Received : 24 May 2025
Revised : 29 October 2025
Accepted : 9 December 2025
Published: 25 December 2025
Issued : 30 December 2025

DOI: doi.org/10.21009/1.11210

Development of Digital Ethno-STEM Teaching Materials on Renewable Energy for Patriotism

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Abstract

This research produced a product in the form of ethno-STEM-based digital teaching materials on renewable energy. The research method used was Research and Development (R&D) with the Analyze, Design, Development, Implementation, and Evaluation (ADDIE) development model. The development stage was limited to the development stage because this study focused on the content validity and design of ethno-STEM-based digital teaching materials on renewable energy. The purpose of this study was to produce teaching materials that were feasible and effective in fostering a love for the homeland in students. The results showed that the ethno-STEM-based digital teaching materials were developed in accordance with BSNP standards and digital media. The characteristics of the digital teaching materials produced lie in the holistic integration of the bamboo spinning top culture in the STEM approach. The material validity test results for the teaching materials obtained a score of 96.35%, and the media validity obtained a score of 97.41%. Thus, it can be stated that ethno-STEM teaching materials are suitable for use in learning. The teaching materials developed not only meet technical requirements but also have pedagogical potential in supporting physics learning that fosters a sense of patriotism through the integration of regional cultural potential. However, this study is limited to the development stage, so further studies are needed to test the effectiveness of teaching materials in fostering a sense of patriotism in students.

Keywords: Ethno-STEM, Teaching Materials, Renewable Energy, Patriotism

INTRODUCTION

Indonesia is a country with a wealth of diversity. Indonesia has enormous potential for renewable energy, but its use remains low compared to fossil fuels (Saraswati et al., 2024). Education about renewable energy needs to be taught so that students have the awareness and competence to design sustainable solutions (Tunggal Prasetiyo et al., 2022; Fitriani et al., 2024). Efforts to preserve the environment are a tangible manifestation of patriotism (Salfadilah et al., 2024). Patriotism is a feeling of pride in one's culture, language, and traditions, as well as a commitment to preserve and protect them (Nasution & Daulay, 2024). Patriotism as an affective aspect is very important to foster in learning. Patriotism can be fostered by introducing the concept of renewable energy alongside traditional technology and local wisdom (Maryam et al., 2022). Local wisdom can be implemented through an ethnoscience approach (Lestarani et al., 2021).

The ethnoscience approach is an approach that integrates learning materials with local culture (Fianti & Neratania, 2024). Ethnoscience is an important aspect of education (Pangga et al., 2023). The application of ethnoscience in the learning process benefits the preservation of local culture (Rahmi at al., 2024). Ethnoscience encourages students to explore and learn science by utilizing the potential in their surroundings (Widarti et al., 2025). Ethnoscience can be combined with the Science, Technology, Engineering, and Mathematics (STEM) approach. The STEM approach combines four disciplines, namely science, technology, engineering, and mathematics (Fransiska & Sidabutar, 2022; Maslichah et al., 2024). STEM is a very effective approach to apply in 21st-century education (Kamal et al., 2024). The STEM approach combined with ethnoscience is called the ethno-STEM approach.

Ethno-STEM is a culture-based STEM approach that integrates local culture into the STEM learning process (Utrujjah et al., 2024). Ethno-STEM is an approach that can help students face global competition (Awaliyah et al., 2022). The Ethno-STEM approach focuses on interdisciplinary learning (Utrujjah et al., 2024). The integration of ethno-STEM in learning enables students to interpret renewable energy material in the context of culture and the surrounding environment, so that science can be understood as part of national identity. The results of interviews with physics teachers at State Senior High School 1 Jatilawang in Banyumas Regency, Central Java, show that science learning in the classroom remains focused on school teaching materials oriented toward memorizing concepts. The values of love for the homeland are not implemented in learning. This type of learning hinders the growth of scientific awareness and national values among students. The problem of the low correlation between scientific knowledge and local cultural realities shows the need for innovation in the presentation of more relevant teaching materials.

Teaching materials are learning media that contain material that must be studied, examined, and learned by teachers and students (Yonanda et al., 2020). Digital teaching materials are multimedia-based electronic teaching materials that serve to convey material so that learning becomes more interactive (Rachmah et al., 2018; Natisr et al., 2022). Digital instructional materials offer advantages in providing learning experiences and enhancing students' motivation to learn (Suhendra et al., 2024). Learning using digital instructional materials is more effective and efficient than using printed instructional materials (Darmansyah et al., 2023).

Therefore, the development of ethno-STEM-based digital teaching materials is a relevant and strategic solution. The ethno-STEM approach integrates renewable energy concepts with local wisdom, enabling students to understand science as part of their nation's life and culture. Meanwhile, digital formats can create practical, engaging, and user-friendly learning experiences. With this in mind, this study aims to develop digital teaching materials based on ethno-STEM on the subject of renewable energy that can foster students' love for their homeland.

METHODS

This study uses a research and development (R&D) approach with the Analyze, Design, Development, Implementation, and Evaluation (ADDIE) model. The procedure for developing renewable energy teaching materials using the ADDIE model begins with the analyze stage. At this stage, researchers analyze the problems and needs in the learning process used in product development. Data in the analysis stage was obtained based on the results of a literature review and interviews with physics teachers. Semi-structured interviews were conducted with two high school physics teachers to identify learning needs and the local cultural context. The interview instrument focused on three main parts, namely the need for digital media, the integration of cultural values in learning to foster love for the country, and the local cultural context of Banyumas. The interview results were analyzed using qualitative descriptive analysis.

The second stage is the design stage. At this stage, researchers create a draft or design for the product being developed, namely digital teaching materials on renewable energy. The teaching materials are designed to foster love for the homeland in students through ethno-STEM learning. The design stage begins with an analysis of learning outcomes and objectives, the collection of renewable energy materials, the development of indicators of love for the country, and the design of teaching materials.

The next stage is the development stage. At this stage, researchers realize the designed teaching materials into digital teaching materials using Canva software. After that, material validity and media validity tests were conducted on the teaching materials to ensure that they were suitable for use in learning. The validity test was carried out by five validators consisting of three lecturers and two high school physics teachers. The validation instrument used a Likert scale. The validity test results were analyzed using a percentage formula and Aiken's V.

The ADDIE stages are limited to the development stage. This is because this study focuses on the content validity and design of ethno-STEM-based digital teaching materials on renewable energy. The implementation and evaluation stages have not been carried out because the product must be tested for feasibility by experts before being implemented in the classroom. In addition, the limited time available for the study and the scope of field testing were also considerations in limiting the study to the development stage, so that the analysis could focus on content quality and the potential for integrating values of love for the homeland. Thus, this study produced a product that is ready to be implemented in further studies to measure its effectiveness in fostering love for the homeland among students.

RESULTS AND DISCUSSION

This research produced digital teaching materials on renewable energy. The digital teaching materials developed consist of three main parts: introduction, content, and conclusion. The introduction includes the cover, preface, table of contents, teaching material features, learning instructions, content standards, and concept maps. The teaching materials are supplemented with summaries, exercises, learning reflections, and images or videos related to the material. The videos and images in the teaching materials make it easier for students to understand the material (Armini et al., 2023). The conclusion section of the teaching materials contains a glossary, bibliography, and author biography. The glossary section contains terms used in the teaching materials. The bibliography section contains references used by the author. The author biography section contains the author's personal details.

Digital teaching materials have characteristics that distinguish them from other teaching materials, namely the holistic integration of local culture into the STEM approach. Some of the local cultures featured in these teaching materials include the tradition of cooking using anglo in Banyumas to explain how chemical energy stored in wood is converted into heat energy, lighting torches in the tradition of Malam Satu Suro in Solo to explain the concept of light energy originating from torches and lamps, the use of solar energy for drying fish in Karimunjawa, Jepara to explain one of the concepts of renewable energy, namely solar energy, and others. The main cultural focus raised in the teaching materials is the bamboo spinning top game. The bamboo spinning top is a traditional game that originated in Jepara, Central Java. This game is an example of cultural practices or customs of traditional communities that have been passed down from generation to generation. Traditional communities use bamboo spinning tops for entertainment. The bamboo spinning top game is used as a medium for teaching renewable energy material to explain the concept of energy conversion, the principle of the law of conservation of energy, and the concept of renewable energy. The local cultural context in the teaching material is shown through the "Get to Know Science Through Culture" feature. This feature is shown in FIGURE 1.

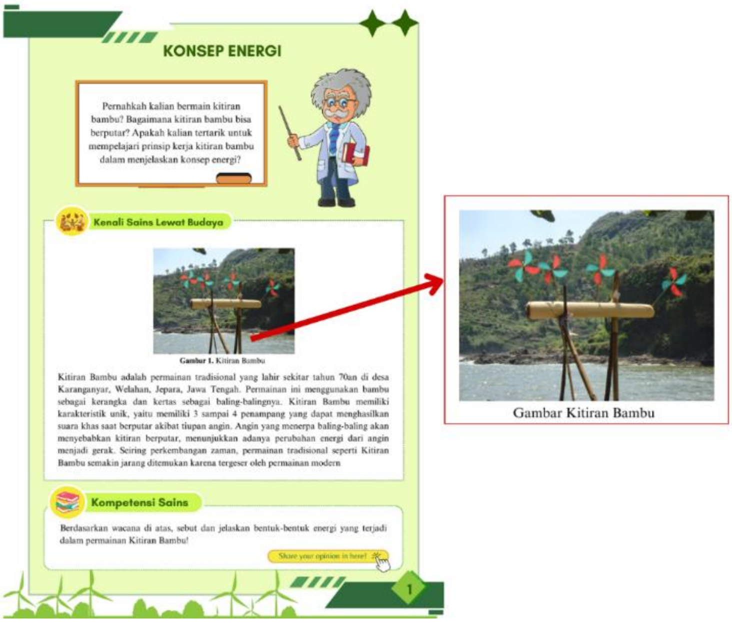

FIGURE 1. "Learn Science Through Culture" feature

The teaching materials developed are based on ethno-STEM, the integration of local culture into STEM perspectives. The scientific aspect is demonstrated through the study of a single renewable energy source: wind. Wind energy is inexhaustible and can be continuously renewed. Wind energy is used to move bamboo windmills. The kinetic energy from the wind hitting the stationary bamboo pinwheel is converted into kinetic energy that can move the blades on the bamboo pinwheel. This change means that energy cannot be lost or destroyed, but can be converted into other forms. This is in accordance with the law of conservation of energy. The scientific aspect is demonstrated through the "Smart Science" feature, as shown in FIGURE 2.

FIGURE 2. "Smart Science" feature

The teaching materials also present a technological perspective through the use of bamboo pinwheels as a medium for learning about renewable energy. This medium applies simple engineering principles to harness wind energy into a functional tool that can even be developed into a mini power plant. Bamboo pinwheels capture wind energy and convert it into kinetic energy. When a dynamo is added, this energy can be converted into electrical energy, similar to the principle of a wind power plant (WPP). In this regard, students are introduced to WPP technology, which operates on a principle similar to that of bamboo pinwheels. The technological aspect is also demonstrated through examples of giant wind turbines generating electricity. Thus, students not only understand the concept of renewable energy theoretically but can also relate it to technological innovations in real life. This approach is expected to foster curiosity, creativity, and critical thinking skills in the design of environmentally friendly technology-based solutions. The technological aspect is illustrated by the "Techno Innovation" feature in FIGURE 3.

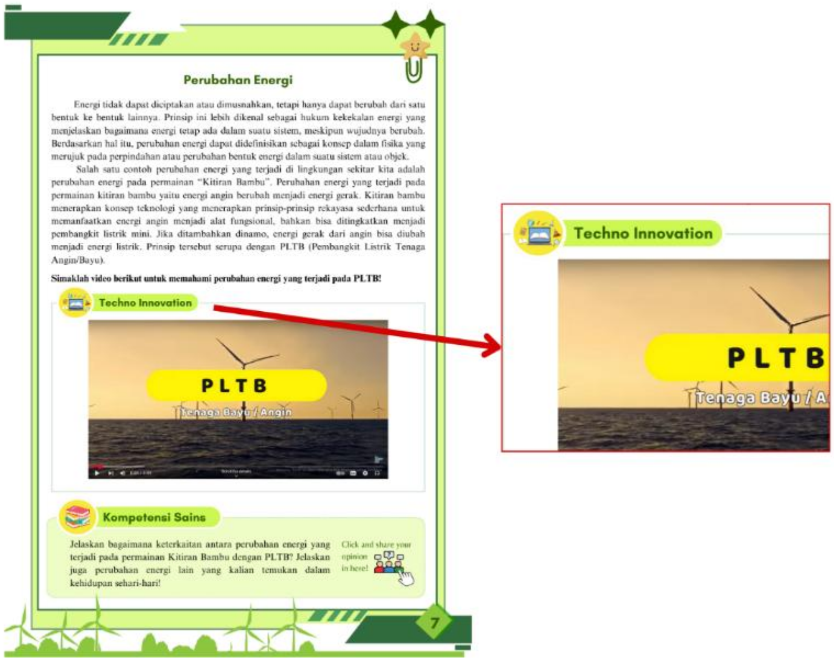

FIGURE 3. "Techno Innovation" feature

The next perspective is the technical or engineering aspect, which is demonstrated through the students' activities in designing a prototype of a bamboo windmill into a modern technological device by adding a small dynamo to generate electricity. The bamboo windmill serves as a small-scale prototype of environmentally friendly technology with a working principle similar to that of a wind power plant. In wind turbines, wind energy moves the blades, causing the shaft to rotate the generator or dynamo to produce electrical energy. This activity trains students' skills in analyzing needs, planning, and creating simple technological models. Through direct involvement in the engineering process, students not only gain practical experience but also learn to think systematically and develop creative solutions to future energy challenges. The engineering aspect is demonstrated through the "Engineering Mastery" feature, as shown in FIGURE 4.

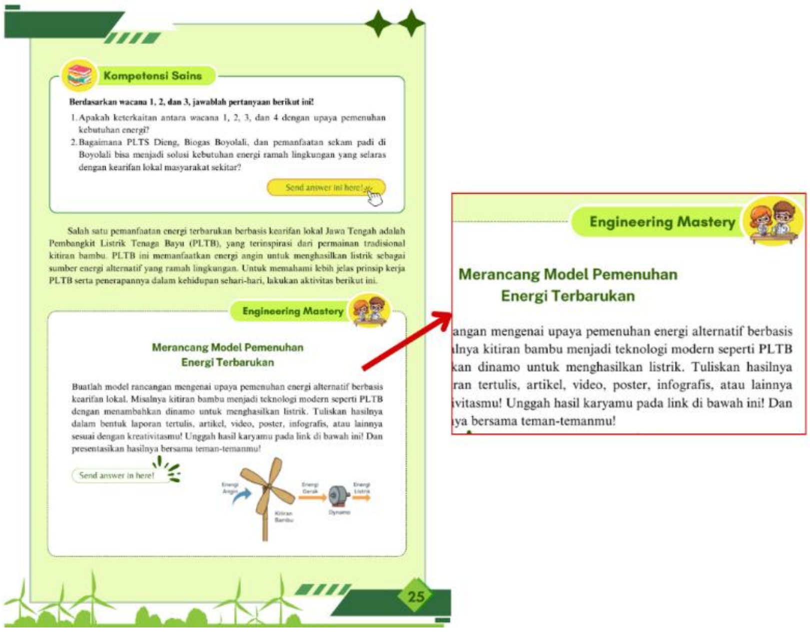

FIGURE 4. "Engineering Mastery" feature

The final perspective in the teaching material is mathematics, presented through data on wind speeds in several areas, including Cilacap, Semarang, and Tegal. Students are asked to calculate the kinetic energy in each area, assuming that the bamboo sticks have the same surface area or mass and are moved by the wind. After calculating the kinetic energy in the three regions, students are asked to compare their calculations to determine the region with the greatest kinetic energy. From this activity, students can understand that in addition to wind speed, other factors that affect kinetic energy are the area of the bamboo rotor and the number of blades. The mathematical aspect is demonstrated through the "Math Genius" feature, as shown in FIGURE 5.

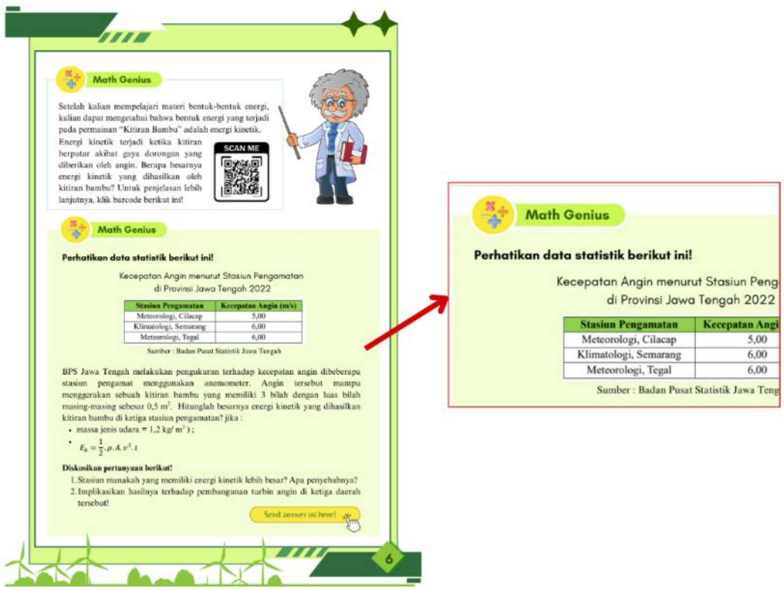

FIGURE 5. "Genius Math" feature

The teaching materials also have another characteristic: they are designed to foster a love of country in students. The aspect of love of country in the teaching materials comprises two elements: recognizing and respecting Indonesian culture (Salfadilah et al., 2024). Both aspects are demonstrated through activities that encourage students to learn about and utilize the culture of Central Java, particularly the bamboo spinning top game. The bamboo spinning top game reflects the basic principle of utilizing wind energy, which has inspired the development of renewable energy technologies, such as wind power plants. Thus, students not only learn to respect Indonesian culture but also understand its contribution to sustainable technological innovation.

In addition to the above characteristics, the digital teaching materials developed are compiled in accordance with BSNP standards and digital media guidelines. BSNP standards cover four areas of suitability, namely content suitability, presentation suitability, language suitability, and graphic suitability. These areas of suitability are measured through material validity tests and media validity tests. The validity test assesses whether the teaching materials are suitable for learning. The validity of the material and media in teaching materials is explained in the following description.

1. Material Validity

The validity test of the material aims to ensure that the material presented in the teaching materials is valid for use in learning. The validity of digital teaching materials covers three aspects, namely content, presentation, and language. The results of the validity test of the material in the teaching materials are shown in TABLE 1.

TABLE 1. Results of Material Validity Testing

No	Assessment Aspect	Percentage		Aiken's V		
		Value (%)	Criteria	Calculated V	Table V	Criteria
1	Contents	97.04	Very Valid	0.96	0.79	Valid
2	Presentation	95.42	Very Valid	0.94	0.79	Valid
3	Language	96.67	Very Valid	0.96	0.79	Valid

The results of the material validity test shown in TABLE 1 are included in the validity criteria (Meiningsih et al., 2019). The teaching materials are considered valid because the material presented has a strong theoretical basis. This aligns with the research by Fitriyani et al. (2020), which states that valid teaching materials have a strong foundation.

The aspects tested in the material validity test include content, presentation, and language. The content aspect comprises three parts: material suitability, material accuracy, and material integration with the ethno-STEM approach. The content of instructional materials aligns with learning outcomes and objectives. This aligns with the research by Armini et al. (2023), which states that aligning content with learning outcomes and objectives can increase students' curiosity and enthusiasm for learning.

The presentation aspect comprises three parts: presentation techniques, learning presentation, and presentation completeness. The presentation techniques for teaching materials are consistently and systematically applied, including titles, images, and engaging content. The learning presentation is contextualized to the local culture of Central Java and guides students in discovering the concept of renewable energy. The teaching materials are presented comprehensively with three main sections: introduction, content, and conclusion.

The language validity aspect includes readability and appropriateness of writing. The language used in the teaching materials is clear, easy to understand, and does not cause multiple interpretations. The writing explaining a concept uses standard, consistent language. Activity instructions in the learning process are conveyed with clear sentences. Additionally, the sentence structure of the teaching material content is organized according to SPO and SPOK, in accordance with the rules of proper Indonesian (Nurjanah & Kadaryati, 2024).

2. Media Validity

Media validity testing aims to ensure that ethno-STEM-based digital teaching materials are valid for use as learning media. The validity of digital teaching materials covers three aspects, namely size or format, content, and cover design. The results of the media validity test are shown in TABLE 2.

TABLE 2. Media Validity Test Results

No	Assessment Aspect	Percentage		Aiken's V		
		Value (%)	Criteria	Calculated V	Table V	Criteria
1	Size or format	98.33	Very Valid	0.98	0.79	Valid
2	Cover design	98.33	Very Valid	0.98	0.79	Valid
3	Content design	95.56	Very Valid	0.94	0.79	Valid

The results of the teaching material media validity test shown in TABLE 2 are included in the validity criteria (Meiningsih et al., 2019). The aspects tested in the media validity test include size or format, content design, and cover design. The teaching materials developed have a size that complies with the ISO standard: A4 (210 x 297 mm). BSNP 2014 states that the ISO standard size for teaching materials aims to ensure that the teaching materials produced are of good quality (Susanti & Astuti, 2020). The images and font sizes in the teaching materials are also presented clearly, making it easier for students to understand the content. Research by Waluyo & Wahyuni (2021) indicates that appropriate font type and size make it easier for students to understand the content of teaching materials.

The validity assessment of the content design in this teaching material has good validity results. The content of the teaching material is arranged with consideration of the composition of layout elements such as titles, subtitles, and appropriate illustrations. The illustrations and images used are also clear. In addition, the selection of colors, font types, and sizes in the teaching materials can improve students' enthusiasm for learning.

The validity assessment of the instructional materials' cover design yielded strong validity results. The cover of the instructional materials features a strong focal point. The layout elements of fonts and images on the cover are arranged harmoniously. The cover design of the instructional materials also includes images that are relevant to the content and appealing to students. The selection of colors, font types, and sizes on the cover can attract students' attention and enthusiasm to the instructional materials' content.

Overall, the validation results show that the ethno-STEM-based digital teaching materials on renewable energy meet the eligibility criteria. The integration of local cultural elements, such as the use of bamboo windmills to represent wind energy, not only enriches the science content contextually but also fosters a sense of patriotism by introducing local energy potential and by fostering appreciation of traditional culture that embodies the values of innovation and sustainability. This aligns with the research by Khusyairin et al. (2024), which shows that integrating local wisdom into education can enhance cultural preservation and moral development among students, such as a sense of patriotism. This ethno-STEM education can create more inclusive, meaningful, and dynamic learning by encouraging students to recognize local culture and understand how it relates to scientific principles (Listiyani et al., 2025). The integration of culture into STEM learning design can also create a more interesting, relevant, and meaningful learning experience for students (Nurhairani et al., 2024). Thus, these validation results indicate that the development of Etno-STEM-based digital teaching materials is not only technically feasible but also has pedagogical potential to link physics learning with the values of love for the homeland. These findings also provide further evidence of the implications of teaching material development for fostering students' love for their homeland.

CONCLUSION

Based on the results of the research and discussion described above, this study has produced ethno-STEM-based digital teaching materials that are highly valid for learning. The integration of local culture, such as bamboo pinwheels representing wind energy, makes physics learning more conceptual and meaningful. The teaching materials developed not only meet technical requirements but also have pedagogical potential to support physics learning that fosters a love for the homeland through the integration of regional cultural resources. However, this study is limited to the development stage, so further studies are needed to test the effectiveness of teaching materials in fostering students' love for the homeland.

ACKNOWLEDGEMENTS

The author would like to thank Semarang State University for its financial support through the UNNES DPA research scheme No. B/1591/UN37.3.1/PT.01.05/2025 dated March 12, 2025. The author would also like to thank all parties who contributed to the completion of this research.

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