JURNAL LITERASI PENDIDIKAN FISIKA

Volume 7 No. 1
Halaman: 70 - 79
April 2026

Development of STEM–EDP-Based Student Worksheets on Energy Topics to Support Environmental Awareness among Junior High School Students

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Abstract

Environmental awareness is an important attitude that needs to be instilled through science education in junior high schools. However, current learning practices still lack worksheets that are able to contextualize environmental problems. This study aims to develop and evaluate the feasibility of STEM-EDP-based student worksheets on the topic of energy to support students' environmental awareness. This study used the Research and Development (R&D) method with a modified 4D model, including the Define, Design, Develop, and Disseminate stages. The product was validated by content, media, and learning, then tested on 113 eighth-grade students in Samarinda. The results showed that the developed worksheet obtained an average validation score of 90.25% in the very good category, consisting of content validation of 90.25%, learning validation of 89.00%, and module validation of 91.50%. Student responses to the product were also in the very good category with an average of 85.20%, covering aspects of visual design, material quality, presentation, language clarity, and STEM integration. Furthermore, 82.8% of students experienced improved learning outcomes. These results indicate that the developed STEM-EDP-based student worksheet is valid, feasible, and effective for use in energy learning, and has the potential to increase students' environmental awareness through contextual learning.

Keywords: Environmental Awareness; STEM–EDP-Based Worksheets; Secondary Science Education; R&D

Abstrak

Kesadaran lingkungan merupakan sikap penting yang perlu ditanamkan melalui pendidikan sains di sekolah menengah pertama. Namun, praktik pembelajaran saat ini masih kekurangan lembar kerja yang mampu mengontekstualisasikan permasalahan lingkungan nyata. Penelitian ini bertujuan untuk mengembangkan lembar kerja siswa berbasis STEM–EDP pada topik energi guna mendukung kesadaran lingkungan siswa. Penelitian ini menggunakan metode Research and Development (R&D) dengan model 4D yang dimodifikasi, meliputi tahap Define, Design, Develop, dan Disseminate. Produk divalidasi oleh ahli konten, media, dan pembelajaran, kemudian diujicobakan kepada 113 siswa kelas VIII di Samarinda. Hasil penelitian menunjukkan bahwa lembar kerja yang dikembangkan memperoleh rata-rata skor validasi sebesar 90,25% dengan kategori sangat baik, yang terdiri atas validasi konten sebesar 90,25%, validasi pembelajaran sebesar 89,00%, dan validasi modul sebesar 91,50%. Respons siswa terhadap produk juga berada pada kategori sangat baik dengan rata-rata sebesar 85,20%, meliputi aspek desain visual, kualitas materi, penyajian, kejelasan bahasa, dan integrasi STEM. Selain itu, sebanyak 82,8% siswa mengalami peningkatan hasil belajar. Hasil tersebut menunjukkan bahwa lembar kerja siswa berbasis STEM–EDP yang dikembangkan valid, layak, dan efektif digunakan dalam pembelajaran energi, serta berpotensi meningkatkan kesadaran lingkungan siswa melalui pembelajaran yang kontekstual.

***Kata kunci**: Kesadaran Lingkungan; LKPD STEM-EDP; SMP, R&D.*

Article History: **Received: 25 April 2026** **Revised: 13 May 2026**
Accepted: 13 May 2026 **Published: 14 May 2026**

How to cite: Pramesti, I. A. A., Zahidsyahtya, M. A., Sari, E., Wandira, A. R., Nuryadin, A., Sulaeman, N. F., & Efwinda, S**.** (2026). *Development of STEM–EDP-Based Student Worksheets on Energy Topics to Support Environmental Awareness among Junior High School Students*, Jurnal Literasi Pendidikan Fisika, 7 (1), 70-79. https://doi.org/10.30872/jlpf.v7i1.6525

INTRODUCTION

The increasing complexity of environmental problems increases the urgency of high-quality education as a strategic instrument for fostering students' environmental awareness (UNESCO, 2020). Therefore, science education plays a crucial role as it connects scientific concepts with real-world phenomena while cultivating students' sense of care and responsibility toward the environment (Sarira, 2025). At the junior high school level, science learning not only aims to build conceptual understanding but also to shape students' scientific attitudes and behaviors in responding to environmental issues (Mulbar et al., 2025). Previous studies have demonstrated that science instruction contributes to the development of environmental care attitudes and enhances students' awareness of energy conservation (Ikhsan et al., 2025). Therefore, integrating environmental issues into science learning has become a necessity in formal education.

Energy is one of the science topics closely related to environmental issues and students' daily lives. Energy is one of the science topics closely related to environmental issues and students' daily lives. However, energy instruction in schools remains predominantly theoretical and concept-oriented, with limited contextual and application-based learning activities (Kusuma et al., 2025). Existing worksheets generally emphasize routine exercises, which do not encourage students to comprehensively analyze environmental problems or develop solutions through higher-order thinking processes (Amelia et al., 2022). In science lessons, particularly on energy topics, students are often simply asked to calculate energy quantities or identify energy transformations without relating these to real-world problems, such as household electricity waste, fossil fuel use, or the use of alternative energy sources. This condition aligns with findings showing that conventional worksheets do not optimally facilitate students' critical thinking and problem-solving skills (Syukri et al., 2023), underscoring the need for contextual worksheets in energy learning (Anita et al., 2023).

The Science, Technology, Engineering, and Mathematics (STEM) approach integrates scientific concepts with technology, engineering, and mathematics to solve contextual problems in science education (Triwulandari et al., 2022). Its implementation in junior high school science encourages active student engagement through application-based learning activities and problem-solving (Armelia et al., 2025). Integrating STEM into student worksheets provides opportunities for students to develop higher-order thinking skills through exploratory and collaborative tasks (Budiarti et al., 2023). Furthermore, STEM-based worksheets have been shown to effectively facilitate contextual science learning and improve students' scientific literacy through authentic problem-solving activities (Alfiza et al., 2024). In an environmental context, the STEM approach enables students to analyze real-world problems such as energy waste, environmental pollution, and the use of alternative energy sources through investigation and solution design. Previous research also reports that STEM-based learning can increase students' environmental awareness and concern because students are directly involved in solving contextual environmental problems (Annisa et al., 2024). Therefore, innovation in learning is urgently needed. STEM-EDP-based student worksheets were developed as an effort to increase students' environmental awareness through contextual learning.

To clarify, the STEM approach would be combined with a variance learning model, one of which is EDP. The Engineering Design Process (EDP) serves as a systematic framework within STEM learning that encourages students to think and act like engineers. This process involves problem identification, solution design, prototyping, testing, and evaluation (Lin et al., 2021). STEM–EDP-based science learning has been proven to improve junior high school students' higher-order thinking skills in addressing real environmental problems and positively contributes to fostering environmental awareness and responsibility through formal education (Ikhsan et al., 2025; Sarira, 2025).

Although numerous studies have examined STEM-based learning and the EDP model, most focus primarily on cognitive achievement and higher-order thinking skills (Alfiza et al., 2024; Budiarti et al., 2023). Science education should also play a vital role in cultivating students' environmental awareness and responsibility (Panjaitan et al., 2021). Within the STEM framework, the EDP model trains students to identify real-world problems, design solutions, and evaluate the environmental impact of those solutions through reflective engineering processes (Bybee, 2013; Lin et al., 2021). Therefore, the development of STEM–EDP-based student worksheets on energy topics offers novelty by simultaneously integrating conceptual mastery, higher-order thinking skills, and environmental awareness formation in junior high school science learning (Ikhsan et al., 2025). Therefore, our research aims to design and develop a STEM-EDP-based worksheet on energy to support environmental awareness among junior high school students.

METHODS

This study employed a Research and Development (R&D) design. The development model adopted was the 4D model, consisting of four phases: Define, Design, Develop, and Disseminate, originally proposed (Thiagarajan et al., 1974). The 4D model was selected because it provides a systematic framework from needs analysis to product dissemination, ensuring that the developed instructional materials are aligned with learning objectives and classroom needs.

This study involved three experts: one content expert, one media expert, and one process design expert. Additionally, 113 eighth-grade students from a junior high school in Samarinda, Indonesia, participated in the study. Participants were selected using purposive sampling based on science teacher recommendations and the class's suitability to the research objectives. Of these, 113 students participated in a student response test, while 58 students from two different classes received a pre-test and post-test to measure energy awareness. Data from these treatments were used to analyze improvements in students' understanding and awareness of energy concepts.

The development procedure in this study followed the four stages of the 4D model, namely defining, designing, developing, and disseminating. In the Development stage, the previously designed plan was transformed into a complete instructional product ready for validation. The developed materials included lesson plans, learning activities, content materials, and animated videos that functioned as supporting media for STEM integration. The instructional product underwent two forms of evaluation: expert validation and student acceptance testing. Expert validation ensured that the product met feasibility standards in terms of content accuracy, presentation quality, visual design, language use, and alignment with STEM principles. Meanwhile, student responses provided practical insights into the extent to which the product was acceptable, understandable, and engaging for the actual users. The Disseminate stage was conducted on a limited scale by distributing the validated and revised worksheets to science teachers at the research site and sharing the digital version for instructional reference and broader utilization.

The validity analysis aimed to assess the feasibility of the instructional materials before implementation. Content validity through expert judgment is an essential stage in development research to ensure the alignment of the product's content and components with the learning objectives (Fernández-Gómez et al., 2020). The assessment was conducted using a four-point Likert scale as presented in Table 1.

Table 1. Assessment Criteria for Instructional Material Validity

Score	Criteria
1	Poor
2	Fair
3	Good
4	Very Good

The total score given by the validators was then converted into a validity percentage using Equation (1).

$$\%\,Validity = \frac{Total\ Score}{Maximum\ Score} \times 100\% \tag{1}$$

Student response analysis aimed to identify the level of acceptance, ease of use, and students' perceptions of the instructional materials. Student responses constitute an important component of formative evaluation as they reflect the extent to which the learning product meets the needs of its end users (Mertasari & Candiasa, 2022). Data collection was conducted using a four-point Likert scale as presented in Table 2.

Table 2. Assessment Criteria for Student Responses

Score	Criteria
1	Strongly Disagree
2	Disagree
3	Agree
4	Strongly Agree

The percentage of student responses was calculated using Equation (2):

$$\%\mathit{Student\ Resp.} = \frac{\mathit{Total\ Score}}{\mathit{Maximum\ Score}} \times 100\% \tag{2}$$

The validity percentages and student responses were then classified according to the assessment criteria, as presented in Table 3. The categories range from Very Poor to Very Good, providing a clear framework for interpreting the results. This classification is intended to simplify the analysis process, allowing researchers to more systematically determine the quality of the developed instructional materials. Using these categories allows for easier comparison and communication of the results. Furthermore, this classification adheres to approaches commonly applied in instructional materials development research. Therefore, the use of these criteria ensures consistency with previous research and strengthens the credibility of the findings.

Table 3. Classification Categories of Student Responses Siswa

Score (%)	Criteria
$X < 20$	Very Invalid
$20 \le X < 40$	Invalid
$40 \le X < 60$	Fairly Valid
$60 \le X < 80$	Valid
$80 \le X \le 100$	Very Valid

Environmental awareness data were collected through test instruments administered before (pre-test) and after (post-test) the treatment using the EDP learning model. The collected data were then analyzed using descriptive statistics and the normalized gain (N-Gain) test to determine the effectiveness of the learning model in improving student learning outcomes.

RESULTS AND DISCUSSION

Define

At the Define stage, an analysis of the National Curriculum documents and a mapping of specific learning needs were conducted. Based on the analysis of the curriculum, the relevant learning outcomes at Phase D state that students are able to analyze interactions among living organisms and their environment in designing efforts to prevent and address climate change, and are able to analyze the relationship between work and energy. These learning outcomes were further elaborated into learning objectives (LOs), including: (1) students are able to distinguish between renewable and non-renewable energy sources based on their characteristics, examples, and impacts; (2) students are able to explain the flow of energy transformation in energy systems (solar panels/wind turbines) through simple diagrams; (3) students are able to conduct simple experiments on heat transfer and record temperature changes in observation tables; (4) students are able to classify materials as conductors or insulators based on their properties and provide brief justifications; and (5) students are able to analyze the challenges of implementing renewable energy and relate them to relevant solutions.

Based on the number of learning objectives, the time allocation to achieve all objectives was set at six meetings. Each meeting was designed with a different focus, starting with understanding the concepts of energy and fossil fuels. Next, students were guided to design environmentally friendly coal mining, understand energy transformation, and plan energy-efficient homes. In the next stage, students designed and tested house projects until they produced a final design that met the criteria for an energy-efficient home. In addition, some students were given special treatment, namely a pre-test and post-test to assess their understanding.

The results of the literature review indicate that environmental awareness has not been adequately integrated into energy learning processes in schools (Hasudungan et al., 2025; Kusuma et al., 2025; Muhardika et al., 2025). Teachers tend to deliver content conceptually without linking it to current environmental issues, particularly fossil energy crises and global warming (Fajarwati, 2025; Hastuti et al., 2025). This condition reinforces the need to systematically integrate environmental awareness into learning activities.

In addition, it was found that current science learning practices have not widely implemented the STEM Engineering Design Process approach. Students are not facilitated to go through the stages of Define, Learn, Plan, Try, Test, and Decide in the context of energy-related problems. According to previous research, one of the challenges faced by teachers in teaching energy concepts is the limited visualization in explaining abstract energy transformation processes (Kusuma et al., 2025). Another research report also stated that the use of interesting science learning media can increase students' active participation in understanding and applying energy concepts (Nuraini et al., 2025). Therefore, STEM–EDP-based instructional media equipped with animated videos are needed to visualize energy transformation concepts and to enhance students' environmental awareness.

Design

At this stage, the worksheets were designed and produced to facilitate learning across six meetings, each meeting consisting of two instructional hours (IH), with one IH equivalent to 40 minutes. The worksheets were designed following the STEM approach and the Engineering Design Process (EDP) syntax, as illustrated in Figure 1. This design adopted a transdisciplinary type, in which content from two or more disciplines is applied to real-world problems (Roehrig et al., 2021), with the learning focus centered on the problem of designing an energy-efficient house.

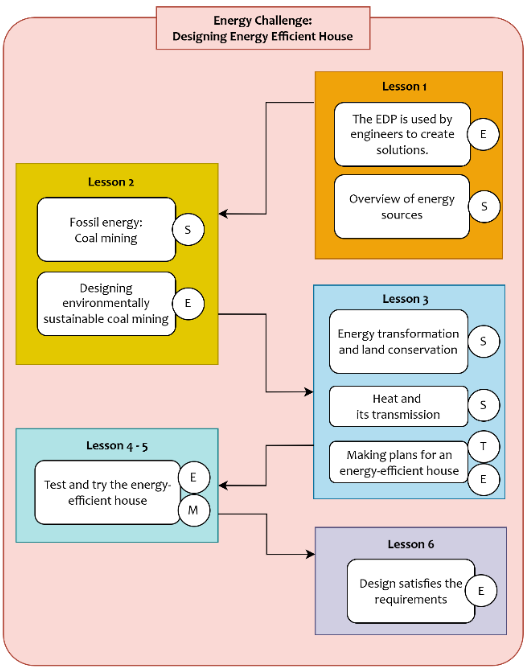

Figure 1. STEM Project Storyline in the Energy Unit

The worksheets were complemented with instructional media in the form of an animated video incorporating environmental awareness within the energy topics, entitled *"Suara Borneo."* The animation was designed based on the learning objectives established during the Define stage, which were subsequently translated into scripts and storyboards. The scripts were developed according to the topics of each meeting. Three sequential episode scripts were produced: the forms of energy, coal energy, and renewable energy. The storyboard was created to guide the visualization of each scene before proceeding to the animation process.

After careful planning, the production stage was carried out. At this stage, most visual assets, including characters, backgrounds, and graphic elements, were created independently using Krita software. A small portion was developed using Canva, combined with AI Gemini through its image generation feature. The visual assets were then animated using CapCut software in combination with AI Gemini's video generation feature. Each animation segment was aligned with the narrative script and included visualizations of general energy concepts, fossil energy, and its formation process, as well as renewable energy. The animated videos also incorporated prompts encouraging students to engage in project activities described in the worksheets according to the EDP stages.

Finally, the animation was integrated with recorded audio narration and background music using CapCut. Subtitles and transitions between segments were added to clarify the flow of the material. The final output consisted of three animated videos with an average duration of five minutes each, ready for validation in the subsequent stage.

Develop

1. Expert Validation

This stage is conducted to assess the feasibility of the developed product based on content, presentation, and language aspects. The validation process involves four validators with competencies in related fields who assess three main aspects: materials, learning, and teaching modules, to provide assessments, suggestions, and constructive feedback. The validation results serve as the basis for making improvements and refinements to the product before implementation in learning activities. The product feasibility stage can be seen in Table 4.

Table 4. Results of Expert Validation

Learning Materials	validator 1	validator 2	validator 3	validator 4	Average	Percentage	Catagory
Subject Matter Expert	3,27	3,67	3,60	3,93	3,61	90,25	Very Good
Learning Expert	3,14	3,62	3,62	3,86	3,56	89,00	Very Good
Teaching Module	3,35	3,65	3,80	3,85	3,85	91,50	Very Good
Overall Module					3,67	90,25	Very Good

The validation results in Table 4, regarding learning materials, show that the Learning Module aspect achieved a score of 90.25% (Very Good category), the Learning Tools aspect achieved 89.00% (Very Good category), and the Content Presentation aspect achieved 91.50% (Very Good category). The overall average validity of the instructional materials reached 90.25%, categorized as Very Good. These results demonstrate that the product meets the feasibility criteria in terms of content substance and systematic presentation.

The validation of the instructional media showed that the Visual Appearance aspect obtained 86.00%, the Content aspect 89.50%, the Presentation and Flow aspect 85.00%, the Language aspect 82.00%, and the STEM Integration aspect 83.50%. The overall average was 85.20%, categorized as Very Good. This indicates that the worksheets have a representative visual design, communicative language, and appropriate integration of the STEM–EDP approach aligned with the learning objectives.

Before being distributed to students for feedback, the worksheets were first revised based on feedback received during the validation process. After revisions, the worksheets were printed and prepared for student assessment. This step ensured that the material was appropriate and ready for student evaluation. Some examples of the developed worksheets are shown in Figure 2.

Figure 2. Examples of the developed worksheets

Figure 2 shows the final results of the revised worksheet after receiving input and suggestions from the validators. The figure shows examples of two activities in the developed worksheet. In the first activity, students are introduced to the material on forms of energy as an introduction to help them understand the basic concepts of energy in everyday life. Furthermore, in the second activity, students carry out an activity to design more environmentally friendly coal through the STEM-EDP stages, enabling them to connect energy concepts with efforts to solve environmental problems contextually.

2. Student Response

After being revised based on input from the validator, the product was piloted to obtain student feedback with 113 eighth-grade students at a junior high school in Samarinda. Analysis of student feedback showed a very good rating, indicating that the developed worksheet was well-received by students. Furthermore, the worksheet was deemed easy to understand and capable of supporting contextual energy learning through the EDP stages. In the project activities, students designed simple solutions related to energy utilization and environmental issues around them through the stages of identifying the problem, learning about the problem, planning the solution, trying the solution, testing the solution, and determining whether the solution was good enough. This activity helped students connect energy concepts to real-life situations. These findings are detailed in Table 5.

Table 5. Student Responses to the Worksheets

Aspect	Score	Percentage (%)	Catagory
Visual Appearance	3,44	86,00	Very Good
Content	3,58	89,50	Very Good
Presentation and Flow	3,40	85,00	Very Good
Language	3,28	82,00	Very Good
STEM Integration	3,34	83,50	Very Good
Average	3,41	85,20	Very Good

Product validation through expert validation sheets and student responses constitutes an essential procedure in instructional material development research to ensure the product's feasibility and acceptability before broader implementation. This finding is consistent with previous studies indicating that the developed E-worksheets were categorized as highly valid based on evaluations by content and media experts and received very positive student responses during the trial phase (Jannah et al., 2024).

3. Student environmental awareness

Students' environmental awareness is a crucial aspect that needs to be developed in learning. It plays a role in shaping students' attitudes and behaviors toward the environment. Furthermore, this awareness also influences students' future desires and actions (Jaenudin et al., 2025).

Figure 3. Students work on pre and post regarding environmental awareness.

The results of the pre-test and post-test data in Figure 3 were analyzed to obtain an overview of the improvement in student learning outcomes before and after the treatment was implemented. A summary of the descriptive statistics from both data sets is presented in the following table 6.

Table 6. Pre-Post Test Results

Statistical Parameters	Pre-Test Score	Post-Test Score
Mean	9,91	14,64
Max	22	24
Min	3	5
Standard Deviation	5,02	5,50
Number of Participants	58	58

Based on the research results, the average pre-test score of students was 9.91 which then increased to 14.64 in the post-test score. This increase was analyzed using the N-Gain test and produced a value of 0.31 which is included in the 'Moderate' category. This indicates that the implementation of the EDP Learning Model has a positive impact on the mastery of energy concepts of junior high school students in Samarinda. However, there are variations in the results where the majority of students experienced rapid improvement, while around 17% of students required a remedial approach due to a decrease in scores that may have been influenced by external factors during the post-test administration.

The Disseminate stage was conducted on a limited scale by distributing the product to science teachers at the research site and sharing the soft file of the worksheet as a reference for instructional use. In addition, the development results were disseminated through scientific publications to enable access and utilization by educators with similar needs. This limited dissemination aimed to introduce the STEM–EDP-based worksheets as an innovative instructional alternative for energy topics, emphasizing not only conceptual mastery but also the development of students' environmental awareness.

CONCLUSION

The STEM–EDP-based worksheets on energy topics developed through the 4D model were declared valid and feasible for use in junior high school science learning. The results of expert validation indicated a Very Good category, with average percentages above 85% for both material and media aspects. Student responses were also categorized as Very Good, with an average percentage above 80% across aspects of visual appearance, content, presentation of materials and media, language use, and STEM integration. The results of the study also showed that 82.8% of students experienced an increase in scores, while 17.2% required special attention or remedial work. These findings indicate that the product is easy to understand, engaging, and aligned with instructional needs. The integration of STEM with the EDP model in this worksheet is capable of facilitating contextual energy learning while supporting the development of students' environmental awareness. Therefore, the developed product has the potential to serve as an innovative instructional alternative in junior high school science education.

ACKNOWLEDGEMENT

The authors would like to thank the Directorate of Research, Technology, and Community Service (DRTPM), Directorate General of Higher Education, Research, and Technology (Ditjendiktiristek) Ministry of Research, Technology and Higher Education Indonesia, for the funding support through Regular Fundamental Research, with main contract number 080/C3/DT.05.00/PL/2025 and derivative contract number 562/UN17.L1/HK/2025.

REFERENCES

Alfiza, P. N., Susilawati, S., Syukri, M., Ridha, S., Saminan, Umar, M. F., & Hamid, A. (2024). An Innovative STEM-Based Worksheet to Enhance Scientific Literacy at Senior High School. *Atlantis Press*, 310–317. https://doi.org/10.2991/978-2-38476-216-3_32

Amelia, N., Leksono, S. M., & Resti, V. D. A. (2022). Development Of Student Worksheets Based On Science Process Skills And Air Pollution Themes To Grow Critical Thinking Ability In Junior High School Students. *Jurnal Pena Sains*, *9*(2), 47–56. https://doi.org/10.21107/jps.v9i2.14076

Anita, A., Asmah, S. N., & Nurcahyo, M. A. (2023). Pengembangan Lembar Kerja Peserta Didik (LKPD) Bermuatan STEM pada Materi Energi Kelas IV Sekolah Dasar. *Jurnal Inovasi Pendidikan*, *1*(2), 111–128. https://doi.org/10.60132/jip.v1i2.11

Annisa, D. P., Kaniawati, I., & Eliyawati, E. (2024). STEM ESD-Based Learning with “Arduino Uno-Based Trash Can” to Improve Students’ Critical Thinking Skills and Sustainable Awareness in Learning Environmental Pollution. *Jurnal Penelitian Dan Pembelajaran IPA Annisa, et Al*, *10*(1), 114–145. https://doi.org/10.30870/jppi.v10i1.24008

Armelia, A., Hakim, A., Syam, M., Nuryadin, A., & Sulaeman, N. F. (2025). Challenges of crafting junior high school students ’ argumenta- tion skills : An exploration in an integrated STEM-EDP unit. *Research and Development in Education*, *5*(2), 1151–1161. https://doi.org/https://doi.org/10.22219/raden.v5i2.4 1002

Budiarti, R. S., Harlis, & Siburian, J. (2023). Development Of STEM-Based PjBL E-Student Worksheet to Foster Character Building. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9818–9828. https://doi.org/10.29303/jppipa.v9i11.6169

Bybee, R. W. (2013). The Case for Education: STEM Challenges and Opportunities. In *NSTA (National Science Teachers Assocation)*.

Fajarwati, W. S. (2025). Model Pembelajaran Berbasis Proyek Untuk Meningkatkan Karakteristik Peduli Lingkungan Pada Mata Pelajaran IPA. *Peran Ilmu Lingkungan Untuk Kecermelangan Pendidikan Sains Menuju Indonesia Emas*, *4*(1), 15–27.

Hastuti, A., Suprapto, P. K., Badriah, L., & Hernawati, D. (2025). PROFIL LITERASI BIODIVERSITAS PESERTA DIDIK KELAS VII SMP NEGERI. *Inovasi Penelitian Pendidikan Dan Pembelajaran*, *5*(2). https://doi.org/10.51878/learning.v5i2.4885

Hasudungan, J., Marsuki, A. I., Ikhsan, R. R. N., Maharani, N. S., Kristi, M. S., & Padillah, S. N. (2025). Peningkatan Kesadaran Energi Baru Terbarukan (EBT) Di SMKN 6 Bandung Melalui Program Penyuluhan Terpadu. *Nobel Community Services Journal*, *5*(1), 25–33. https://doi.org/10.37476/ncsj.v5i1.5221

Ikhsan, M., Atun, S., & Pamungkas, Ok. (2025). Exploring Junior High School Students’ Environmental Care Attitudes through Science Learning: Towards a Green Mindset Development. *Indonesian Journal of Science and Education*, *09*(01), 38–48. https://doi.org/https://doi.org/10.31002/ijose.v9i1.2145

Jaenudin, D., Nurhayati, N., Sukmanasa, E., Program, E. M., Pakuan, U., Program, E. E., & Pakuan, U. (2025). *Implementation of Local Wisdom-Based e-Module on Ecosystem Concepts to Enhance Elementary School Students ’ Environmental Awareness*. *11*(1), 132–143. https://doi.org/10.30870/jppi.v11i1.25378

Jannah, S. A., Kusasi, M., & Khairunnisa, Y. (2024). Pengembangan E-LKPD Berbasis PBL Menggunakan Liveworksheet Untuk Meningkatkan Kemampuan Literasi Sains Siswa SMP. *EDUPROXIMA : Jurnal Ilmiah Pendidikan IPA*, *6*(4), 1503–1512. https://doi.org/10.29100/.v6i4.5494

Kusuma, M. W., Nuramalia, T., Ain, T. Q., & Heryadi, Y. (2025). Persepsi Siswa terhadap Penggunaan Media Video Animasi dalam Pembelajaran Energi dan Perubahannya di Sekolah Dasar. *Ibtida'i : Jurnal Kependidikan Dasar*, *12*(1), 37–64. https://doi.org/10.32678/ibtidai.v12i1.11367

Lin, K. Y., Wu, Y. T., Hsu, Y. T., & Williams, P. J. (2021). Effects of infusing the engineering design process into STEM project-based learning to develop preservice technology teachers' engineering design thinking. *International Journal of STEM Education*, *8*(1), 1–15. https://doi.org/10.1186/s40594-020-00258-9

Mertasari, S., & Candiasa, M. (2022). Formative evaluation of digital learning materials. *Journal of Education Technology*, *6*(3), 507–514. https://doi.org/https://doi.org/10.23887/jet.v6i3.44165

Muhardika, Abadi, A., Savira, R., Kamisa Putri, Y., & Meka Seftiani, Y. (2025). Sosialisasi Energi Hijau untuk Masa Depan : Mengenal Energi Terbarukan Sejak Dini di SMA Negeri 16 Padang. *Jurnal Andalas: Rekayasa Dan Penerapan Teknologi*, *5*(1), 48–52. https://doi.org/10.25077/jarpet.v5i1.116

Mulbar, U., Nasrullah, N., & Abbas, N. F. (2025). Scientific-based Digital Storytelling to Enhance Science Literacy and Environmental Awareness in Junior High School Students. *Jurnal Ilmiah Pendidikan MIPA*, *15*(2), 47–58. https://doi.org/https://doi.org/10.30998/zbqhn729 INTRODUCTION

Nuraini, J. A., Salsabila, I., Faturrohman, R., Novianti Taufik, A., Fajariyanti, N., & Nulhakim, L. (2025). Implementasi Model 4-D dalam Pengembangan Video Animasi Pembelajaran dengan Berbantuan Powtoon. *Kosmologi: Jurnal Pendidikan IPA Dan Sains*, *1*(1), 44–50. https://ejournal.untirta.ac.id/kosmologi

Panjaitan, M. H., Aznam, N., Pujianto, P., Erlini, N., & Illahaqi, A. A. D. (2021). Students' Environmental Literacy Understanding in Science Learning: A Preliminary Study. *Proceedings of the 6th International Seminar on Science Education*, *541*(Isse 2020), 768–774. https://doi.org/10.2991/assehr.k.210326.110

Roehrig, G. H., Dare, E. A., Ring-Whalen, E., & Wieselmann, J. R. (2021). Understanding coherence and integration in integrated STEM curriculum. *International Journal of STEM Education*, *8*(1). https://doi.org/10.1186/s40594-020-00259-8

Sarira, E. G. A. (2025). Pemanfaatan Lingkungan Sekitar Sebagai Sumber Belajar IPA Di Sekolah Dasar : Strategi Membangun Karakter Dan Logika Anak. *Intelektual*, *1*(2), 48–59.

Syukri, M., Herliana, F., Maryono, M., Ngadimin, N., & Artika, W. (2023). Development of Physics Worksheet based on STEM integrating Engineering Design Process (EDP) through Guided Inquiry Model to Improve Students' Critical Thinking. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *9*(2), 225–236. https://doi.org/10.21009/1.09205

Thiagarajan, S., Semmel, S. D., & Semme, I. M. (1974). Instructional development for training teachers of exceptional children. In *Journal of School Psychology* (Vol. 14, Issue 1). Indiana University.

Triwulandari, S., Sulaeman, N. F., & Syam, M. (2022). Development of Stem-Based Teaching Materials With Engineering Design Process Model on Global Warming: Validity Aspect. *Jurnal Pembelajaran Fisika*, *11*(2), 69–76. https://doi.org/10.19184/jpf.v11i2.31534

UNESCO. (2020). Education for Sustainable Development: A Roadmap. In *Education for sustainable development: a roadmap*. United Nations Educational, Scientific and Cultural Organization (UNESCO). https://doi.org/10.54675/yfre1448