15 (2) (2026) 270-278

Unnes Science Education Journal

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Integrating Local Wisdom: The Impact of Jember Batik E-Modules on Science and Digital Literacy Among Future Physics Educators

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DOI: http://dx.doi.org/10.15294/usej.v15i2.33706

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Article Info

Submitted 2025-11-09
Revised 2026-04-03
Accepted 2026-08-29

Keywords

Digital Literacy; Digital Module, Literacy; Local Wisdom; Science Literacy

Abstract

Digital modules can be integrated with local wisdom as a region's cultural wealth, encompassing moral values, knowledge, and potential as a source of contextual science. Local wisdom is viewed as ideas, beliefs, rules, and cultural dimensions inherent in a society. The purpose of this study is to examine the impact of the Jember Batik local wisdom-based digital module on students' science and digital literacy. The research method employed was a One-Group Pretest–Posttest design replicated across three classes to assess the consistency of the module's effectiveness. This study involved 101 Physics Education students, selected through purposive sampling. The results showed that for the science literacy indicator, the N-Gain values were consistent across the three classes at 0.36–0.37, indicating moderate improvement. Additionally, the paired-sample t-test results showed a significant (2-tailed) value of 0.000 across all classes, indicating that implementing the digital module based on Jember Batik's local potential significantly improved students' science literacy. Furthermore, the digital literacy assessment revealed that students achieved a good category with an average score of 79.99. These findings indicate that the Jember Batik local wisdom-based digital module is practical in the learning process and supports the development of future teacher competencies in the 4.0 era. In addition, this module can be adapted by schools in other regions by integrating local wisdom from their own areas into digital-based teacher training content.

How to Cite

Nuraini, L., Dewi, N. M., Sani, A. S., Wulandari, R. D., & Syarkowi, A. (2026). Integrating Local Wisdom: The Impact of Jember Batik E-Modules on Science and Digital Literacy Among Future Physics Educators. *Unnes Science Education Journal*, 15(2), 270-278.

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p-ISSN 2252-6617

INTRODUCTION

Science literacy refers to the ability to understand, interpret, and apply scientific information in life. Science literacy is very important because it can help solve various problems and make wise decisions related to science and technology, so that by mastering science literacy, individuals are more active and critical in facing the developments of the times (Haryanto et al., 2024; Naila et al., 2021). The importance of science literacy for prospective physics teachers lies in their ability to create relevant and contextual learning by linking scientific concepts, culture, and the environmental conditions of students. Through the integration of local wisdom into learning materials, prospective teachers can design learning experiences that are more meaningful, deepen students' understanding, and increase their involvement in the learning process (Syahda & Deta, 2023). Research by Mardiani et al., (2024) shows that the use of digital tools in science education can improve students' science literacy. The integration of technology with effective literacy teaching methods strengthens scientific understanding and supports more interactive and diverse learning. The challenges of technological developments in designing innovative physics learning tools pose complex dilemmas for educators, particularly regarding their limited knowledge and skills in integrating technology, which hinders them from creating learning that meets the demands of the times and designing creative and effective learning tools (Naen et al., 2024).

The ability of educators to design learning tools is part of pedagogical competence (Haji et al., 2023). However, in reality, the ability of physics teachers to implement digital-based physics learning is still relatively low. The limited components related to technology is one of the reasons for the lack of maximization of physics teachers' ability to integrate technology into the learning process. This is also due to the lack of ability of physics teachers in understanding the use of tools and technology in learning, which makes them feel less confident to try digital-based learning approaches. In addition, the lack of adequate guidance and support is also a challenge in learning this digital-based technology (Yusro et al., 2023). Complementing these pedagogical challenges is the critical shortage of educational resources that integrate local wisdom. According to an analysis by Herdiana et al. (2021), the development of e-modules based on local potential is still in its early stages and remains highly limited. This scarcity is a significant concern because integrating local context into digital media is essential for a substantial improvement in scientific literacy. As emphasized by Humairah & Wahyuni (2024), the struggle to enhance science literacy is often worsened by the inadequacy of conventional media, which fails to facilitate complex competencies. Consequently, the development of digital modules serves as a strategic solution, as they possess the unique ability to transform abstract scientific concepts into interactive visual formats that are more accessible and engaging for students.

One of the efforts to increase students' interest in learning is by integrating culture into learning, such as in physics lessons (Asbanu, 2023). Local wisdom-based learning can certainly be created through a learning environment and learning experiences that aim to develop students' competencies so that they are able to understand the natural world more effectively and interestingly from a scientific perspective (Wulansari & Admoko, 2021). One of the cultures that is currently developing in the Jember community is the making of Jember Batik crafts. Jember batik motifs have undergone significant development with inspiration coming from the exploration of natural resources. Therefore, physics learning can be linked to local wisdom integrated through the use of digital modules as a way to deliver physics material in a more interesting and accessible way to students (Nuraini et al., 2023). The patterns and process of making Jember Batik involve various physics concepts. In terms of patterns and geometry, batik motif creation uses the principles of translation, rotation, reflection, and dilation to create repeating patterns. In terms of coloring (optics), the colors of batik cloth are produced by chemical compounds in dyes that absorb part of the light spectrum and reflect certain colors. Meanwhile, mechanical concepts can be seen in the pressure and force used during the canting process, as well as the fluid flow that utilizes the viscosity of liquid wax during the canting process. In addition, the wax heating process involves the principles of thermodynamics.

The development of digital modules integrated with local wisdom can be an effective solution when applied to digital literacy. The development of these e-modules is an alternative solution to problems and a new breakthrough in the development of innovative teaching materials in the era of the 4.0 industrial revolution in science and digital literacy simultaneously (Hendri et al., 2021). The development of digital modules will be more significant in facilitating science and dig-

ital literacy if it is linked to local wisdom because learning can be easily understood and accepted by students. One of the local wisdoms applied in the development of these digital modules is the making of Jember Batik crafts, which can be integrated into the science and digital literacy of students (Dimyati et al., 2024). However, despite the importance of these literacies, recent PISA data indicates that Indonesian students' science literacy remains low and has shown a declining trend over the last two decades (Madawistama et al., 2024). This is further aggravated by students' poor conceptual understanding, especially in physics topics perceived as difficult (Sukma & Diyana, 2024). Current teaching methods often remain conventional and lack innovative media that bridge abstract concepts with local reality. While digital modules and local wisdom have been studied separately, the novelty of this research lies in the simultaneous integration of Jember Batik local wisdom into a digital platform to enhance both science and digital literacy concurrently. This integrated approach specifically targeting prospective physics teachers has not been extensively explored.

Rapid technological developments and demands for relevant and meaningful learning are both challenges and opportunities for prospective physics teachers, so that the integration of technology, science, and local culture can be an innovative solution to overcome these challenges. Advances in technology and social media can support prospective physics teachers in understanding science and digital literacy, especially in physics subjects based on local wisdom (Rahmawati et al., 2021; Válek, 2025; Putri & Silaban, 2023). Therefore, this study aims to examine the influence of a digital module based on local wisdom, namely Jember batik, on science literacy and analyze its impact on the digital literacy of prospective physics teacher students.

METHOD

This study employed a quantitative approach with a one-group pretest–posttest design across three classes to ensure consistent results (Sugiyono, 2013). Prior to implementation, the digital module was developed using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation)(Branch & Varank, 2009). In the analysis phase, an exploration of Jember's local potential was conducted through Batik Mboeloe craftsmen to identify physics concepts within the batik-making process. The design phase was executed based on these analysis results by drafting a module design that integrated the batik process with relevant physics material. The module was designed to be interactive, offering menus for competencies, materials, simulation videos, and quizzes. Subsequently, during the development phase, the module was developed and validated by three experts, including media and materials experts. The validation results showed that the module was in the very valid category, with an average validity score of 89.17%, indicating that it is feasible for implementation. The implementation phase was carried out by piloting the module in a Basic Physics learning course involving 101 prospective physics teacher students, divided into three classes. The final stage was evaluation, which aimed to assess the module's effectiveness on students' science and digital literacy using pretest and posttest results.

Data collection methods used three main instruments: a science literacy test, a digital literacy questionnaire, and a student response questionnaire. The science literacy test consisted of 10 multiple-choice items administered before and after learning. These questions were developed based on science literacy indicators, namely explaining phenomena scientifically, evaluating and designing scientific inquiry, and interpreting data and evidence scientifically. The digital literacy instrument and student response questionnaire were measured using a self-assessment Likert scale. Scores were assigned on a scale of 1 to 5, with the following criteria: strongly disagree (SD) = 1, disagree (D) = 2, neutral (N) = 3, agree (A) = 4, and strongly agree (SA) = 5. The digital literacy questionnaire comprised 10 statements, while the student response questionnaire comprised 16. The digital literacy questionnaire was structured based on indicators of information retrieval, content evaluation, and knowledge assembly. Meanwhile, the student response questionnaire was administered at the end of the lesson to measure student perceptions of the digital module's quality. This questionnaire covered three response indicators: interest, relevance, and understanding.

Data were analyzed using descriptive and inferential statistics. In science literacy data, the improvement of learning outcomes was calculated using the Normalized Gain (N-Gain) formula according to (Hake, 1998):

$$N - Gain = \frac{S_f - S_i}{S_{max} - Si}$$

The N-Gain results were then interpreted based on the criteria in Table 1.

Table 1. N-Gain Criteria

N-gain	Category
N-gain ≥ 0.70	High
0.30 ≤ N-gain < 0.70	Medium
N-gain < 0.30	Low

Furthermore, to determine the significance of the difference between pretest and posttest scores, a paired sample t-test was performed with a significance level of $\alpha = 0.05$.

Digital literacy and student response data were analyzed using percentage descriptive statistics with the formula:

$$percentage = \frac{f}{N} \times 100\%$$

with f as the obtained score and N as the maximum score. The digital literacy percentage results were converted to qualitative categories based on Table 2.

Table 2. Criteria for student digital literacy

Interval	Category
84 < X ≤ 100	Excellent
68 < X ≤ 84	Good
52 < X ≤ 68	Fair
36 < X ≤ 52	Poor
0 < X ≤ 36	Very Poor

Meanwhile, the student response percentages were categorised according to Table 3 to determine the level of module practicality.

Table 3. Student Response Criteria

Interval	Category
81 – 100%	Very Positive
61 – 80%	Positive
41 – 60%	Fairly Positive
21 – 40%	Less Positive
< 21%	Not Positive

RESULT AND DISCUSSION

Implementation of a Digital Module Based on Local Wisdom of Jember Batik on the Science Literacy of Physics Education Students

In this study, the results of the pretest and posttest analysis were used as a method of evaluating students' science literacy in the context of physics learning. The assessment was carried out using a digital module based on the local wisdom of Jember batik crafts. Data were obtained by measuring the pretest scores to assess the students' initial abilities before the application of the digital module and the posttest scores to assess their final abilities after using the digital module.

The pretest results showed that the average initial scores of students in class A were 41.17, class B were 39.41, and class C were 37.27. After the implementation of the digital module, the posttest scores increased to 64.51 for class A, 61.76 for class B, and 60.60 for class C. Furthermore, an N-gain analysis was conducted to determine the effectiveness of a method or treatment in the study. The N-gain test was used to evaluate the effectiveness of using learning media in the form of digital modules based on the local wisdom of Jember batik crafts in physics learning. The effectiveness of a treatment can be seen from the N-gain results. The pretest, posttest, and N-gain results for science literacy in Table 4.

Table 4. Pretest, posttest, and N-Gain results for science literacy

No	Class	Pretest	Posttest	N-Gain	Category
1	A	41.17	64.51	0.36	Moderate
2	B	39.41	61.76	0.37	Moderate
3	C	37.27	60.60	0.37	Moderate

Based on the results of the N-Gain analysis, class A had an N-Gain of 0.36, while classes B and C had an N-Gain of 0.37. According to the N-Gain score criteria, all classes were classified as moderate. Therefore, it can be concluded that the use of a digital module based on the local potential of Jember batik crafts is effective in improving students' science literacy. Then, statistical analysis using a t-test was used to evaluate the significant difference between the pretest and post s in science literacy after the implementation of the digital module based on local wisdom of Jember batik crafts. The results of the paired sample t-test are shown in Table 5.

Table 5. Paired Sample T-test

		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Pretest-Posttest	-22.9703	11.00405	1.09494	-25.14263	-20.79796	-20.98	100	.000

Based on the t-test table 5, it was found that sig (2-tailed) in class A, B and C was *0.000*. The sig (2-tailed) values of the three tests are < *0.05*, which means that there is a difference in the average science literacy data between pretest and posttest. This proves that there is a significant effect of the application of learning using digital modules based on the local potential of Jember batik crafts on the science literacy of students.

Implementation of Digital Modules Based on Local Wisdom of Batik on the Digital Literacy of Physics Education Student

The evaluation of students' digital literacy achievement was carried out through the use of a questionnaire after the implementation of the digital module based on the local wisdom of Jember batik crafts. The achievement of digital literacy was analyzed based on three indicators, namely use skills, critical understanding, and communicative abilities. The results of digital literacy achievement after the implementation of the module can be seen in Table 6.

Table 6. Digital Literacy

No	Digital Literacy Indicators	Class			Average	Category
		A	B	C		
1	Use skill	84	83	85.9	84.3	Very good
2	Critical understanding	80	80	81	80.33	Good
3	Communicative abilities	75	75	76	75.33	Good
Total					79.99	

Based on Table 6, after implementing the digital module, students' average digital literacy was 79.99. This result shows that students can operate and utilise the features of the digital module during the learning process. In more detail, digital literacy in each indicator is as follows. For the use skill indicator, the average score for classes A, B, and C was 84.3, which is in the excellent category. For the critical understanding indicator, the average score for the three classes was 80.33, which is in the good category. Similarly, for the communicative abilities indicator, the average score was 75.33, which is in the good category.

Implementation of Local Wisdom-Based Digital Batik Modules on the Responses of Physics Education Students

Student response assessment was based on three indicators: interest, relevance, and understanding. The results of the student response evaluation after the module implementation can be seen in Table 7.

Table 7. Student Responses

No	Student Response Indicators	Class			Average	Category
		A	B	C		
1	Interest	89.4	86.8	88.9	Very good	Very good
2	Relevance	85.6	82	81.9	Good	Good
3	Understanding	86.2	82.4	83.6	Good	Good

Based on Table 7, after implementing the digital module, the responses of students from classes A, B, and C showed a very positive category. The indicators of interest, relevance, and understanding of students were in the range of 81–100%, indicating very positive criteria. The results of the evaluation of student responses showed that the implementation of a digital module based on the local potential of Jember batik crafts received a very positive response.

Discussion

Science literacy

Science literacy can be defined as scientific knowledge and skills to be able to identify questions, acquire new knowledge, explain scientific phenomena, and draw conclusions based on facts, understand the characteristics of science, awareness of how science and technology shape the natural, intellectual, and cultural environment, and the willingness to engage and care about science-related issues (OECD, 2019). The scientific literacy analysed in this study is manifested in pretest and posttest scores. Based on the N-gain test results, the average value was 0.36-0.37, which falls within the moderate range. It can therefore be concluded that the use of local potential-based digital modules is efficacious in improving students' science literacy. The next step is to determine whether there is a difference in effectiveness before and after learning with local potential-based digital modules on Jember batik crafts, using a paired-samples t-test. This test aims to determine the difference in physics literacy scores before and after learning using a digital module based on the local potential of Jember batik crafts. The results of the paired-sample t-test show that sig (2-tailed) for the three classes is 0.000, indicating a difference in the average science literacy scores between the pretest and posttest. This shows that applying learning through digital modules based on the local potential of Jember batik crafts significantly improves

students' science literacy.

The digital module developed has proven effective in strengthening students' abilities to explain phenomena, design investigations, and interpret data and scientific evidence (Adri, 2023; Herlina & Abidin, 2024; Wardhana & Hidayah, 2022). However, in this study, the indicator most facilitated by the module was the indicator of explaining phenomena. In general, this indicator measures the extent to which students can apply scientific knowledge and concepts to phenomena around them, rather than simply memorising definitions (Ashari et al., 2023). The digital module used in learning activities serves to bridge theory with batik culture. This is because the module is designed with in-depth visualisation and simulation features, particularly in the material on temperature and heat (Thermodynamics). In conventional learning, students are often only presented with equations or formulas in the thermodynamics chapter, which prevents them from visualising the process. As a result, students tend to memorise formulas but do not fully understand the concepts. Through these digital modules, students are shown how heat affects the bonds between wax particles, including the process by which wax changes form when heated. This helps students better understand the concept of latent heat. The visualisation also supports students' ability to construct logical scientific explanations, for example, why the waxing temperature must be kept stable. This finding is consistent with the multimedia learning theory, which states that well-organised words and images can aid human memory, thereby reducing unnecessary cognitive load, managing complexity, and promoting deep information processing (Mayer, 2024).

Digital literacy

Integrating digital literacy into the teaching of fluid physics is an important step in shaping students' character. Digital literacy can be an effective means of through various open applications. In addition to making it easier for teachers and students to access learning, digital literacy can be the key to improving the quality of education (Dewi et al., 2021). According to Safitri et al. (2020), digital literacy refers to a person's ability to understand digital content. However, in the early stages of development, literacy is defined as the skill of using various forms of language and video to read, write, listen, speak, see, express ideas, and reflect on ideas critically. Further developments in the understanding of literacy reveal that literacy also involves social and situational contexts in its use.

In this study, digital literacy was analyzed through a questionnaire consisting of 10 statements for each indicator, namely use skill (3 statements), critical understanding (3 statements), and communicative abilities (4 statements). This questionnaire was given to classes A, B, and C. The results of analysis show that average digital literacy score for the use skill indicator is 84.3, categorized as very good, indicating that students have excellent skills in using digital physics modules. For the critical understanding indicator, the average score is 80.33, categorized as good, indicating students' ability to critique and evaluate information in digital physics learning modules well. Meanwhile, for the communicative abilities indicator, the average score was 75.33, also categorized as good, indicating that students' ability to communicate and convey ideas clearly was good. Given the technological era, students have adapted to the times and developed adequate digital literacy skills (Aisyah, 2021). These findings indicate that implementing digital modules affects all digital literacy indicators, including use skills, critical understanding, and communicative abilities. This aligns with Zufahmi et al. (2025) findings, which show an increase in digital literacy scores after implementing AR-based e-modules. The findings indicate feature-rich e-modules can hone digital skills, not just subject content.

In an era where technology plays an important role in learning and communication, the results of this study show that students have successfully integrated digital literacy into their daily lives. With excellent use skills, they are able to utilize digital physics modules smoothly and efficiently. In addition, good critical understanding skills show that students have the expertise to assess and understand the information encountered in the context of digital physics learning. They are able to dig deeper, identify relevant information, and develop a deep understanding of the subject matter (Zubaidah, 2018).

Good communicative abilities also indicate students are able to communicate clearly and effectively in conveying ideas and thoughts (Hikamah et al., 2021). They not only have knowledge, but are also able to communicate that knowledge well to others through digital media (Reyna et al., 2018). Thus, the results of this study not only reflect students' digital literacy achievements in the context of physics learning but also reflect their adaptation to digital era. This shows digital literacy is not just an additional skill but has become an integral part of students' lives and learning in the present day (Wahyudin & Adiputra, 2019).

Student responses

Student responses can be defined as the behavior or reactions of students during learning activities. A response can arise when the five senses are involved in observing and paying attention to an object of observation. There are several factors that influence a response, namely experience, learning process, and personality traits (Arini & Lovisia, 2019). The student responses analyzed in this study were manifested in the form of questionnaire scores after implementing a digital module based on the local potential of Jember batik crafts. The assessment of student responses was based on three indicators, namely interest, relevance, and understanding. The student response questionnaire consisted of 16 questions, with 5 questions from the interest indicator, 5 questions from relevance indicator, and 6 questions from the understanding indicator. The results of the student response questionnaire after the implementation of the digital module based on the local potential of Jember batik crafts in class A were 87.17 with a very positive category, in class B were 83.73 with a very positive category, and in class C were 84.8 with a very positive category.

Science learning can be adapted according to the uniqueness and characteristics of a region so that students no longer see science as a foreign culture to learn, but as part of the local culture and wisdom in the area where they live (Sulistri et al., 2020). Thus, the integration of culture and local wisdom into the Batik Jember local wisdom-based digital module can increase the attractiveness and meaning of science learning for students. In addition, Batik Jember local wisdom-based digital module is used to teach digital literacy and science literacy to students. Apart from improving students' understanding of the use of information and communication technology, this module also helps students understand physics concepts found in their surroundings, especially in Jember Batik crafts. Haryanto et al. (2024) suggests showing concept videos so that students can understand concepts and explain phenomena around them scientifically in accordance with the competency indicators in science literacy. With digital module, students can access information not only from instructors, so they no longer depend on instructors as their sole source of knowledge. This enables more interactive and student centered learning, where students can actively engage in the learning process (Dini et al., 2023).

CONCLUSION

Based on the results of the study on the effect of digital modules based on the local wisdom of Batik Jember on students' science literacy and digital literacy, it can be concluded that implementing the module produced a moderate improvement in science literacy that was consistent across all three classes involved in the study (A, B, and C), and this improvement was statistically significant, indicating that digital modules grounded in the local potential of Jember batik crafts have a meaningful effect on strengthening students' science literacy. The students also responded very positively to the module, expressing strong interest, perceiving it as highly relevant to their learning, and demonstrating a solid understanding of the material it presented.. This shows that the digital module based on local wisdom of Jember Batik is effective in the learning process.

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