Jurnal Pemberdayaan Masyarakat
Volume 4 Nomor 2 Tahun 2025 | Hal. 390 – 39
ykgm.org

ISSN 2962-8091
DOI: 10.46843/jpm.v4i2.449

Integration of Local Wisdom in Science Learning: Project-Based Additive Substance E-Module to Improve Science Literacy

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ABSTRACT

This study aims to develop an e-module for learning about additives in Natural Sciences, incorporating project-based learning and local wisdom to enhance the scientific literacy of Grade VIII junior high school students. The method employed is Research and Development (R&D) with the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation. The study involved 32 students from SMPN 2 Padarincang. The module validation was conducted by material and media experts, as well as science teachers, using the Content Validity Ratio (CVR) and Content Validity Index (CVI), both of which indicated that the module is highly feasible and valid. A one-group pretest-posttest experimental design was used for the module trial, demonstrating a significant improvement in students' scientific literacy with an average N-gain value of 0.6421 (moderate category). The integration of local wisdom through the context of milkfish satay processing offers a relevant and engaging learning experience, promoting a deeper understanding of the concept of additives. Students responded positively to the e-module, providing strong feedback on its effectiveness. This research contributes to science education by offering an innovative, culturally relevant approach to teaching natural sciences, fostering improved scientific literacy, and illustrating the potential of project-based learning integrated with local wisdom. The findings suggest that project-based e-modules, when combined with local context, can be effective tools for enhancing scientific literacy in middle school students, advancing both pedagogical strategies and educational outcomes in science.

ARTICLE INFORMATION

Keywords:
teaching materials additives; project based; local wisdom; scientific literacy

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Recommended citation: Wiwin., Rubini, B., Permana, I., Rachman, I., & Kodama, Y. (2025). Integration of Local Wisdom in Science Learning: Project-Based Additive Substance E-Module to Improve Science Literacy. *Jurnal Pemberdayaan Masyarakat, 4*(2), 399-41.

INTRODUCTION

Science is a strategic subject that plays a role in developing students' scientific thinking, including mastery of scientific products, processes, and attitudes. The primary competency that must be achieved in science learning is scientific literacy, which refers to students' ability to apply scientific knowledge to identify problems, draw conclusions, and understand natural phenomena and the impacts of human activities (Yulianti, 2017; Oktaviani, 2019). Scientific literacy is one of the main indicators in global education assessments, such as *the Programme for International Student Assessment* (PISA). *The Organization for Economic Cooperation and Development* (OECD) conducted an assessment of international students aimed at measuring their knowledge and skills in sustainable development, as part of the PISA study. The results show that science literacy in Indonesia is very low. Table 1 presents the results of the PISA analysis.

Table 1. Analysis of science literacy scores based on PISA

Year	Indonesia average score	PISA average score	Indonesia Ranking	Number of Participating Countries
2012	375	500	64	65
2015	403	500	62	70
2018	396	500	70	78
2022	383	500	64	81

(OECD, 2023; Kementerian Pendidikan dan Kebudayaan, 2023)

PISA 2022 data recorded Indonesia's average score of 383, far below the international standard of 500, with a ranking of 64th out of 81 participating countries (Kementerian Pendidikan dan Kebudayaan, 2023). This illustrates the challenges students face in applying scientific knowledge contextually and analytically in everyday life. This condition not only affects students but also teachers, who serve as learning mediators and still rely heavily on standard printed modules without considering the needs and local context of students (Syatriana et al., 2015; Putra et al., 2022).

Various strategies have been developed to enhance science literacy, including discovery learning, problem-based learning, and integrated learning (Pursitasari et al., 2019; Ardianto & Rubini, 2016; Putri et al., 2023). However, the development of project-based e-modules that integrate elements of local wisdom into science learning remains limited. Local wisdom has excellent potential as a learning context that is familiar to students and rich in scientific value (Rahayu et al., 2020; Wulandari et al., 2022). One example of appropriate local wisdom is the process of making milkfish satay, a typical Banten culinary dish, which incorporates the concept of natural additives and can be explored in science learning. Based on this, this study aims to develop a science e-module on additive materials that is project-based and integrates local wisdom in the process of making milkfish satay, serving as an innovation to enhance students' science literacy. This module is expected to be a learning medium that is not only informative but also contextual and meaningful for students.

METHOD

This study employs the Research and Development (R&D) method, utilizing the ADDIE model, which consists of five systematic stages: *Analysis, Design, Development, Implementation, and Evaluation* (Rafles, 2023; Branch, 2020). This model was chosen because it can produce learning products that align with user needs and learning contexts. The subjects of the study were 32 students of class VIII of SMPN 2 Padarincang, who were selected using a purposive sampling technique based on specific criteria to represent the target population (Creswell & Creswell, 2018). Data were collected using several instruments, including expert validation sheets to assess the quality of learning materials and media, science literacy tests in the form of multiple-choice questions and essays, and response questionnaires to measure students' responses to the module. Table 2 presents the interpretation of the calculation results.

Table 2. Percentage Criteria

Level of Achievement	Criteria
81-100%	Highly Eligible
61-80%	Eligible
41-60%	Fairly Eligible
21-40%	Uneligible
<20%	Highly Uneligible

Module validation is conducted using the Content Validity Ratio (CVR) and Content Validity Index (CVI) to ensure the quality and feasibility of the module prior to implementation (Lawshe, 1975; Yusoff, 2020). After the module was declared valid, a trial was conducted using a one-group pretest-posttest experimental design to measure the effectiveness of the module in improving students' scientific literacy (Sugiyono, 2021). Data analysis used quantitative and qualitative approaches. Quantitative analysis includes a normality test using the Shapiro-Wilk test, a homogeneity test, a t-test to determine significant differences between the pretest and posttest, and an N-Gain calculation to measure the level of improvement in students' scientific literacy (Hake, 1998). Qualitative analysis was conducted by examining student and teacher responses to the developed module to gain a comprehensive understanding of the quality and effectiveness of module use (Creswell & Creswell, 2014).

RESULTS AND DISCUSSION

The development of this *e-module* utilizes the ADDIE (Analysis, Design, Development, Implementation, Evaluation) research model, with adjustments made to the teaching materials being developed. Through these stages, *the e-module* is developed systematically to ensure effective implementation in learning. Analysis Stages (Analysis) At this stage, the analysis involves examining the needs of project-based e-modules that integrate local wisdom. The first step is to analyze the teaching materials used in schools related to the topic of additives, as well as the needs of teachers based on the questionnaires distributed. The needs analysis shows that the teaching materials used in schools are not optimal in integrating project-based approaches, local wisdom, and science literacy. A survey conducted among science teachers revealed that 80.51% of teachers wanted teaching materials that were contextual, applicable, and aligned with local culture. This finding aligns with the work of Rahayu et al. (2020) and Wulandari et al. (2022), who demonstrate that integrating local wisdom into learning can enhance students' motivation and understanding of science concepts.

Design Stages: At the design stage, learning objectives are clearly defined, and the structure of the e-module is designed to incorporate the concept of additives and integrate local wisdom in the context of making milkfish satay. This supports a relevant and meaningful learning experience, as recommended by Kartika et al. (2023). Development stages: The development stage aims to produce an e-module of additive substances based on local wisdom to enhance students' scientific literacy, which has been validated based on suggestions and input from expert validators. The expert validators consist of two media expert validators and two material expert validators. Table 3 presents the validation results conducted by two media expert validators.

Table 3. Validation by Media Experts

Aspect	Validation Percentage	Criteria
Module Size Design	90%	Highly Eligible
Module Cover Design	75%	Eligible
Module content design	81.4%	Highly Eligible

The media expert validation results assess three aspects: the module size design received a score of 90%, categorized as Highly Eligible; the module cover design was categorized as Eligible; and the module content design received a score of 81.4%, categorized as Highly Eligible. This can be interpreted as meaning that the development of an e-module that integrates projects and local wisdom is easy to use, and the content within the e-module can be effectively utilized in learning. Both validation results from media experts and material experts align with Eliza et al. (2024), who suggest that applications created by combining local wisdom and accessible via Android devices make

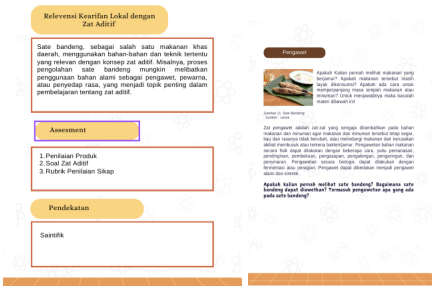
learning more practical and enjoyable. Table 4 presents the validation results carried out by two material experts, in addition to the media expert validation.

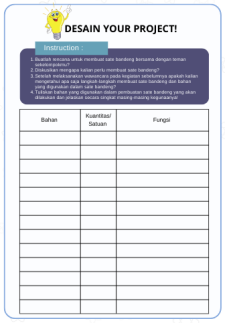
Table 4. Validation by Material Experts

Aspect	Validation Percentage	Criteria
Content Suitability Aspect	82%	Highly Eligible
Aspects of Language Feasibility	82%	Highly Eligible
Presentation Aspects	77%	Eligible
Aspects of scientific literacy	85%	Highly Eligible
Project-based additive module conformity assessment aspects	83%	Highly Eligible

The e-module validation show that the presentation of the Content Feasibility aspect gets a presentation value of 82% with the criteria of Very Feasible, the Language Feasibility Aspect with the criteria of Very Feasible, the Presentation Aspect gets a percentage of 77% with the criteria of Feasible, the Science Literacy Aspect gets a percentage of 85% with the criteria of Very Feasible, the Assessment Aspect of the suitability of the project-based additive module gets a percentage of 83% with the criteria of Very Feasible. In addition to providing assessments, both media expert validators and material experts provide several inputs to ensure that the developed e-module is more optimal and still relevant for use today. This fact is supported by Syuzita et al. (2023), who suggest that suggestions from validators can help refine and improve e-modules for optimal educational quality. Table 5 presents the suggestions and results of the e-module revision.

Table 5. Suggestions From Media and Material Experts and Results of e-Module Revisions

Suggestion	Before Revision	After Revision
Consistency in the use of fonts		
Discussion of additives in relation to local wisdom would be good if it started with the context of milkfish satay, followed by an introduction/ explanation of additives.		

Suggestion	Before Revision	After Revision
Next, present students with challenges/problems that must be solved by producing specific products. Let students explore and plan projects in groups. In project activities, do not write down the tools and materials, nor the steps in detail.		

Next, the e-module, which material experts and media experts have improved, is assessed by 20 science teachers to determine the Content Validity Ratio (CVR) and Content Validity Index (CVI), thereby evaluating the feasibility of the developed e-module. Table 6 shows the results of the CVR and CVI analysis.

Table 6. Analysis of CVR and CVI

Aspect	CVR	CVI	Criteria
Language Eligibility Aspects	1	1	Valid
Presentation Feasibility Aspect	0.95	0.975	Valid
Content Suitability Aspect	0.808	0.985	Valid
Average	0.919	0.986	Valid

The average CVR is 0.919, and the CVI is 0.986, both of which meet the 'Valid' criteria. According to Lawshe (1975), the minimum CVR value for 20 respondents to be considered valid is 0.42. Based on these criteria and the average CVR results, it can be concluded that the e-module developed is suitable for use in learning. Implementation Stages: The module was tested on 32 Grade VIII students for 16 lesson hours. Learning was conducted face-to-face, with online e-module access and project-based group activities. The material includes an introduction to natural and artificial additives, as well as an exploration of making milkfish satay, a local wisdom that incorporates natural additives. Learning Activity 1 contains material on sweeteners, colorings, preservatives, flavorings, and aromas. In addition, Activity 1 students identify additives in food and drinks. Then, students explore local wisdom by conducting an exploration activity of making milkfish satay.

Figure 1. Activities of Identifying Food and Beverages and Observation

Activity 2: Students reveal additives in the content of milkfish satay as a local wisdom of Serang City, create projects, observe, present project results, and evaluate. Activity 2 is displayed in Figure 2. Some local wisdom related to Serang's milkfish satay is presented in Table 7.

Figure 2. Creating and Presenting a Project

Table 7. Relationship between additive material and local wisdom of milkfish satay

Aspects Analyzed	Relationship with Additive Material	Student Findings from the Milkfish Satay Project
Natural ingredients in milkfish satay	Use of natural ingredients as natural additives (preservatives, colorings, flavorings)	Students identified kluwek and garlic as natural additives used in the processing of milkfish satay.
Traditional preservation process	The concept of additives as natural preservatives versus artificial preservatives	Students discovered that roasting and natural seasonings function as traditional food preservatives.
Local food processing techniques	Application of additives to maintain the texture, taste, and color of food	Students analyzed that regional spices not only provide flavor but also extend shelf life.
Comparison of natural and artificial additives	Evaluation of the effectiveness and impact of natural vs. artificial additives	Students experimented comparing the durability of milkfish satay using natural and artificial additives.
Local cultural and economic values	The social context of the use of additives in typical foods	Students realize that the use of natural additives in milkfish satay reflects local cultural values and the economic potential of the community.
Impact on health	Scientific literacy about the effects of artificial additives if consumed excessively	Students relate the results of the analysis to scientific information about the risks associated with consuming artificial additives, such as formaldehyde and synthetic sweeteners.
Awareness of healthy and wise consumption	Scientific attitude in choosing healthier foods	Students concluded the importance of using natural additives and avoiding excessive use of artificial additives.

Table 7 presents the analysis showing that integrating additive materials with local wisdom in the milkfish satay processing project significantly improved students' scientific literacy. The findings indicate that students could identify natural ingredients, such as kluwek and garlic, as common additives used in food processing. These ingredients function as preservatives, flavorings, and natural colorings, consistent with the concept of additives covered in the learning module (Rahayu et al., 2020; Wulandari et al., 2022).

In this project, observations were made on the shelf life of milkfish satay that had been given kluwek as a natural preservative. The purpose of the trial was to determine the extent to which kluwek can extend the shelf life of the product without altering its organoleptic quality, including taste, aroma, and texture (Ismanto et al., 2023; Putri et al., 2023). The results of the observations showed that on the first to third day, the milkfish satay was still in good condition with a fresh color, fairly good texture, and aroma and taste that remained delicious. However, starting on the fourth day, changes occurred, including the appearance of mold, a pale color, and a decrease in the quality of aroma and taste. However, on the fifth day, although the texture began to soften and the smell became unpleasant, the use of kluwek was proven to slow down the decay process that usually occurs faster without preservatives.

In general, the use of kluwek successfully increased the shelf life of milkfish satay by 3-4 days with organoleptic quality that was still acceptable to consumers. In addition, based on student observations during the cleaning, seasoning, and grilling stages, the processing process was carried out according to the procedure, resulting in a final milkfish satay that was quite stable and evenly cooked. Thus, kluwek has the potential to be a natural preservative that is environmentally friendly and safe to use in processed fish products, especially milkfish satay, without compromising taste and aroma (Ismanto et al., 2023; Susanti & Pranoto, 2021). Next, students demonstrated scientific literacy skills in the process dimension by conducting a scientific investigation into the grilling mechanism and the use of natural spices in preserving milkfish satay. They observed that the grilling process and traditional spices play a role in naturally extending the shelf life of food. This reflects the understanding that preservation is not only achieved with artificial additives but can also be accomplished through traditional processing techniques that utilize natural ingredients containing antimicrobial and antioxidant compounds. Tubagus (2019) discuss the revitalization of traditional fish-based food processing techniques, including milkfish satay, to add cultural value as well as effective shelf life.

In addition, students can analyze how regional spices not only provide flavor but also play a role in maintaining the texture and color of food. This confirms that natural additives have a dual function similar to artificial additives, but with lower health risks (Sen, 2021; Awulachew, 2024). The results of the experiment show that although the effectiveness of natural additives tends to be slower, they are still able to maintain food quality without causing adverse health impacts. Students relate the project analysis results to scientific information on the negative impacts of using artificial additives, such as formaldehyde and synthetic sweeteners, on human health (Warner, 2024). This understanding fosters an awareness of the importance of consuming safe and healthy food, encouraging students to develop a critical and discerning attitude when choosing food ingredients.

From a social and cultural perspective, students recognize that the incorporation of natural additives in traditional dishes like milkfish satay reflects local cultural values and has economic potential that supports community empowerment. This demonstrates that contextual learning not only enhances students' scientific understanding but also cultivates an appreciation for local cultural heritage and resources (Emda, 2023; Aramyanta et al., 2024). Evaluation Stages (Evaluation): After all learning activities are completed, the results of students' scientific literacy are determined before and after using the e-module through a posttest and pretest. Table 8 shows the results of the improvement in students' scientific literacy based on the pretest and posttest of the project-based modules and local wisdom.

Table 8. Results of Science Literacy Test

Description	Scientific literacy test	
	Pretest	Posttest
Number of students	32	32
Lowest value	20	50
The highest score	65	100
Average value	39.625	77.218
Std Deviation	18.61003	
Average N gain	0.6421 (Medium Category)	

Table 8 shows an improvement in students' scientific literacy before and after the implementation of the project-based e-module on additives and local wisdom. The N-Gain value of 0.6421 falls into the 'Medium' category, indicating that the e-module is 'quite effective' in enhancing students' scientific literacy, as supported by Hake's (1998) effectiveness criteria. Furthermore, to determine the level of significance before and after learning, an inferential test was conducted. Table 9 presents the results of the analysis conducted using the SPSS application.

Table 9. Results of Normality and Hypothesis Tests

Score	Number of students	Normality Test		Hypothesis Test	
		Score	Information	Score	Information
Pretest	32	0.626	Normal	0,000	Significant
Posttest	32	0.183			

The significance of using project-based e-modules and local wisdom was tested through a prerequisite normality test, using the Shapiro-Wilk test due to the sample size being less than 100. The normality test results show that the Sig. values for the pretest and posttest are 0.626 and 0.183, respectively. Since both values are greater than 0.05, the data are likely to be normally distributed. According to Ghozali (2016), data with a significance value greater than 0.05 can be considered normally distributed. Therefore, both the pretest and posttest data in this study meet the assumption of normality.

After the prerequisite test is met, the next step is to conduct a Paired T-test, which is used to compare the average measurement of scientific literacy before and after implementation. The results of the analysis show a t-count of -18.166 and a Sig. (2-tailed) value of 0.000. The significance value is smaller than the alpha value of 0.05. The results of this study are based on research conducted by Yasir et al. (2022), which found a significant difference between the pre- and post-implementation of local culture-based learning. The fact that the null hypothesis (H0) is rejected indicates that there is a difference in the value of the scientific literacy measurement before and after implementation. This suggests that the e-module of additives based on projects and local wisdom can be used to improve students' scientific literacy. After all learning activities were completed, the research continued by examining student responses to the use of e-modules, the results of which are presented in Figure 3.

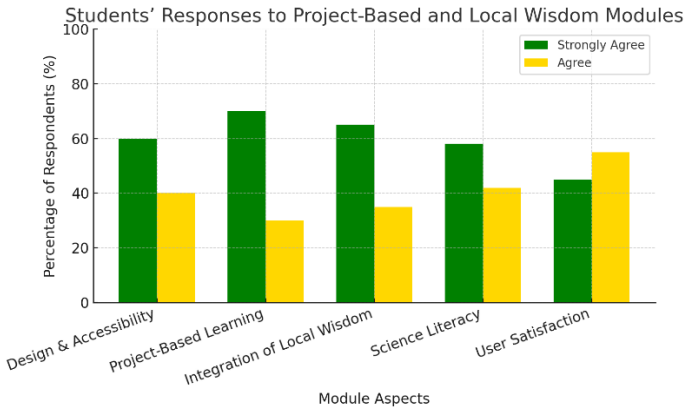


Figure 3. Student Responses to Project-Based Modules and Local Wisdom

Based on the results of the questionnaire administered to students, the student responses to the e-module were overwhelmingly positive. As many as 60% of students stated that they strongly agreed that the module had a good appearance and accessibility, 66.7% strongly agreed with the project-based learning method, and 63.35% strongly agreed with the integration of local wisdom. The scientific literacy aspect also received a positive response, with 57.7% strongly agreeing. This response suggests that the use of the module enhances students' understanding and engagement in science learning (Putri et al., 2023; Rahayu et al., 2020). However, the aspect of satisfaction with the use of the module had the lowest percentage of "strongly agree" (43.35%), indicating the need for improvements in comfort and the overall learning experience.

The results of this study confirm previous findings that combining project-based learning with the integration of local wisdom can significantly improve students' scientific literacy (Kartika et al., 2023; Wulandari et al., 2022). The use of local wisdom, such as processing milkfish satay, not only makes learning more contextual but also raises students' awareness of local cultural values and economic potential (Ismanto et al., 2023). Although the N-Gain value is still in the moderate category, this can be influenced by the relatively short learning duration and variations in students' initial abilities. Therefore, the development of advanced modules with longer durations and more diverse variations of activities is recommended to increase effectiveness further.

The novelty of this research lies in the Integration of project-based e-modules with local wisdom in enhancing students' scientific literacy. Unlike previous studies that primarily focused on generic e-modules or conventional teaching methods, this research specifically incorporates local cultural knowledge and materials, such as additives traditionally used in food processing, to foster a deeper understanding of scientific concepts. The focus on local wisdom as a learning tool is a distinctive aspect that sets this study apart from others in the field. When compared with previous research, this study's results show significant improvements in students' scientific literacy, evidenced by a moderate N-Gain value of 0.6421, indicating a "quite effective" level of enhancement. In contrast, studies by Rahayu et al. (2020) and Wulandari et al. (2022) also found positive impacts of educational interventions on scientific literacy, but they did not integrate local wisdom in the way this research does.

Furthermore, the pretest and posttest results here meet the normality assumption, as indicated by the Shapiro-Wilk test, reinforcing the reliability of the findings. In summary, the novelty of this research lies in its application of local wisdom through project-based modules, a feature that has not been extensively explored in similar educational contexts. The findings are consistent with previous

studies, but the inclusion of local knowledge provides an additional layer of cultural relevance that enhances students' learning experience and scientific understanding.

CONCLUSION

The development of an e-module on additives, based on projects and local wisdom, is an effective innovation in science education that can enhance students' scientific literacy. This e-module combines interactive visual design with a project-based learning approach and the integration of local wisdom, particularly in the context of milkfish satay processing, making the material more relevant and contextual. Through real-world activities such as project creation, observation, and experimentation, this e-module not only strengthens students' understanding of the concept of additives but also raises their awareness of the potential of local resources and the health benefits of natural ingredients. Expert validation indicates that the e-module is highly feasible in terms of presentation, content, and language. Additionally, positive student responses and an increase in scientific literacy, with an average N-Gain value of 0.6421, confirm that this e-module is effective for use in the learning process. The impact of applying the research findings is the enhancement of science learning quality that is more contextual and relevant to students' everyday lives, particularly in recognizing and utilizing local wisdom. This not only enriches students' knowledge but also introduces them to the use of local resources in a broader context, while supporting the development of their scientific literacy.

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