



Miniature micro hydro power center to improve critical thinking skills for elementary school students

Ristiana Dyah Purwandari^{1*}, Desi Putrianasari², Abdul Haris Mulyadi³, Vina Zahra Al-Kharis¹, Vira Zahra Alkharis⁴

¹Elementary Education Study Program, Universitas Muhammadiyah Purwokerto
K.H. Ahmad Dahlan Street, Dukuhwaluh, Kembaran, Banyumas Regency, Central Java 53182, Indonesia

²Sekolah Dasar Negeri 3 Plumbungan

Plumbungan Village Street, Pagentan, Banjarnegara, Central Java 53455, Indonesia

³Chemical Engineering Study Program, Universitas Muhammadiyah Purwokerto
K.H. Ahmad Dahlan Street, Dukuhwaluh, Kembaran, Banyumas Regency, Central Java 53182, Indonesia

⁴Nursing Department, Akademi Keperawatan Patria Husada Surakarta
Sumpah Pemuda Street No. 50/58, Mojosongo, Banjarsari/Jebres, Surakarta, Central Java 57136, Indonesia

*Corresponding Author. E-mail: ristianadyah@yahoo.com

Received: 23 January 2025; Revised: 8 September 2025; Accepted: 12 February 2026

Abstract: The Miniature Micro Hydro Power Center (MHPC) is a learning media development designed to improve critical thinking skills in elementary science education. The operation of this miniature resembles that of the actual MHPC Karekan, located in Banjarnegara, Indonesia. This study aimed to develop the MHPC Miniature media, evaluate its validity, and test its effectiveness in enhancing students' critical thinking skills. This research employed the Research and Development (R&D) method, using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. The research stages included an assessment of teacher and student needs, followed by product validation by material experts (one science lecturer and five experienced teachers), technicians, and nine practitioners. To test its effectiveness, 102 fifth-grade students from the Ki Hajar Dewantara Cluster in North Purwokerto District were selected as the research sample. The sample was divided into an experimental and a control group using a cluster sampling technique. Data from the posttest were analysed for normality and homogeneity before an Independent-Samples T-Test. The results indicated that validation by science experts and practitioners yielded a Content Validity Index (CVI) of > 0.85 , indicating the media is highly suitable for learning. Furthermore, the Independent Samples T-test showed that the experimental group using the MHPC miniature performed significantly better than the control group, which used only video-based media ($p < 0.05$). In conclusion, the developed MHPC miniature is a valid and effective tool for fostering critical thinking skills in elementary science learning. These findings imply that integrating contextualized miniatures into the science curriculum can bridge the gap between abstract concepts and real-world applications, providing a scalable model for innovative STEM education.

Keywords: critical thinking, learning media, miniature, micro hydro power center

How to Cite: Purwandari, R. D., Putrianasari, D., Mulyadi, A. H., Al-Kharis, V. Z. & Alkharis, V. Z. (2026). Miniature micro hydro power center to improve critical thinking skills for elementary school students. *Jurnal Prima Edukasia*, 14(1), 60-72. DOI: <https://doi.org/10.21831/jpe.v14i1.82835>



Introduction

Critical thinking is a clear, reasonable, precise, and systematic cognitive process rooted in scientific logic and reasoning. These skills encompass the ability to communicate diverse thoughts, make informed decisions, and analyze complex problems to evaluate and refine ideas. Furthermore, critical thinking involves exploring situations, phenomena, or questions to arrive at sound hypotheses and conclusions (Alsaleh, 2020; Ikhsan et al., 2020; Lau, 2011). However, recent studies indicate that

This is an open access article under the [CC-BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



the critical thinking skills of elementary school students in Indonesia remain significantly low (Hsu et al., 2022; Kwangmuang et al., 2024; OECD, 2024).

Learning media are essential for helping students acquire new concepts, skills, and competencies. It serves to convey educational messages and can stimulate learners' thoughts, emotions, attention, and motivation (Heruprahoro et al., 2023). Rapid technological advancements continuously influence the evolution of learning media (Peng et al., 2025). One relevant application in science education is the Micro Hydro Power Center (MHPC). MHPC uses small-scale water discharge to convert potential energy from falling water into kinetic and mechanical energy, which is then converted into electrical energy. The flow capacity and the height of the installation directly determine the potential energy available for power distribution (Liang et al., 2023). MHPC typically uses rivers as an energy source, often in Run-of-River (ROR) systems.

The integration of effective learning media can significantly enhance students' critical thinking skills, including the ability to evaluate and infer information logically and rationally. According to Yonanda et al. (2019), teaching materials developed based on student and teacher needs—such as problem-based resources—can foster high-level thinking skills. Fajari et al. (2020) further state that critical thinking is vital for problem-solving in real-world contexts. In assessing these skills, the Norris-Ennis framework identifies five core aspects: basic clarification, gathering information, inference, advanced clarification, and strategy/tactics (Ennis, 1996).

Stiggins (1994) offers a framework for assessing these skills through five fundamental cognitive operations: 1) recall, recognizing facts and principles; 2) analysis, breaking down components or arguments; 3) comparison, identifying similarities and differences; 4) inference, engaging in deductive or inductive reasoning to propose hypotheses; and 5) evaluation, assessing the quality and credibility of an idea based on specific criteria. Learners are not required to meet all indicators simultaneously; rather, indicators are selected based on the discipline's specific requirements (Ma, 2023).

In the fifth-grade elementary science curriculum, the topic "Magnetism, Electricity, and Technology for Life" explores how electrical energy is obtained. The novelty of this study lies in the development of a portable, miniature MHPC. This media serves as a functional replica that allows students to observe directly how mechanical energy transforms into electrical energy. Unlike static video media, this tool is designed for hands-on use, ensuring a safe and interactive learning experience. This is particularly relevant as the Karekan Village area already hosts an actual MHPC, providing a local context for students.

Given the urgent need for contextual learning tools, it is necessary to implement MHPC miniature media to improve students' critical thinking. Based on this background, the problem formulation of this study focuses on the stages of MHPC miniature development, product validation, and the effectiveness of utilizing MHPC miniature media in science learning to enhance critical thinking skills.

This research contributes to both the theory and practice of elementary science education. Theoretically, it strengthens the application of Piaget's concrete operational stage by demonstrating how physical miniatures bridge abstract energy concepts with tangible observations. Practically, it provides a localized, validated instructional tool that transforms the nearby Karekan MHPC into a relevant pedagogical resource. This portable model enables teachers to shift from passive video-based instruction to active, inquiry-based learning that effectively fosters higher-order thinking skills.

Methods

The development of the MHPC Miniature learning media utilized the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) Research and Development (R&D) model (Ambarita et al., 2022). This model is recognized as a highly efficient method for creating educational products and instructional resources (Friedman & Schneider, 2018).

The analysis stage was conducted using a Google Form survey involving nine fifth-grade teachers from 10 schools in the Diponegoro Cluster, Pagentan District. The analysis encompassed: 1) the implementation of knowledge development, including identified learning problems and students' current critical thinking skills; 2) potential instructional solutions; and 3) the specific needs of teachers and students based on their suggestions and recommendations.

The design stage involved a collaboration between the researcher and the MHPC technician supervisor at MHPC Karekan. This collaboration ensured that the MHPC miniature was designed in accordance with the original proportions and mechanical principles of the actual facility.

During the development stage, product validation tests were performed. This involved material experts (one science content lecturer and five experienced teachers), technical experts, and sembilan practitioner teachers. Validation included assessments, qualitative feedback, and product improvement suggestions. The science content validation was conducted by a lecturer in Basic Education at the University of Muhammadiyah Purwokerto and five teachers with over 10 years of experience from the Teacher Working Group (TWG) in Banjarnegara. Professionals from MHPC Karekan, PT Putra Tirta Nusantara provided technical expertise. The validated MHPC miniature was subsequently pilot-tested at Plumbungan 3 Elementary School and Karekan 3 Elementary School, involving eight students.

The implementation stage tested the MHPC miniature's effectiveness on critical thinking skills. A quasi-experimental design was employed, comparing two groups using an independent sample t-test. The experimental group used MHPC miniature media, while the control group used MHPC Karekan video media. This stage involved three classes from three schools in the Ki Hajar Dewantara Cluster, North Purwokerto District, Banyumas: Grendeng 1 Elementary School, Grendeng 2 Elementary School, and Grendeng 3 Elementary School. The Evaluation stage involved distributing questionnaires to practitioners, specifically teachers in the Teacher Working Group (TWG) in the Banjarnegara Regency, to assess the overall utility and impact of the developed media.

Results and Discussion

Results

The results of the research and development of MHPC miniature media products using the ADDIE model are as follows:

1. Analysis Results

a. Results of The Analysis of Learning Problems

The analysis was carried out with 9 practitioner teachers from the Diponegoro Cluster, Pagentan District, Banjarnegara Regency, and 5th-grade students from State Elementary School 3 Plumbungan and State Elementary School 3 Karekan, Pagentan District, Banjarnegara Regency. Teacher involvement in the analytical aspect includes analysis of learning problems, teacher potential, and teacher needs, while student involvement in the analysis of learning media needs.

Results of interviews with teachers about learning issues: 1) The Independent Curriculum that applies in Indonesia has provided flexibility in the presentation of learning, where teachers can focus on important content so that they can deepen students' knowledge and skills. However, the contextualization of learning is still very minimal, so some of the content that students learn is still limited to theoretical explanations in textbooks; 2) the unavailability of concrete and contextual learning media in schools to support the improvement of critical thinking skills about the learning material "How to Generate Electrical Energy"; 3) teachers need learning media that supports the improvement of critical thinking skills in the learning material "How to Generate Electrical Energy" in the teaching and learning process, so that it is easier to explain abstract material; 4) students are less interested in textbook material because it is considered difficult to imagine how energy sources, especially water, have potential energy because they are in high places and convert energy to produce electricity used daily; 5) low critical thinking skills; 6) Efforts that need to be made to support the improvement of critical thinking skills.

b. Potential Analysis Results

The results of interviews with teachers about potential analysis: 1) Pagentan District, especially Karekan Village, which is close to the neighborhood where students live, has the location of a Mini Hydro Power Plant (MHPC) that can be used as a source of contextual learning; 2) the existence of MHPC Karekan can be felt to this day, both in terms of environmental sustainability and economic aspects of the surrounding community; 3) MHPC Karekan was able to answer that the natural potential in Pagentan Regency is able to support sustainable development.

c. Results of Teacher Needs Analysis

This data was obtained from a questionnaire administered to 9 teacher practitioners in the Diponegoro Cluster, Pagentan District, Banjarnegara Regency. The questionnaire answers are recapitulated in percentages.

- 1) No teacher uses concrete object media to explain MHPC's working principles;
- 2) The learning that has been carried out by teachers: 33.3% of teachers stated that they used the lecture method, 33.3% of teachers conducted demonstrations in the form of pictures, 21.2% of teachers said they conducted group discussions, and 11.1% of teachers used video media;
- 3) Teachers' challenges to provide learning content "how electrical energy is generated and used as an energy source": 66.74% of teachers revealed that the main challenge in teaching electrical energy materials is low critical thinking skills;
- 4) Teacher support for the development of MHPC miniature media: 100% of teachers agree and support the development of MHPC miniature media to strengthen students' critical thinking skills.

d. Results of student needs analysis

The analysis of student needs was carried out by giving questioners to 8 students, 4 students of State Elementary School 3 Plumbungan and four students of State Elementary School 3 Karekan, The results of the questioners were recapitulated in percentages.

- 1) Students' knowledge about the existence of MHPC Karekan as a source of Electrical energy: 77.8% of students do not know the existence of MHPC Karekan which can be used as a learning resource for the topic "How to Get Electrical Energy?";
- 2) Student statements about learning media that can help understand the content of how electrical energy is generated and used as an energy source: 88.33% of students stated that they need contextual and interesting learning media to support their learning;
- 3) All students (100%) expressed interest and willingness to learn using MHPC's miniature media.

2. Design Results

The stages of MHPC Miniature design are aligned with the problems, potentials, and needs that have been analysed; the researcher then formulates the Learning Indicators as shown in Figure 1.

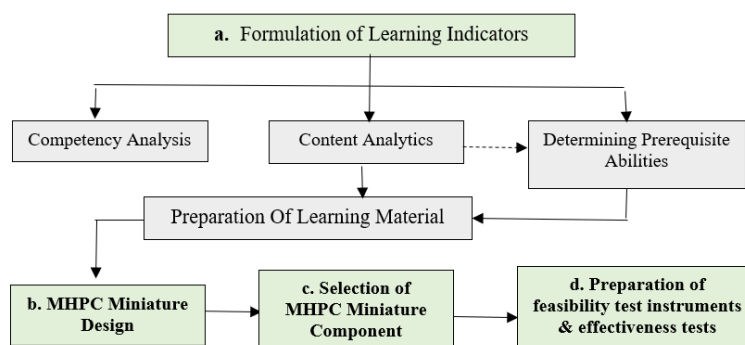


Figure 1. MHPC Miniature Media Design Stage

Figure 1 shows that the formulation of the Learning Indicators was carried out so that the MHPC Miniature Media focused on explaining the process of changing potential energy in the flow of water at a certain height into electrical energy based on the learning outcomes of grade 5 semester 1, namely "Students describe the threat of energy crisis that can occur and propose individual and collective efforts that can be made to save energy use and also the discovery of alternative energy sources that can be used by using the resources that exist around it". Based on the learning results, the researcher compiled objectives and formulated learning indicators that were adjusted to the concept understanding indicators presented in Table 1 below.

Table 1. Formulation of Learning Indicators

Learning Outcomes	Learning Objectives	Concept Understanding Indicators	Learning Indicators
Students describe the threat of energy crisis that can occur and propose individual and collective efforts that can be made to save energy use and as well as the discovery of alternative energy sources that can be used using the resources around them.	Tell the process or how to generate electrical energy from the surrounding resources. Conserve alternative energy sources that exist around it so that it can be used as a power plant.	Restating a concept.	Students can define electrical energy and how electrical energy is generated correctly.
		Classifying objects according to their nature or according to their concept.	Students are able to identify water as one of the energy sources that can be used for mini-hydro power plants correctly.
		Give examples and non-examples of a concept.	
		Presenting concepts in various forms of representation.	Students can detail the basic principles of how a mini-hydro power plant uses water energy to generate electricity correctly.
		Developing conditions is quite a concept.	Learners can understand the importance of using energy resources in a sustainable way, and properly relate them to the proper use of water energy for power generation.
		Using, utilizing, and selecting specific procedures or operations.	
		Apply concepts or problem-solving.	Students can describe the benefits of using water energy as an alternative energy source, including its positive impact on the environment and the proper availability of natural resources.

After formulating learning indicators, the researcher determines the learning experience students need before learning the content, using MHPC Miniature Media as a basis for this knowledge. The basic knowledge that students must have before studying the topic "How to Obtain Electrical Energy" using the MHPC Miniature Media includes: the types of energy sources that can produce electrical energy, the definition and different forms of energy, and the basic concepts of electricity (e.g., voltage, electric current, and the basic components of electrical circuits). The product design stage is carried out in collaboration between MHPC Karekan researchers and technicians, under the supervision of MHPC Karekan, so that the MHPC mini-media maintains its original size and functionality, as shown in Figures 2 and 3 below.

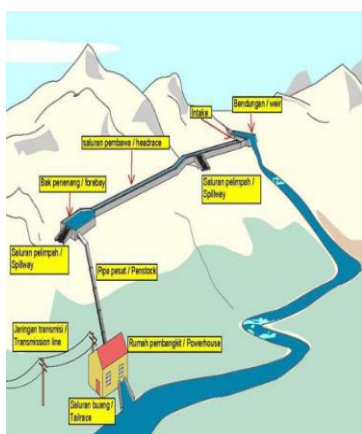


Figure 2. MHPC Miniature Media Product Components



Figure 3. MHPC Miniature Media Products

Figures 2 and 3 depict the miniature components of the MHPC, which consist of: sedation tub (Bay front), overflow duct (Overflow duct). The other parts are the fast pipe (Penstock), the home generator (Rumah Electric), the exhaust (Tail race), and the transmission network (Transmission Line). Meanwhile, as a marker that the energy conversion process actually generates electricity, the researchers added a section of the lamp to the customer's miniature home. The most complex part is in the generator house. The generator house is a core part of the MHPC, functioning as a house or place for mechanical and electrical equipment to produce electricity. Sketch of the inside of the power house, designed from research by Miskat et al. Components in the home generator set (Electric House), in this section there are 5 components as the miniature core of MHPC as shown in Figure 4.

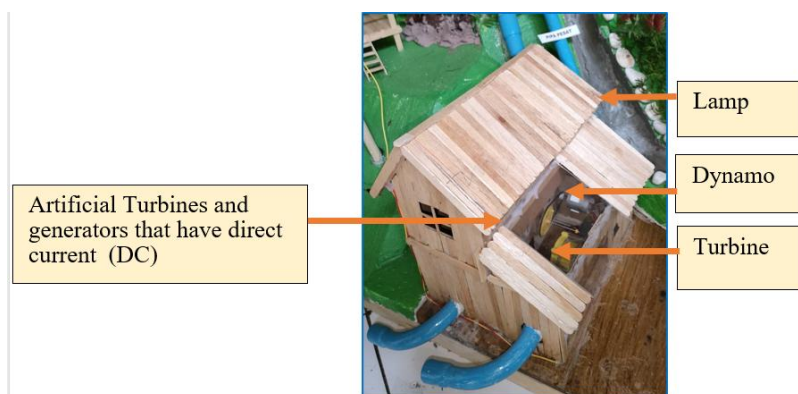


Figure 4. MHPC Generator House

In Figure 4, the inside of the generator house is described which consists of several mechanical and electrical equipment, namely 1) turbines and generators that have an electric current (DC) with a yield of 12 volts; 2) artificial turbines are used as drives to convert the potential energy of water into kinetic energy; 3) The mini dynamo functions as a generator that converts kinetic energy into electrical energy with an output of 12 volts; 4) Micro USB Step Up DC acts as a power stabilizer while increasing the generated electrical voltage; and 5) the function of the switch to disconnect and connect the electricity generated by the generator. The MHPC miniature media are designed to be easy to use, so students can operate independently during learning.

3. Development Results

During the development stage, product validation and testing are conducted. Media validation is carried out by science learning content experts, technicians, and teachers who are members of the TWG. The results of the validation of science learning content experts consisted of 3 aspects: on the technical aspects, content, and appearance, MHPC obtained a score of 75 with a statement of suitability. The results of the validation of MHPC technicians consist of 3 aspects, namely appearance, technical and work aspects. The expert technician assessment was carried out twice. The results of the first expert technician's assessment of the technical aspects, content, and appearance of MHPC obtained a score of 39 out of a total of 50, with the statement "Less Suitable" used, with many revisions. In the second expert technician assessment, a maximum score of 50 (Good) was obtained, with a good product statement and a good explanation of how it works according to the original.

The results of the practitioner validation consisted of 3 aspects: the technical, content, and miniature aspects of the MHPC display. The data analysis technique for practitioner responses uses the CVI (Content Validity Index) by Polit and Beck (2006) and Wynd et al. to evaluate the relevance of the content scale through expert assessment. The I-CVI result obtained an average I-CVI of 0.89, while the Content Validity Index (S-CVI) Scale-Level is the number of items approved by the practitioner. In this study, the results of S-CVI (12 items) were compared with those of Universal Agreement (14 items) and were 0.85.

The MHPC miniature media, validated by experts, technicians, and practitioners, was then tested in science lessons for students at Plumbungan 3 Elementary School and Karekan 3 Elementary School. Learning begins with a pretest, learning with MHPC miniature media and ends with a posttest. Students are given a pretest and a posttest of 10-question essay questions that assess critical thinking skills,

namely Interpretation, Analysis, Inference, Evaluation, and Explanation. The average pretest results for each indicator are 38, 81, 31, 69, and 33, while the posttest results are 38, 81, 31, 69, and 33. 77, 84, 66, 92, 67.



Figure 5. MHPC Miniature Media Trial in Science Learning

4. Implementation Results

At this stage, a test was conducted to evaluate the effectiveness of MHPC miniature media on students' critical thinking skills. The implementation in the Ki Hajar Dewantara Cluster, North Purwokerto District, Banyumas Regency, involved three schools divided into experimental classes and control classes. In the learning experiment class, the learning uses MHPC Miniature Media while the control class uses MHPC Kareka video media. Furthermore, students are given a 10-question content test that assesses critical thinking skills (Interpretation, Analysis, Inference, Evaluation, and Explanation). The results of the Independent Sample Test showed a difference in critical thinking ability between the experimental class using MHPC media and the control class, with sig. $0.00 < 0.05$, shown in Table 2 below.

Table 2. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower		Upper
Critical Thinking	Equal variances assumed	.559	.456	-18.251	100	.000	-31.616	1.732	-35.053	-28.179
	Equal variances not assumed			-18.232	99.161	.000	-31.616	1.734	-35.057	-28.175



Figure 6. Science Learning using MHPC Miniature Media in Experiment Class

Figure 6 shows the implementation of science learning in experimental classrooms using MHPC miniature media. Students perform their own operations on the MHPC miniature according to its intended use. Questionnaires were also distributed to practitioners, involving 9 teachers of the Teacher Working Group (TWG) in the Banjarnegara Regency area about the use of MHPC media in learning. The questionnaire results showed that 90% of teachers stated that the use of media facilitates learning, 89% stated that MHPC miniature media helps students understand learning, and 93% stated that the use of MHPC miniature media can improve students' critical thinking skills.

5. Evaluation Results

The evaluation is carried out by creating an evaluation table based on the stages of MHPC mini-media development that have been implemented. The results of the evaluation were obtained that the MHPC miniature product developed was in accordance with the ADDIE development stage with excellent results, the MHPC miniature product was suitable for use, the results of the implementation in learning that the use of MHPC miniature media had a positive effect on the critical thinking skills of elementary school students.

Discussion

The development of learning media in the form of miniatures has been carried out in line with the ADDIE development model (Dick & Carry, 1996; Jais et al., 2022; Mulyati, 2024). Based on the results of the trial and the implementation of MHPC miniature media in science learning, the theme "How to Get Electrical Energy?" can improve and enhance students' critical thinking skills in the areas of Interpretation, Analysis, Inference, Evaluation, and Explanation. This is in accordance with research by Fatmawati et al. (2019), which shows a significant correlation between critical and creative thinking skills and students' cognitive learning outcomes. Therefore, it is necessary to develop thinking skills in learning to further improve critical and creative thinking, as well as learning outcomes, through innovative learning. These recommendations are used to improve the quality of learning.

In addition, another study on the influence of learning media on improving critical thinking skills by Gunawan et al. (2023) states that the development of picture storybook learning media meets the criteria of quality, practicality, and product effectiveness in terms of the critical and creative thinking skills of fifth-grade elementary school students. Learning activities developed in this learning media were embedded in daily-life contexts and activities that can facilitate students in developing critical and creative thinking skills. The developed learning media include titles, pictures, illustrations, and knowledge aligned with core competencies, basic competencies, indicators of competency achievement, and indicators of students' critical and creative thinking skills (Álvarez-Huerta et al., 2022). This pictorial learning media can stimulate students' motivation, curiosity, and enthusiasm for learning (Anggito & Sartono, 2022; Atma et al., 2021; Siburian et al., 2019).

The MHPC miniature was developed based on the original design of a micro hydro power plant. According to Mardiyanto et al. (2023), power quality issues arising from nonlinear loads require frequency control via a load-balancing strategy using an Electronic Load Controller (ELC). Run-of-river micro hydro power plants use water energy with a relatively fixed flow; therefore, they often use a dummy load ELC as a frequency stabilizer.

The MHPC learning media is easy for students to use because its miniature form allows them to visualise the energy-forming process clearly. To operate the media, students fill the water tank and turn the pipe valve to generate a flow that rotates the miniature turbine and drives the dynamo. The resulting electricity is indicated by the Light Emitting Diodes (LEDs) turning on. This contextual media allows students to learn science while stimulating their thinking skills.

The advantage of this medium is that it is medium-sized (70 cm x 70 cm x 70 cm) and weighs about 5 kilograms, making it easy to move or place in a classroom. Students can begin by preparing water to pour into a miniature tub as a depiction of river water. The appliance also does not require a power source and can be operated manually. How the tool produces electricity (lights on) can be observed directly by students in the tool's division. Teachers can ask in-depth questions as students observe. The shortcomings of this media cannot yet be mass-produced, but in the future this is not impossible.

Consistent with the development research by Lathifah (2024) on miniature media, this study found that 3D diorama-based learning positively impacted students' conceptual understanding and creative thinking skills. This finding was further supported by Melinda and Ariyani (2024), who noted that diorama-based learning motivated students and helped both teachers and students explain and understand complex material. Similarly, Nasution and Anas (2024) found that diorama media, which provides realistic depictions of original objects, was both effective and feasible for the instructional process, falling into the "very good" category.

Other studies by Mulyati (2024) and Rudin et al. (2021) also demonstrated that diorama media improved conceptual understanding among elementary school students. Furthermore, research by Dewi and Tyas (2025) on 3D learning media found that dioramas offered significant benefits, enabling students to explore knowledge directly and providing opportunities for independent learning. Ultimately, such media provided concrete experiences for students, making the learning process less monotonous and more engaging.

In this study, the use of MHPC miniature media allows students to be actively involved in learning, gain new experiences, directly observe how it works, and develop critical thinking skills about energy changes and the use of electrical energy. In line with the research of (2024), the application of the PjBL (Project-Based Learning) model, supported by diorama media, can enrich the learning experience and stimulate student creativity. The implication of this interactive and collaborative learning model is increased student engagement and motivation in the learning process. Based on other research by 3-dimensional diorama learn, grade 5 elementary school social science materials can improve grade 5 students' learning outcomes, even students' learning outcomes.

Regarding critical thinking skills in science content, such as "How to Get Electrical Energy," teachers were required to develop learning media that facilitated student cognition by considering the concrete operational stage of elementary students. At this stage, students effectively applied logic primarily to physical objects. In line with Lathifah's (2023) research, most teachers agreed that developing flexible, effective media to explore abstract science concepts could significantly enhance students' critical thinking skills.

Consequently, the development and application of interactive multimedia based on scientific inquiry were deemed feasible for teaching and learning. This research also served as a reference for educators in creating active and engaging instructional models. Furthermore, according to Syarifuddin (2018), scientific process skills involve formulating hypotheses to draw conclusions. The scientific approach guided students to function as young scientists by following systematic steps to discover theories. This approach engaged students in complex problem-solving activities through discussion, creative thinking, research, and conceptual construction. Ultimately, using a scientific approach provided students with broad opportunities for contextual learning, making the educational process more meaningful.

Not all students can build critical thinking skills easily through textbooks or learning videos alone, therefore, teachers need to provide a real learning experience and make it easier for students to understand the content. The use of miniature media is one of the things that supports the success of the learning process based on a study by Dewi et al. (2023) arguing that artificial or miniature objects, such as three-dimensional objects that can be held and felt by students, can help students understand the concept of content taught by the teacher more easily, so in this case MHPC miniature media that can also move cooperatively like the real can provide an overview real about existing concepts and support the improvement of critical thinking skills. In addition, another study that uses learning media to improve critical thinking skills is according to Artobatama et al. (2023) which explains related to STEM learning with literacy-based Pop-Up Book media will integrate the four components capable of producing students' thinking activities that are useful for bringing out students' critical thinking patterns, which are characterized by the ability to solve problems, make decisions, analyze assumptions, evaluate, and conduct investigations.

Conclusion

The MHPC miniature media developed in this study include comprehensive operational

guidelines and assessment instruments to measure critical thinking skills. Validation results from science content experts, technicians, and practitioners indicated that the media is of high quality and highly suitable as a learning tool for elementary school students, specifically on the topic "How to Get Electrical Energy?" Furthermore, the MHPC miniature is effectively utilized in science learning to enhance students' critical thinking skills across five key dimensions: interpretation, analysis, inference, evaluation, and explanation. The integration of this contextual media significantly improves learning outcomes compared to conventional video-based resources, making it a viable innovation for science education in elementary schools.

References

- Alsaleh, N. J. (2020). Teaching critical thinking skills: Literature review. *The Turkish Online Journal of Educational Technology, 19*, 21–39. <http://files.eric.ed.gov/fulltext/EJ1239945.pdf>
- Álvarez-Huerta, P., Muela, A., & Larrea, I. (2022). Disposition toward critical thinking and creative confidence beliefs in higher education students: The mediating role of openness to diversity and challenge. *Thinking Skills and Creativity, 43*. DOI: <https://doi.org/10.1016/j.tsc.2022.101003>
- Ambarita, C. F., Sirait, D. E., & Ambarita, P. (2022). The effectiveness of developing interactive learning media on learning basic concept material. *International Journal of Computer Applications Technology and Research, 11*(12), 413–415. DOI: <https://doi.org/10.7753/ijcatr1112.1004>
- Anggito, A., & Sartono, E. K. E. (2022). The development of multicultural education comics to embed tolerance character for 4th grade of elementary school. *Jurnal Prima Edukasia, 10*(1), 66–81. DOI: <https://doi.org/10.21831/jpe.v10i1.40504>
- Artobatama, I., Hastuti, W. S., Zubaidah, E., & Wibowo, S. E. (2023). STEM learning design with literation-based pop-up book media in elementary schools. *Jurnal Prima Edukasia, 11*(2), 152–160. DOI: <https://doi.org/10.21831/jpe.v11i2.56628>
- Atma, B. A., Azahra, F. F., & Mustadi, A. (2021). Teaching style, learning motivation, and learning achievement: Do they have significant and positive relationships? *Jurnal Prima Edukasia, 9*(1), 23–31. DOI: <https://doi.org/10.21831/jpe.v9i1.33770>
- Dewi, R. P., & Tyas, D. N. (2025). The development of PBL-based water cycle diorama media to improve grade V learning outcomes. *Jurnal Prima Edukasia, 13*(2), 256–272. DOI: <https://doi.org/10.21831/jpe.v13i2.83639>
- Earl, L., & Katz, S. (2006). *Rethinking Classroom Assessment with Purpose in Mind*. Province of Manitoba. https://www.edu.gov.mb.ca/k12/assess/wncp/full_doc.pdf
- Ennis, R. H. (1996). Critical thinking dispositions: Their nature and assessability. *Informal Logic, 18*(2), 165–182. DOI: <https://doi.org/10.22329/il.v18i2.2378>
- Fajari, L. E. W., Sarwanto, & Chumdari. (2020). Student critical thinking skills and learning motivation in elementary students. *Journal of Physics: Conference Series, 1440*(1). DOI: <https://doi.org/10.1088/1742-6596/1440/1/012104>
- Fatmawati, A., Zubaidah, S., Mahanal, S., & Sutopo. (2019). Critical thinking, creative thinking, and learning achievement: How they are related. *Journal of Physics: Conference Series, 1417*(1). DOI: <https://doi.org/10.1088/1742-6596/1417/1/012070>
- Friedman, A., & Schneider, E. (2018). Developing a visualization education curriculum in the age of

big data using the Dick and Carey model. *Visual Communication Quarterly*, 25(4), 250–256. DOI: <https://doi.org/10.1080/15551393.2018.1530115>

Gunawan, G., Suhardi, S., & Makawawa, J. C. (2023). Developing picture storybook learning media in terms of students' critical and creative thinking skills. *Jurnal Prima Edukasia*, 11(2), 161–175. DOI: <https://doi.org/10.21831/jpe.v11i2.56795>

Hanifah, C. S., & Setyasto, N. (2024). 3D diorama learning media on the history of the independence of Indonesia to improve learning outcomes in social studies learning. *MIMBAR PGSD Undiksha*, 12(1), 47–56. DOI: <https://doi.org/10.23887/jjsgsd.v12i1.72828>

Hasanah, U., Astra, I. M., & Sumantri, M. S. (2023). Exploring the need for using science learning multimedia to improve critical thinking elementary school students: Teacher perception. *International Journal of Instruction*, 16(1), 417–440. DOI: <https://doi.org/10.29333/iji.2023.16123a>

Heruprahoro, T., Anggoro, S., & Purwandari, R. D. (2023). Designing material learning for 5th grade elementary school using Science, Technology, Engineering, and Mathematics (STEM). *Proceedings Series on Social Sciences & Humanities*, 12, 445–452. DOI: <https://doi.org/10.30595/pssh.v12i.832>

Hsu, F. H., Lin, I. H., Yeh, H. C., & Chen, N. S. (2022). Effect of Socratic reflection prompts via video-based learning system on elementary school students' critical thinking skills. *Computers and Education*, 183, 104497. DOI: <https://doi.org/10.1016/j.compedu.2022.104497>

Ikhsan, J., Sugiyarto, K., & Astuti, T. (2020). Fostering student's critical thinking through a virtual reality laboratory. *International Journal of Interactive Mobile Technologies*, 14(08). DOI: <https://doi.org/10.3991/ijim.v14i08.13069>

Jais, N. F. M., Ishak, S. A., & Yunus, M. M. (2022). Developing the self-learning interactive module using ADDIE model for Year 5 primary school students. *International Journal of Academic Research in Progressive Education and Development*, 11(1), 615–630. DOI: <https://doi.org/10.6007/ijarped/v11-i1/11919>

Kwangmuang, P., Jarutkamolpong, S., Duangngern, P., Gessala, N., & Sarakan, P. (2024). Promoting analytical thinking skills development in elementary school students through animated cartoons. *Computers in Human Behavior Reports*, 15, 100467. DOI: <https://doi.org/10.1016/j.chbr.2024.100467>

Lathifah, H. (2024). Feasibility of PLTB miniature learning media on the material on how to get electrical energy at SDN Diwek 1 Jombang. *EduCurio*, 2(3), 457–466. DOI: <https://doi.org/10.71456/ecu.v2i3.880>

Lau, J. Y. F. (2011). *An Introduction to Critical Thinking and Creativity: Think More, Think Better*. John Wiley and Sons. DOI: <https://doi.org/10.1002/9781118033449>

Liang, R., Al-Huqail, A. A., Elhosiny Ali, H., Ponnore, J. J., Alkhalifah, T., Alturise, F., & Assilzadeh, H. (2023). Wireless water consumption sensing system for building energy efficiency: A visual-based approach with self-powered operation. *Energy and Buildings*, 301, 113584. DOI: <https://doi.org/10.1016/j.enbuild.2023.113584>

Ma, Y. (2023). Exploration of flipped classroom approach to enhance critical thinking skills. *Heliyon*, 9(11), e20895. DOI: <https://doi.org/10.1016/j.heliyon.2023.e20895>

Mardiyanto, I. R., Raharjo, J., Utami, S., Mursanto, W. B., & Rahardjo, A. H. (2023). An improvement

in power quality and by-product of the run-off river micro hydro power plant. *Energy Engineering*, 120(6), 1295–1305. DOI: <https://doi.org/10.32604/ee.2023.027756>

Melinda, W., & Ariyani, Y. D. (2024). Development of diorama based learning media to improve elementary school students' creative thinking ability. *Indonesian Journal of Classroom Action Research*, 2(20), 5–9. DOI: <https://doi.org/10.53866/ijcar.v1i2.310>

Miskat, M. I., Ahmed, A., Rahman, M. S., Chowdhury, H., Chowdhury, T., Chowdhury, P., Sait, S. M., & Park, Y. K. (2021). An overview of the hydropower production potential in Bangladesh to meet the energy requirements. *Environmental Engineering Research*, 26(6). DOI: <https://doi.org/10.4491/eer.2020.514>

Muliyati, D. (2024). Designing educational games for teaching hydro-electric power stations in elementary school curriculum. *Current STEAM and Education Research*, 2(1), 35–42. DOI: <https://doi.org/10.58797/cser.020103>

Nasution, N. S., & Anas, N. (2024). Development of water cycle diorama media to improve students' critical thinking ability. *Scaffolding: Jurnal Pendidikan Islam dan Multikulturalisme*, 6(2), 58–72. DOI: <https://doi.org/10.37680/scaffolding.v6i2.5204>

Nurul A., Sintayana, M., & Syafruddin, M. (2024). The effects of CTL and PjBL models assisted by diorama media on students' creative thinking abilities. *MIMBAR PGSD Undiksha*, 12(3), 472–481. DOI: <https://doi.org/10.23887/jjsgsd.v12i3.76468>

OECD. (2024). Pisa 2022. *Perfiles Educativos*, 46(183). DOI: <https://doi.org/10.22201/iisue.24486167e.2024.183.61714>

Peng, W., Jiang, Z., Yao, H., Zhang, L., & Yu, J. (2025). Short-term hydropower generation prediction model for run-of-river hydropower plants considering hydrometeorological factors. *Renewable Energy*, 254. DOI: <https://doi.org/10.1016/j.renene.2025.123790>

Polit, D. F., & Beck, C. T. (2006). The content validity index: Are you sure you know what's being reported? Critique and recommendations. *Research in Nursing & Health*, 29(5), 489–497. DOI: <https://doi.org/10.1002/nur.20147>

Rudin, B. R., Raharjo, T. J., & Utomo, K. B. (2021). The effect of project-based learning making dioramas from inorganic wastes on elementary school to enhance student's conceptual understanding and creativity. *Journal of Primary Education*, 10(3), 297–307. DOI: <https://doi.org/10.15294/jpe.v10i3.49927>

Stiggins, R. J. (1994). *Classroom Assessment for Student Success*. National Education Association. <https://files.eric.ed.gov/fulltext/ED429990.pdf>

Syarifuddin, S. (2018). The effect of using the scientific approach through concept understanding and critical thinking in science. *Jurnal Prima Edukasia*, 6(1), 21–31. DOI: <https://doi.org/10.21831/jpe.v6i1.13333>

Sylvia Dewi, P., Cahya Prima, E., Widodo, A., & Rochintaniawati, D. (2023). Inquiry ability of students to develop cognitive ability in learning hydrostatic pressure. *Research in Physics Education*, 2(2), 138–153. DOI: <https://doi.org/10.31980/ripe.v2i2.75>

Wynd, C. A., Schmidt, B., & Schaefer, M. A. (2003). Two quantitative approaches for estimating content validity. *Western Journal of Nursing Research*, 25(5), 508–518. DOI: <https://doi.org/10.1177/0193945903252998>

Yonanda, D. A., Yuliati, Y., & Saputra, D. S. (2019). Development of problem-based comic book as learning media for improving primary school students' critical thinking ability. *Mimbar Sekolah Dasar*, 6(3), 341–348. DOI: <https://doi.org/10.17509/mimbar-sd.v6i3.22892>