



## PROJECT BASED LEARNING DESIGN DEVELOPMENT OF FOOD ADDITIONAL INGREDIENTS GREEN CHEMISTRY APPROACH TO SUPPORT SCIENTIFIC LITERACY OF CULINARY VOCATIONAL HIGH SCHOOL STUDENTS: AN INTRODUCTORY STUDY

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**Abstract.** *This research aims to determine the need for PjBL learning design and learning tools that use a green chemistry approach to food additives to support the scientific literacy of culinary vocational school students. The type of research used is evaluation research using needs assessment to describe the need for learning designs that can be used to support the learning outcomes of culinary vocational school students. Data was collected in the form of a 12 question survey via Google-form with a total of six culinary vocational school teachers using purposive sampling. The results of the research found that (1) all vocational school teachers in culinary field already understand the specifics of the independent curriculum currently used and are familiar with the scientific literacy competencies listed in the general achievements; (2) 4 out of 6 teachers understand the concept of Cleanliness Health Safety Environmental Sustainability (CHSE), 5 out of 6 teachers understand green chemistry and all teachers state that there is a relationship between these two concepts; (3) 5 out of 6 teachers have implemented PjBL and; (4) all teachers stated that there was a lack of learning resources available to support scientific literacy. The results of this research show that culinary vocational school teachers need a pjbL learning design with a green chemistry approach along with learning tools to support the scientific literacy of culinary vocational school students.*

**Keywords:** *PjBL, food additives, green chemistry, scientific literacy, culinary vocational school students*

### INTRODUCTION

The Vocational High School (*Sekolah Menengah Kejuruan*) curriculum currently in use is the Independent Curriculum. The Independent Curriculum is used to address learning loss due to the COVID-19 pandemic (Jojo & Sihotang, 2022) and to catch up in literacy and numeracy (Arisanti, 2022). The characteristics of the development of the Independent Curriculum are intended for students to explore their talents and interests. In its learning principles, educators must consider the stage of students' development and achievements at present so that learning objectives are in line with students' needs, making learning meaningful and enjoyable (Purnawanto, 2022).

Learning is designed and implemented so that students become lifelong learners who can develop students' competencies and characters holistically, and learning is oriented towards a sustainable future designed according to the context, environment, and culture of students involving parents as partners (Kemdikbud, 2022). Research studies conducted by Sari & Gumindari (2022) and Lince (2022) showed the implementation of the Independent Curriculum in vocational high schools involving good cooperation among teachers, staff, and students in schools, but there are some obstacles in its implementation, namely limited facilities and infrastructure, assessment methods that are still confusing, and limited learning resources.

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The structure of the Independent Curriculum in vocational high schools is divided into two, namely intracurricular learning and strengthening projects for Pancasila student profiles. Intracurricular learning is divided into two groups, namely general and vocational subject groups. The general subject group is used to shape students into integrated individuals in their developmental phases as individual beings and social beings as citizens of Indonesia and the world. Some subjects included in the general group are IPAS Project (Natural and Social Sciences), Mathematics, English, and Informatics. The vocational group includes Vocational Subjects, Creative and Entrepreneurship Subjects, and Elective Subjects that function to shape students to have competencies according to the needs of the job market (Kemdikbud, 2023b).

In the general subject group, there are general achievements that must be achieved by SMK students referring to scientific literacy competencies, namely explaining phenomena scientifically, designing and evaluating scientific investigations, and interpreting data and evidence scientifically (Kemdikbud, 2023a). Several ways can be done to develop scientific literacy competencies of SMK students, namely through STEM-based practicums (Amahorie, 2021), the use of E-LKPD (Siagian et al, 2022) and learning with project-based learning models (Aristawati, 2022).

On the other hand, the characteristics demanded by subjects in the vocational group include Cleanliness Health Safety Environment Sustainability (CHSE), covering food safety, equipment and workplace safety, area and equipment cleanliness, health, and environmental sustainability, which can support knowledge topics regarding food additives (Kemdikbud, 2023a). In line with the concept of CHSE, green chemistry also aims to prevent further damage to health and the environment (Mohammed & Errayes, 2020). Green chemistry refers to the design of processes and products to reduce or eliminate the use and production of toxic and hazardous substances (Moosvi, Naqash, & Najar, 2021).

The relationship between general and vocational subject groups is crucial. If general subject groups can accommodate the needs of vocational subjects, meaningful learning will be achieved, thus enhancing the scientific literacy of SMK students (Solikha, 2016).

Several supportive learning models need to be used to achieve learning outcomes, including discovery learning, inquiry learning, project-based learning, problem-based learning, teaching factories, or other relevant models and methods (Kemdikbud, 2023a). Dwiantoro & Basuki (2021) state that the Project-based Learning (PjBL) model can improve learning outcomes and competencies of SMK students. This learning model also enhances the critical thinking skills of SMK students (Sova, Caswita, & Nurhanurawati, 2022) and increases student engagement (Dharmayani, 2021). The project-based learning model, according to Almulla (2020), provides opportunities for students to solve problems, find valid answers, assist in project selection, think, criticize, reconsider projects, and create products. In culinary vocational high school students, learning is conducted through practical activities in making various food products that can be produced by students. The implementation of learning in culinary vocational high school students is carried out through teaching factory learning, which involves the production process of goods or services to produce products that are in accordance with real conditions in the industry (Febriani et al., 2021).

Other learning methods used include project-based learning (PjBL) to prepare graduates ready to work in entrepreneurship and industry (Qur'ani, 2020a). These learnings, according to Laili et al (2023), focus on practical activities such as making

basic seasonings and various processed products such as spices and herbs to enhance flavor and aroma, such as pepper, thyme, bay leaf, sage, rosemary, etc (Demayanti & Soenarto, 2018). Several studies related to food additives are: (1) making royal icing as a cake coating by adding color using mangosteen peel extract to create a pink color (Harahap & Harahap, 2021); (2) Santiasih et al., (2023) coloring wet noodles using natural colors derived from grape skin extract; (3) Addition of preservatives to wet noodles in the form of gambier extract (Kamsina et al., 2020); (4) the use of tuna by-products as natural flavorings (Mandang et al., 2022). In addition to spices and herbs, the addition of food additives can also use synthetic food additives. For example, (1) adding red color using amaranth (Fardani, 2023); (2) adding benzoic acid, propionate as preservatives (Angeline, *et al*, 2023); and (3) MSG as flavor enhancers (Amanda et al., 2023). The use of synthetic ingredients is allowed if it complies with the regulations, but there are still many instances where food additive regulations are not followed, such as the use of rhodamine B dye found in sauce (Adriani & Zarwinda, 2019), borax preservatives found in meatballs (Sari, 2020), and cannabis flavorings in some typical Aceh dishes (Pohan, 2022).

Based on the aforementioned discussion, this study aims to gain an understanding of the needs for designing project-based learning on the topic of food additives with a green chemistry approach to develop scientific literacy in culinary vocational high school students. This information would be used to create a didactic hypothesis design to produce innovative learning designs and tools on the topic of food additives.

## METHOD

This study employed an evaluation research type with a qualitative and quantitative approach that emphasizes phenomena in real conditions using need assessment (needs analysis) (Altschuld & Eastmond, 2012). Needs analysis is the discrepancy between a series of existing conditions and a series of desired conditions, usually conducted before the development of the required program. The participants in this research were six culinary vocational high school teachers in Cirebon. Purposive sampling was used to obtain a real picture of the didactic design needs and the availability of learning tools at culinary vocational high school.

The data obtained from this preliminary study were specific descriptions of the learning conditions, learning designs used, the need for analysis among teachers, students, and teaching materials so that culinary vocational high school teachers can develop PjBL designs in the Independent Curriculum to support scientific literacy, in addition to designs also available learning resources and PjBL learning tools. The instrument was a survey using Google Forms which included 12 closed and open-ended questions, as well as in-depth interviews. The 12 questions in the preliminary survey were elaborated as follows:

**Table 1. Preliminary survey questions**

Variable and Question Indicator	
<b>Independent Curriculum</b>	
1.	Uniqueness of learning using the independent curriculum
<b>Scientific Literacy Competencies in Vocational High Schools</b>	
2.	Scientific literacy as stated in general outcomes
3.	Needs and reasons for developing scientific literacy competencies in learning using the independent curriculum
4.	Availability of learning resources supporting scientific literacy competencies

<b>Variable and Question Indicator</b>	
5.	Needs and reasons for the availability of learning resources that can be used to develop scientific literacy competencies
<b>Relationship between CHSE and Green Chemistry</b>	
6.	Concept of Cleanliness Health Safety Environmental Sustainability (CHSE) in learning outcomes
7.	Concept of green chemistry
8.	Relationship and reasons for the relationship between Cleanliness Health Safety Environmental Sustainability (CHSE) and green chemistry
<b>Project Based Learning on Food Additive Materials</b>	
9.	Implementation of project-based learning (PjBL) on knowledge of food additive materials
10.	Needs and reasons for the development of PjBL with a green chemistry content on knowledge of food additive materials
11.	Needs and reasons for the availability of learning resources supporting PjBL and green chemistry content on knowledge of food additive materials
12.	Learning design and reasons for the need for PjBL with green chemistry content on knowledge of food additive materials

After conducting the survey, interviews were conducted as follows.

1. Do culinary vocational high school (culinary vocational high school) teachers already understand all green chemistry concepts?
2. Have culinary vocational high school teachers implemented green chemistry concepts in teaching?
3. What green chemistry concepts can be applied to culinary vocational high school teaching?
4. What Project Based Learning (PjBL) designs have been implemented?
5. What teaching materials have been applied in the implemented PjBL designs?

## RESULTS AND DISCUSSION

Based on the preliminary survey results to several culinary vocational high school (culinary vocational high school) teachers in Cirebon using Google Forms, several pieces of information were obtained from the 12 questions in the survey. The survey questions include the uniqueness of learning in the independent curriculum, scientific literacy competencies in vocational high schools, the relationship between the CHSE (Cleanliness Health Safety Environmental Sustainability) concept and green chemistry, and the PjBL (Project Based Learning) design on food additive materials in culinary vocational high school curriculum.

**Table 2. Uniqueness of learning in the independent curriculum**

<b>Question Indicator</b>	<b>Answers</b>
Uniqueness of learning using the independent curriculum	Differentiated learning, student-centered, allows creativity and innovation, authentic learning, not relying on a single learning source, and has freedom while still referring to learning outcomes.

Survey results indicate that all culinary vocational high school teachers already understand the uniqueness of learning using the independent curriculum. This is evidenced by their responses regarding the uniqueness of the curriculum. Consistent with the guidelines for implementing the independent curriculum, differentiated

learning is used in student-centered learning, which is studied thoroughly according to the needs arising from differences among students, including knowledge, learning styles, interests, and understanding of subjects, using various teaching methods to produce meaningful learning.

The uniqueness of the independent curriculum lies in its ability to foster creativity and innovation according to the principles of learning and assessment, which are expected to guide teachers in designing and implementing meaningful learning so that students become more creative, critical thinkers, and innovative. Furthermore, the uniqueness of the independent curriculum lies in the freedom to design learning objectives and the flow of learning objectives that are in line with its learning outcome. This is in line with the guidelines for independent curriculum learning that learning outcome and flow of learning objectives in vocational schools can be formulated together with industry partners. Students do not rely solely on one learning source from teacher explanations in the classroom, but the environment outside the classroom can also be utilized as a learning source (Pitaloka & Arsanti, 2022). Authentic learning and assessment used in the independent curriculum on strengthening the Pancasila learner profile project aim to explore the meaning of the project (Sari *et al.*, 2022).

In addition to the characteristics mentioned above, there are other unique aspects of the independent curriculum, namely the development of soft skills and character. The development of both is carried out through the Pancasila learner profile strengthening project, which is expected to encourage students to become lifelong learners who are competent, have character, and behave in accordance with Pancasila values (Kementerian Pendidikan, Kebudayaan, Riset, 2022).

**Table 3. Scientific literacy competencies in vocational schools**

Question Indicator	Answers
Scientific literacy as stated in general outcomes	All teachers are familiar with scientific literacy
Need for the development of scientific literacy competencies in learning using the independent curriculum	All teachers express the need to develop scientific literacy.
<ul style="list-style-type: none"> <li>Reasons for the need for the development of scientific literacy competencies</li> </ul>	<ul style="list-style-type: none"> <li>Culinary fields are closely related to food and scientific fields, hence literacy is required, with greater variation, as it is a basic competence that vocational school students must have for applying knowledge in daily life and for students to learn to think more logically</li> </ul>
Availability of learning resources supporting scientific literacy competencies	Three teachers responded that learning resources supporting scientific literacy competencies are available, three teachers responded that learning resources supporting scientific literacy competencies are not yet available

Question Indicator	Answers
Need for learning resources that can be used to develop scientific literacy competencies	All teachers express the need for learning resources to strengthen scientific literacy.
<ul style="list-style-type: none"> <li>Reasons for the need for learning resources to strengthen scientific literacy competencies?</li> </ul>	<ul style="list-style-type: none"> <li>To support the teaching-learning process, as learning resources will support teaching-learning processes, for motivation, so that students can more easily apply and develop their competencies, to broaden insights into learning resources, and to increase knowledge so that they can explore culinary science</li> </ul>

Furthermore, the survey results regarding scientific literacy indicate that all culinary vocational high school teachers are already familiar with scientific literacy competencies. This is because scientific literacy competencies are included in the general outcomes of SMK students, which include explaining phenomena scientifically, designing and evaluating scientific investigations, and translating data and evidence scientifically. According to all culinary vocational high school teachers, scientific literacy competencies need to be developed in learning using the independent curriculum. Various reasons for the need to develop scientific literacy competencies include "to enable students to think more logically, apply knowledge in daily life, as it is a basic competence that vocational school students must have, to make learning more varied, and because the culinary field is closely related to food and scientific fields, thus requiring literacy." Yuliati (2017) explains that the role of scientific literacy in learning is crucial for students to think more logically. Scientific literacy is applied in daily life as scientific knowledge to identify, make decisions, and conclude related to interactions with science, the environment, technology, and society (Situmorang, 2016).

Survey results regarding learning resources supporting scientific literacy competencies have been available. Three culinary vocational high school teachers responded that they are available, and three other teachers responded that they are not yet available. Since the results are equal, the researcher investigated the availability of learning resources from the internet. The results showed that there are several learning resources supporting scientific literacy competencies available for culinary vocational high school students. Jofrisha & Seprianto (2020) effectively implemented a food chemistry module through an ethnokimia approach to mastering chemistry learning outcomes, effectiveness, and understanding of ethnokimia. Similarly, Kusumaningtyas & Al (2018) developed reading materials for SMK Tourism majors in Culinary Skills regarding food additives. Based on the limited availability of learning resources, it indicates that culinary vocational high school teachers require additional learning resources to develop scientific literacy competencies.

**Table 4. Relationship between CHSE and green chemistry**

Question Indicator	Answers
Concept of Cleanliness Health Safety Environmental Sustainability (CHSE) in learning outcomes	Four out of six teachers are familiar with the concept of CHSE

Question Indicator	Answers
Concept of green chemistry	Five out of six teachers are familiar with the concept of green chemistry
Correlation between Cleanliness Health Safety Environmental Sustainability (CHSE) and green chemistry	All teachers state that there is a relationship between CHSE and green chemistry.
<ul style="list-style-type: none"> <li>Reasons for the relationship between Cleanliness Health Safety Environmental Sustainability (CHSE) and green chemistry</li> </ul>	<ul style="list-style-type: none"> <li>In the implementation of CHSE, knowledge of green chemistry is needed. There is a close relationship between CHSE and green chemistry; every activity is expected to be in hygienic conditions, with green chemistry, the resulting products are healthier and safer, as they are part of environmental health, and environmental cleanliness is related to environmental health.</li> </ul>

The concept of CHSE is known by 4 culinary vocational high school teachers, and 2 teachers are unfamiliar with this concept. Based on Kemdikbud (2023) the concept of CHSE is listed in the learning outcomes in the culinary vocational high school curriculum. This concept is listed in vocational group subjects, namely Culinary Basics, so some teachers are familiar with this concept. The CHSE concept emerged in the tourism sector as health protocols due to the COVID-19 pandemic, where the pandemic situation necessitates health assurance for tourists when traveling (Kristiana et al., 2021).

The next survey regarding the concept of green chemistry, five out of six culinary vocational high school teachers are already familiar with the concept of green chemistry. Five culinary vocational high school teachers are familiar with 12 green chemistry concepts because they overlap with the CHSE concept, which they have been familiar with, focusing on health and hygiene. Green chemistry is not new in education, but culinary vocational high school teachers have never applied it. Actually, indirectly, culinary vocational high school teachers have applied green chemistry, but they are not aware of it, such as using safe ingredients for making various types of sauces from tomatoes, chili, or mushrooms. Green chemistry has been introduced 20 years ago with its 12 principles: 1. Prevent waste; 2. Atom economy; 3. Less hazardous synthesis; 4. Design benign chemicals; 5. Benign solvents and auxiliaries; 6. Design for energy efficiency; 7. Use of renewable feedstocks; 8. Reduce derivatives; 9. Catalysis; 10. Design for degradation; 11. Real-time analysis for pollution prevention; 12. Inherently benign chemistry for accident prevention (Erythropel *et al.*, 2018). Incorporating green chemistry into lessons can help address problems through multidisciplinary collaboration and be beneficial in preparing students to face global challenges and contribute to sustainable development (Aubrecht *et al.*, 2019). Zuin *et al.*, (2021) mention that the concept of green chemistry can be applied in various educational scopes, including at the upper secondary level, universities, and professional education.

The use of natural food additives is closely related to the application of green chemistry. One example is the extraction of compounds from microalgae as food additives because they are a high-nutrient compound source containing various macronutrients (protein, carbohydrates, and lipids), essential and non-essential amino

acids, chlorophyll, carotenoids, polyphenols, polysaccharides, etc (Barba et al., 2015).

According to all culinary vocational high school teachers, the concepts of CHSE and green chemistry are related. Some reasons why these two concepts are related are "environmental cleanliness is related to environmental health, every activity is carried out in hygienic conditions. With green chemistry, it is expected to produce healthier and safer products, the application of CHSE requires green chemistry." Both concepts focus on the environment and health. In the CHSE concept, green chemistry can be applied by implementing its 12 principles. With the application of CHSE to culinary vocational high school students, support from other multidisciplinary fields such as green chemistry is required, for example, the application of green chemistry principles such as preventing waste from dragon fruit peel. With natural coloring, the use of safer chemicals can be applied instead of synthetic dyes. One natural food additive is the colorant from dragon fruit peel (Lubis *et al.*, 2020) and (Ermawati et al., 2022) utilize green mussel shells that can be used as natural flavors.

**Table 5. Design of PjBL on food additive knowledge**

Question Indicator	Answers
Implementation of project-based learning (PjBL) on food additive knowledge	Four out of six teachers have already implemented PjBL on food additive knowledge
Need for PjBL design with green chemistry content on food additive knowledge <ul style="list-style-type: none"> <li>Reasons for developing PjBL with green chemistry content on food additive knowledge</li> </ul>	All teachers state the need to implement PjBL with green chemistry content on food additive knowledge <ul style="list-style-type: none"> <li>To be able to use safe additives in the production process, to preserve the earth, to minimize chemicals, or not use chemicals at all.</li> </ul>
Need for learning resources supporting PjBL and green chemistry in food additive knowledge <ul style="list-style-type: none"> <li>Reasons for the need for learning resources supporting PjBL and green chemistry in food additive knowledge</li> </ul>	All teachers state the need for learning resources supporting PjBL with green chemistry content on food additive knowledge <ul style="list-style-type: none"> <li>It is necessary to develop these learning resources so that students can explore the material more effectively, achieve optimal learning, add references, understand green chemistry, and have clear sources regarding food additive knowledge.</li> </ul>
Design of PjBL with green chemistry content on food additive knowledge <ul style="list-style-type: none"> <li>Reasons for the need for PjBL with green chemistry content on food additive knowledge.</li> </ul>	All teachers state the need for a PjBL design with green chemistry content on food additive knowledge <ul style="list-style-type: none"> <li>To ensure optimal delivery of learning, the lesson plan will facilitate teachers in achieving learning objectives maximally, making learning more organized, understanding and teaching about green chemistry.</li> </ul>



Four culinary vocational high school teachers have implemented project-based learning (PjBL) in food additive knowledge, while two have not. From the interviews conducted, it was found that teachers who have implemented PjBL in some subjects, such as food production, including various sauces, and Indonesian and Continental cuisines. The projects undertaken are also applied in the school area by selling various food products to cafes within the school so that students not only gain knowledge and skills but also gain experience as entrepreneurs. Teachers who have not implemented PjBL still use lecture methods in their teaching because the available time is limited, so PjBL cannot be conducted. Several studies on PjBL in culinary vocational high school students include: (1) Qur'ani (2020) developed PjBL learning tools in basic culinary material used to develop creative ideas of students due to the passivity of previous learning; (2) Ni *et al.*, (2023) the implementation of PjBL can improve collaboration, communication, problem-solving, and management skills in pastry and bakery product subjects; (3) Laili *et al.*, (2023) also applied PjBL to basic spice materials and produced the same results, which can improve knowledge and skills.

Project-based learning (PjBL) with green chemistry content on food additive knowledge is needed by all culinary vocational high school teachers and requires supportive learning resources for PjBL with green chemistry content on food additive knowledge. Additionally, there is a need for a design of PjBL with green chemistry content on food additive knowledge.

According to the respondents, a project-based learning design on food additive topics with a green chemistry approach is necessary to develop scientific literacy among culinary vocational high school students. In general, culinary vocational high school teachers state that scientific literacy can support the teaching and learning process and enhance knowledge to explore science in the culinary field. So far, the lack of learning resources and teaching tools has been one of the factors preventing the implementation of science literacy-supporting learning on food additive topics.

## CONCLUSION

The preliminary study results indicate the need for a design and teaching tools for project-based learning on food additives using a green chemistry approach. This is to meet the general learning outcomes, namely scientific literacy competencies and learning outcomes in the CHSE concept for culinary vocational high school students. Recommendations for further research include the need for the design and implementation of project-based learning on food additive topics with a green chemistry approach to develop scientific literacy in culinary vocational high school students.

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