computer interaction system design and development course. *Thinking Skills and Creativity*, 31, 1-10. https://doi.org/10.1016/j.tsc.2018.09.001

Laar, E. Van, van Deursen, A.J.A.M., van Dijk, J.A.G.M., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. *Computers in Human Behavior*, 72, 577-588. https://doi.org/10.1016/j.chb.2017.03.010

Lam, P., Doverspike, D., Zhao, J., Zhe, J., & Menzemer, C. (2008). An Evaluation of a STEM program for middle school students on learning disability related IEPs. *Journal of STEM Education*, 9(1).

Lee, S.S., Hung, D., & Teh, L.W. (2014). Toward 21st Century Learning: An Analysis of Top Performing Asian Education Systems' Reforms. *Asia-Pacific Education Researcher*, 23(4), 779-781. https://doi.org/10.1007/s40299-014-0218-x

Li, Y. (2018). Journal for STEM Education Research - Promoting the Development of Interdisciplinary Research in STEM Education. *Journal for STEM Education Research*, 1(1-2), 1-6. https://doi.org/10.1007/s41979-018-0009-z

Lin, X.F., Tang, D., Lin, X., Liang, Z.M., & Tsai, C.C. (2019). An exploration of primary school students' perceived learning practices and associated self-efficacies regarding mobile-assisted seamless science learning. *International Journal of Science Education*, 41(18), 2675-2695. https://doi.org/10.1080/09500693.2019.1693081

Lisa, D., Rusmiati, F., & Kesuma, Y. (2021). Pelestarian bangunan arsitektur mendukung tujuan pembangunan berkelanjutan (SDGs) di pekon kenali kabupaten lampung barat. *Seminar Nasional Ilmu* Teknik dan Aplikasi Industri (SINTA). http://repository.lppm.unila.ac.id/36693/1/SINTA_2021_diana_lisa.pdf

Liu, W.C., & Low, E.L. (2015). Editorial: teacher education for the 21st century. *Educational Research for Policy and Practice*, 14(3), 189-191. https://doi.org/10.1007/s10671-015-9188-x

LPPM UNNES (2019). *Rencana strategis 2015 - 2019 Lembaga Penelitian dan Pengabdian kepada Masyarakat*. Semarang: UNNES.

Masrukhi, M., Priyanto, A.S., Supriyanto, S., & Wahono, M. (2022). Developing Character in Students Based on Conservation Values, Universitas Negeri Semarang. *Proceedings of the Annual Civic Education Conference (ACEC 2021)* (636, 226-229). https://doi.org/10.2991/assehr.k.220108.041

Morrison, J., Frost, J., Gotch, C., McDuffie, A.R., Austin, B., & French, B. (2021). Teachers' role in students' learning at a project-based STEM high school: Implications for teacher education. *International Journal of Science and Mathematics Education*, 19(6), 1103-1123. https://doi.org/10.1007/s10763-020-10108-3

Murphy, S., MacDonald, A., Danaia, L., & Wang, C. (2019). An analysis of Australian STEM education strategies. *Policy Futures in Education*, 17(2), 122-139. https://doi.org/10.1177/1478210318774190

Nancy (2007). *Model Pembelajaran Kimia Untuk Mengembangkan Sikap Kewirausahaan Siswa*. Universitas Negeri Semarang.

National STEM Education Center (2014). *STEM education network manual. Bangkok: The Institute for the Promotion of Teaching Science and Technology*. https://serc.carleton.edu/StemEdCenters/index.html

Ozsoy, N., Ozyer, S., Akdeniz, N., & Alkoc, A. (2017). An Example Of Prepared-Planned Creative Drama In Second Grade Mathematics Education. *European Journal of Education Studies*, 3(8), 213-222. https://doi.org/10.5281/zenodo.841806

Patton, A., & Robin, J. (2012a). *Work That Matters: The Teacher's Guide to Project Based Learning*. United Kingdom: Paul Hamlyn Foundation.

Reeve, E.M. (2013). *Implementing science, technology, mathematics and engineering (STEM) education in Thailand and in ASEAN*. Institute for the Promotion of Teaching Science and Technology (IPST).

Reffiane, F., Sudarmin, Wiyanto, & Saptono, S. (2021). Developing an Instrument to Assess Students' Problem-Solving Ability on Hybrid Learning Model Using Ethno-STEM Approach through Quest Program. *Pegem Egitim ve Ogretim Dergisi*, 11(4), 1-8. https://doi.org/10.47750/pegegog.11.04.01

Renstra, U. (2019). *Rencana Strategis UNNES (Renstra) 2019- 2023 : Lembaga Penelitin dan Pengabdian Kepada Masyarakat Universitas Negeri Semarang*. P2M UNNES.

Rina, L., Murtini, W., & Indriayu, M. (2019). Entrepreneurship Education: Is It Important for Middle School Students? *Dinamika Pendidikan*, 14(1), 47-59. https://doi.org/10.15294/dp.v14i1.15126

Rukayah, R.S., Bharoto, B., & Malik, A. (2018). Conservation Concept on Areas with Overlapping Character (Moslem, Colonial and Post Independence Era). *Asian Journal of Environment-Behaviour Studies*, 3(8), 45-60. https://doi.org/10.21834/aje-bs.v3i8.278

Saifudin, A. (2012). *Senyawa Alam Metabolit Sekunder*. Yogyakarta: CV Budi Utama.

Sampurnaningsih, S.R., Andriani, J., Zainudin, Z.A.B.A., Sunarsi, D., & Sunanto (2020). The Analysis of Entrepreneurship Character and Entrepreneurship Intention among Students. *Palarch's Journal Of Archaeology Of Egypt/Egyptology*, 17(6), 8290-8303. https://www.archives.palarch.nl/index.php/jae/article/download/2247/2215

Satrohamidjojo, H. (2004). *Kimia Minyak Atsiri*. Yogyakarta: Gadjah Mada Press.

So, H.J., Jong, M.S.Y., & Liu, C.C. (2020). Computational Thinking Education in the Asian Pacific Region. *Asia-Pacific Education Researcher*, 29(1), 1-8. https://doi.org/10.1007/s40299-019-00494-w

Stanley, T. (2021). *Project-Based Learning Gifted Students* (2nd ed.). New York. https://doi.org/10.4324/9781003237310

Suastra, I.W. (2010). Model Pembelajaran Sains Berbasis Budaya Lokal Untuk Mengembangkan Kompetensi Dasar Sains dan Nilai Kearifan Lokal di SMP. *Jurnal Pendidikan Dan Pembelajaran*, 43(2), 8-16.

Sudarmin (2015). *Pendidikan Karakter, Etnosains dan Kearifan Lokal (Konsep dan Penerapannya dalam Penelitian dan Pembelajaran Sains)*. Unnes Press.

Sudarmin, Diliarosta, S., Pujiastuti, S.E., Jumini, S., & Prasetya, A. (2020). The instructional design of ethnoscience-based inquiry learning for scientific explanation about Taxus sumatrana as cancer medication. *Journal for the Education of Gifted Young Scientists,* 8(4), 1493-1507. https://dergipark.org.tr/en/pub/jegys/article/792830

Sudarmin, Mastur, Z., & Parmin. (2017). Kearifan Lokal Di Karimunjawa Untuk. *Jurnal Penelitian Pendidikan Sains*, 6(2), 1363-1369. https://doi.org/10.26740/jpps.v6n2.p1363-1369

Sudarmin, S., Sumarni, W., Rr Sri Endang, P., & Sri Susilogati, S. (2019). Implementing the model of project-based learning: integrated with ETHNO-STEM to develop students' entrepreneurial characters. *Journal of Physics: Conference Series*, 1317(1). https://doi.org/10.1088/1742-6596/1317/1/012145

Sudarmin, & Sumarni, W. (2018). Increasing character value and conservation behavior through integrated ethnoscience chemistry in chemistry learning: A Case Study in the Department of Science Universitas Negeri Semarang. *IOP Conference Series: Materials Science and Engineering*, 349(1). https://doi.org/10.1088/1757-899X/349/1/012061

Sudarmin, Sumarni, W., & Mursiti, S. (2019). The learning models of essential oil with science technology engineering mathematic (STEM) approach integrated ethnoscience. *Journal of Physics: Conference Series*, 1321(3). https://doi.org/10.1088/1742-6596/1321/3/032058

Sudarmin, Sumarni, W., & Susilogati, S. (2018). *Model Pembelajaran Kimia Orgnaik Bahan Alam Dengan Pendekatan STEM Terintegrasi Etnosains Untuk Membumikan Karakater Konservasi dan Kewirausahaan Mahasiswa*. LP2M UNNES.

Sumarni, W. (2018). The influence of ethnoscience-based learning on chemistry to the chemistry's literacy rate of the prospective teachers. *Unnes Science Education Journal*. https://journal.unnes.ac.id/sju/index.php/usej/article/view/23722

Sumarni, W., & Kadarwati, S. (2020). Ethno-stem project-based learning: Its impact to critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, 9(1), 11-21. https://doi.org/10.15294/jpii.v9i1.21754

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

Sumarni, W., Sudarmin, Wiyanto, & Supartono (2016). The reconstruction of society indigenous science into scientific knowledge in the production process of palm sugar. *Journal of Turkish Science Education*, 13(4), 281-292. https://doi.org/10.12973/tused.10185a

Thiagarajan, S., Semmel, D.S., & Semmel, M.I. (1974). *Instructional Development for Training Teachers of Exceptional Children: A Sourcebook*. Indiana University.

Tresnawati, N. (2018). Pembelajaran Sains Berbasis Kearifan Lokal dalam Upaya Peningkatan Konservasi Lingkungan pada Mahasiswa PGSD di Batik Tulis Ciwaringin Cirebon. *Al Ibtida: Jurnal Pendidikan Guru MI*, 5(1), 69. https://doi.org/10.24235/al.ibtida.snj.v5i1.2603

Triana, D., Anggraito, Y.U., & Ridlo, S. (2020). Effectiveness of Environmental Change Learning Tools Based on STEM-PjBL Towards 4C Skills of Students. *Jise*, 9(2), 181-187. http://journal.unnes.ac.id/sju/index.php/jise

Urban, M., & Falvo, D.A. (2015). *Improving K-12 STEM Education Out come through Technological Integration*. IGI Global. https://doi.org/10.4018/978-1-4666-9616-7

Uziak, J. (2016). A project-based learning approach in an engineering curriculum. *Global Journal of Engineering Education*, 18(2), 119-123.

Wahono, B., Lin, P.L., & Chang, C.Y. (2020). Evidence of STEM enactment effectiveness in Asian student learning outcomes. *International Journal of STEM Education*, 7(1), 1-18. https://doi.org/10.1186/s40594-020-00236-1

Werner, O., & Fenton, J. (1970). Method and Theory in Ethnoscience or Ethnoepistemology. Naroll, R., & Cohen, R. (eds.), *Handbook of Method in Cultural Anthropology.* Natural History Press.

Wilson, K. (2021). Exploring the Challenges and Enablers of Implementing a STEM Project-Based Learning Programme in a Diverse Junior Secondary Context. *International Journal of Science and Mathematics Education*, 19(5), 881-897. https://doi.org/10.1007/s10763-020-10103-8

Winarto, Sarwi, S., Cahyono, E., & Sumarni, W. (2022). Developing a Problem-Solving Essay Test Instrument (PSETI) in the Instruction of Basic Science Concepts in Ethnoscience Context. *Journal of Turkish Science Education*, 19(1), 37-51. https://doi.org/10.36681/tused.2022.108

Winarto, W., Cahyono, E., Sumarni, W., Sulhadi, S., Wahyuni, S., & Sarwi, S. (2022). Science Teaching Approach Ethno-SETSaR To Improve Pre-Service Teachers' Creative Thinking and Problem Solving Skills. *Journal of Technology and Science Education*, 12(2), 327-344. https://doi.org/10.3926/jotse.1367

Zakiyah, N.A., & Sudarmin (2022). Development of E-Module STEM integrated Ethnoscience to Increase 21st Century Skills. *International Journal of Active Learning*, 7(1), 49-58. http://journal.unnes.ac.id/nju/index.php/ijal

Published by OmniaScience (www.omniascience.com)

Journal of Technology and Science Education, 2023 (www.jotse.org)