

Effectiveness Of Microhydro Power Plant Teaching Aid to Improve The Science Process Skills Of Physics Education Students at UIN Sayyid Ali Rahmatullah Tulungagung
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ABSTRACT: Physics learning in the Electricity and Magnetism course requires strong science process skills; however, abstract instruction with limited laboratory activities often results in low SPS achievement. This study aimed to examine the effectiveness of a Microhydro Power Plant (MHPP) teaching aid in improving students' science process skills. A quasi-experimental method with a nonequivalent control group design was employed. The participants consisted of 20 students in the experimental group and 19 students in the control group. Data were collected through SPS pretests and posttests and analyzed using N-gain and an independent samples t-test. The results showed that the experimental group's SPS scores increased from a range of 6–23 to 24–32, with N-gain values ranging from 0.57 to 0.93 (moderate to high category). In contrast, the control group obtained N-gain values between 0.07 and 0.43 (low to moderate category). The t-test results indicated a significant difference between the two groups ($p = 0.001 < 0.05$). These findings indicate that the MHPP teaching aid is effective in enhancing students' science process skills and is suitable for renewable energy-based physics learning.
Key words: science process skills, microhydropower plant, teaching aid, physics learning, renewable energy.

INRODUCTION

Electrical energy is a primary need in modern life, and its consumption continues to increase. In Indonesia, electricity demand is still dominated by fossil fuels, which are non-renewable and cannot be regenerated quickly (Palintin et al., 2020). This dependence on fossil fuels drives the need to develop renewable energy as a sustainable and environmentally friendly solution (IESR, 2025). One form of renewable energy with potential for development is hydropower through microhydro power plants.

Renewable energy is energy derived from natural sources and can be continuously renewed. One simple and promising form of renewable energy utilization is microhydro power plants. Microhydro power plants utilize small water flows to generate electricity and can be applied to small rivers (Raihan et al., 2022). The principle of microhydro power plants utilizes the conversion of mechanical energy into electrical energy, where

the kinetic energy of water is used to drive a turbine connected to a generator, generating electricity through electromagnetic induction (Okpatrioka, 2023). Microhydro systems essentially involve converting the potential and kinetic energy of water into mechanical energy in a turbine, which is then converted into electrical energy by a generator (Candrasa et al., 2022).

Microhydro power plants (MHPs) are directly related to the topic of Electromagnetism, as they integrate the concepts of fluid dynamics, rotational mechanics, and electromagnetic induction into a single energy conversion circuit. Therefore, microhydro power plants (MHPs) have the potential to be used as contextual learning media in physics courses, particularly in Electromagnetism courses. In the context of physics education, particularly in Electromagnetism courses, the concepts of electricity generation and electromagnetic induction are abstract, requiring practical-based learning. Practical work plays a crucial role in helping students connect theory with real-world phenomena. The use of a microhydro power plant prototype as a demonstration tool allows students to learn the working principles, components, and processes of electricity generation directly and contextually (Adhitama et al., 2019). The development of microhydro power plant demonstration tools has also been reported to be suitable for use as a physics learning medium for renewable energy concepts (Lima et al., 2023). Furthermore, microhydro teaching aids can support more concrete physics learning because students can directly observe the relationship between fluid flow, turbine rotation, and electrical output (Syafira et al., 2024).

Lab-based learning using teaching aids also has the potential to develop students' science process skills. Science Process Skills (SPS) are core competencies in physics learning because they reflect students' abilities to make observations, formulate hypotheses, design experiments, collect and analyze data, and draw evidence-based conclusions. SPS are a crucial part of science learning because they relate to students' ability to apply scientific procedures to systematically understand phenomena (Defianti & Sakti, 2023). Within the framework of contemporary science education, mastery of the scientific process is a key indicator of successful inquiry-based learning and scientific literacy (OECD, 2019). Inquiry-based learning eMPPAsizes students' active involvement in formulating problems, conducting investigations, interpreting data, and developing scientific conclusions (Vo & Simmie, 2025).

Empirical studies over the past five years have shown that learning that positions students as active investigators significantly improves student achievement (SPS) compared to expository learning (Kurniawan et al., 2022). Guided inquiry learning has been shown to positively impact science process skills because students are guided to experience the stages of scientific investigation directly (Tauhidah et al., 2022). Inquiry-

based practicums can also improve students' abilities to observe, measure, process data, and draw conclusions based on experimental results (Panuluh, 2022). Several studies have also reported that microhydro power plant prototypes are suitable for use as laboratory media for understanding the working principles of generators and energy conversion (Hidayat et al., 2020). Research on hydroelectric power plant demonstration equipment also indicates that these media can be used to reinforce physics laboratory learning through more realistic learning experiences (Kencana et al., 2023). However, most of this research focuses on the technical aspects and performance of microhydro power plant systems, while studies examining their impact on improving students' science process skills are still limited.

Based on the description, this study aims to test the effectiveness of the Microhydro Power Plant (MPP) teaching aid in improving the science process skills of Physics Education students at UIN Sayyid Ali Rahmatullah Tulungagung. The results of this study are expected to contribute to the development of contextual, renewable energy-based physics learning that is oriented towards strengthening science process skills.

METHODS

This study employed a quantitative approach with a quasi-experimental design, namely a nonequivalent control group (Sugiyono, 2016). This design was used to test the effectiveness of using a microhydro power plant (MPP) demonstration device in improving students' science process skills.

The study subjects consisted of two classes of students in the Physics Education Study Program at UIN Sayyid Ali Rahmatullah Tulungagung, selected using a purposive sampling technique. Class 4A was designated as the experimental class, conducting practicums using the MPP demonstration device, while Class 4B served as the control class, using conventional practicum media. The experimental and control classes consisted of 20 and 19 students, respectively.

The research procedure involved providing a practicum-based learning treatment using the MPP demonstration device to the experimental class, while the control class followed the practicum as usual. At the end of the study, both classes were given a posttest to measure students' science process skills.

The research instrument was a science process skills test, which covered the ability to observe, measure, analyze data, and draw conclusions. The instrument underwent a validation process before use. Microhydro power plant (MPP) teaching aids were used as the primary medium for practical activities in the experimental class.

Data analysis was conducted quantitatively using classical completeness and independent sample t-tests to determine differences in science process skills between

the experimental and control classes (Sandu Siyoto dan Ali Sodik, 2015). Statistical testing was performed at a significance level of 0.05.

RESULT AND DISCUSSION

Result

The results of this study were obtained from pretest and posttest data on students' science process skills after participating in learning using microhydro power plant (MPP) demonstration equipment. The data analyzed included science process skill scores before and after treatment, improvements in science process skills, and the results of the effectiveness test using the MPP demonstration equipment.

Science Process Skills Pretest and Posttest Results

A description of students' science process skill scores before and after learning using the Microhydro Power Plant (MPP) teaching aids is presented in Table 2. This table compares students' science process skill achievement at the beginning and end of the learning process.

Table 1. Pretest and Posttest Scores of Students' Science Process Skills

Experimental class				Control class			
The student	th	Total pre_test	Total post_test	The student	th	Total pre_test	Total post_test
1		18	31	1		13	16
2		17	30	2		15	18
3		10	24	3		18	19
4		12	29	4		22	25
5		13	29	5		11	15
6		11	24	6		14	18
7		14	28	7		18	23
8		12	24	8		12	14
9		14	28	9		21	26
10		23	32	10		18	23
11		17	28	11		10	14
12		19	31	12		11	18
13		6	26	13		19	21
14		16	27	14		22	24
15		20	30	15		19	25
16		12	28	16		17	22
17		17	30	17		25	27
18		13	27	18		15	20

19	16	30	19	13	18
20	18	32			

Based on the data in Table 2, there is a difference in students' achievement in science process skills before and after participating in the MPP-assisted learning.

Improvement in Science Process Skills

Improvement in students' science process skills was analyzed using the N-gain value. The results of the N-gain calculation for students' science process skills are presented in Table 2.

Table 2. N-gain Values of Students' Science Process Skills

Experimental class			Control class		
The th student	N_gain	Achievement N Gain	The th student	N_gain	Achievement N Gain
1	0,87	High	1	0,15	Low
2	0,81	High	2	0,17	Low
3	0,61	Medium	3	0,07	Low
4	0,81	High	4	0,27	Low
5	0,80	High	5	0,18	Low
6	0,59	Medium	6	0,21	Low
7	0,74	High	7	0,33	Medium
8	0,57	Medium	8	0,10	Low
9	0,74	High	9	0,42	Medium
10	0,90	High	10	0,33	Medium
11	0,69	Medium	11	0,17	Low
12	0,86	High	12	0,32	Medium
13	0,74	High	13	0,14	Low
14	0,65	Medium	14	0,18	Low
15	0,77	High	15	0,43	Medium
16	0,76	High	16	0,31	Medium
17	0,81	High	17	0,25	Low
18	0,70	Medium	18	0,28	Low
19	0,82	High	19	0,25	Low
20	0,93	High			

The N-gain values in Table 2 indicate the level of improvement in students' science process skills after learning using microhydro power plant (MPP) teaching aids.

To provide a clearer picture of the improvement in science process skills, the distribution of pretest and posttest scores is presented graphically in Figure 1.

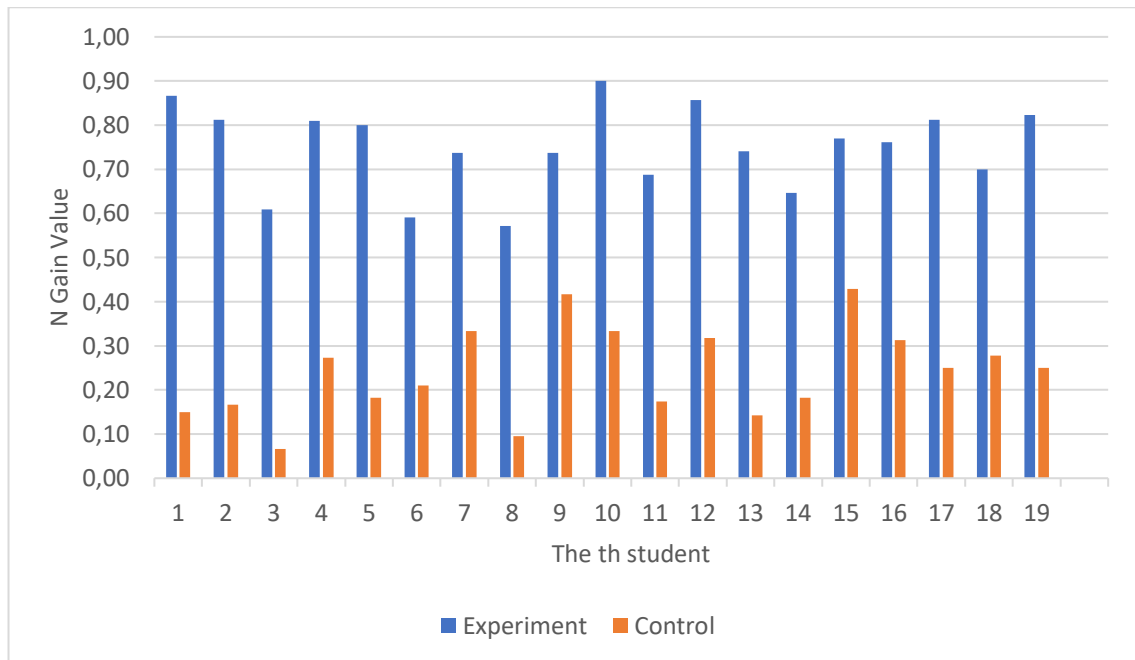


Figure 1. Comparison of Pretest and Posttest Scores for Students' Science Process Skills

Effectiveness Test Results

The effectiveness of the use of the MPP teaching aids was tested by comparing pretest and posttest scores for students' science process skills using parametric statistical tests after the data met the prerequisite requirements. The results of these statistical tests are presented in Table 3.

Table 3. Independent Samples t-Test Results for N-gain Values for Science Process Skills

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	

N	Equal								
	va								
	ria								
	nc								
	es	.025	.875	.37	.001	-.518	.032	-.584	-.453
	as								
	su								
	m								
	ed								
	Equal								
va									
ria									
nc									
es									
no			36.895	.001	-.518	.032	-.584	-.453	
t									
as									
su									
m									
ed									

The statistical test results in Table 3 indicate a significant difference between the pretest and posttest scores for students' science process skills after participating in learning with the MPP teaching aids.

DISCUSSION

The results of the study indicate that learning assisted by Microhydro Power Plant (MPP) teaching aids has a positive and significant impact on improving students' science process skills (SPS). This impact is seen quantitatively from the increase in pretest to posttest scores, N-gain values, and the results of inferential statistical tests. Based on pretest data, students' SPS scores in the experimental class were in the range of 6–23, while posttest scores increased to 24–32. This increase indicates an absolute score increase of 8–18 points per student. Meanwhile, in the control class, pretest scores were in the range of 10–25 and posttest scores only increased to 14–27, with a relatively smaller increase. This difference in range and difference in scores indicates that learning using MPP teaching aids provides a more effective learning experience in developing science process skills compared to learning without contextual teaching aids (Sholikhah, 2025). The use of microhydro power plant-based teaching aids in physics learning is also considered to provide a more concrete learning experience because students can directly observe the principles of energy conversion through a simple generating system (Lima et al., 2023).

Analysis of improvements using N-gain provides a clearer picture of learning effectiveness. The N-gain scores for students in the experimental class ranged from 0.57

to 0.93, with the majority achieving an N-gain of ≥ 0.70 . Based on Hake's criteria, these scores fall into the moderate to high category, with a predominance of students in the high category (Hake, 1999). In contrast, the N-gain scores for the control class ranged from 0.07 to 0.43, all of which fell into the low to moderate category. On average, the difference in N-gain between classes showed a substantial improvement of approximately 0.52 points, indicating a strong practical learning effect.

The high N-gain scores in the experimental class indicate that the use of micro-hydropower plant teaching aids not only improved learning outcomes nominally but also effectively facilitated the development of scientific skills. These findings align with inquiry-based and constructivist learning theories, which emphasize that science knowledge and skills are built through hands-on experience, exploration, and active student engagement. Inquiry-based learning has been shown to improve science process skills because students are involved in formulating problems, conducting investigations, processing data, and drawing conclusions based on evidence (Syahgiah et al., 2023). In learning using microhydro power plants (MPP), students are directly involved in the processes of observation, measurement, data analysis, and drawing conclusions, which are key indicators of science process skills. Practical activities that require students to directly observe, measure, and interpret data can optimally train science process skills (Defianti & Sakti, 2023).

Furthermore, the concrete context provided by microhydro power plant teaching aids bridge abstract concepts in Electromagnetism courses, particularly electromagnetic induction and energy conversion. According to contextual learning theory, conceptual understanding and process skills will improve when students learn in situations that represent the real-world application of these concepts. Contextual learning helps students connect physics concepts to real-world phenomena, making the learning process more meaningful (Burhan & Asrizal, 2023). When students directly observe the relationship between water discharge, turbine rotation, and electrical output, they not only understand the concepts conceptually but also develop evidence-based scientific thinking skills. The development of microhydro teaching aids based on contextual learning has also been reported to help students understand physics concepts through direct engagement with observed phenomena (Syafira et al., 2024).

The effectiveness test results, conducted using an independent sample t-test on the N-gain value, showed a significance level of 0.001 ($p < 0.05$) with a t-value of -15.995. A significance level less than 0.05 indicates a statistically significant difference in the improvement of the Science Process Skills (SPS) between the experimental and control groups. Therefore, the null hypothesis is rejected, and it can be concluded that the implementation of the MHP teaching aids is significantly more effective than traditional

learning methods. The average difference in the N-gain of -0.518 also indicates a significant learning impact, making the results of this study not only statistically significant but also relevant in an educational context. Guided inquiry-based practicums are reported to be more effective than traditional practicums because they provide more space for students to actively engage in the scientific process (Chengere et al., 2025).

This finding is consistent with previous research that reported that practicum-based learning and the use of contextual experimental media can significantly improve science process skills. Syarif et al. (2019) reported that students' active involvement in experimental activities improves their observation, data analysis, and conclusion-drawing skills. Practical work in physics learning can also improve students' science process skills because these activities require them to be directly involved in the stages of scientific work (Panuluh, 2022). Furthermore, research by Rahmawati et al. (2020) showed that learning that directly facilitates the scientific process results in higher KPS increases than expository learning. Learning that integrates direct scientific activities provides opportunities for students to construct knowledge through experience, not just through verbal information (Defianti & Sakti, 2023).

However, this study is unique compared to previous research because it uses a micro-hydro power plant (MHP) system as a renewable energy-based learning medium. Previous research on MHP generally focuses on technical aspects and system performance (Putra et al., 2021), whereas this study positions MHP as an effective pedagogical tool for developing science process skills. Microhydro power plant (MHP) studies in engineering generally focus on evaluating power plant performance, power capacity, efficiency, and the feasibility of implementing microhydro systems (Candrasa et al., 2022). Other studies also show that microhydro research is largely directed at analyzing the feasibility of power plants to support rural electrification (Rumbayan & Rumbayan, 2023). Thus, the findings of this study expand the study of MHP from the engineering realm to the realm of physics education. The use of MHP teaching aids as a medium for physics learning demonstrates that renewable energy technology can be used not only as an object of technical study but also as a pedagogical tool to develop students' scientific skills (Lima et al., 2023).

Overall, the moderate to high increase in SPS, the statistically significant difference in N-gain, and the alignment with inquiry theory and contextual learning indicate that MHP teaching aids are effective in physics learning. These results strengthen the argument that integrating renewable energy as a learning context is not only conceptually relevant but also strategic in sustainably developing students' science process skills. Integrating renewable energy contexts into physics learning can make

learning more applicable, contextual, and aligned with the needs of strengthening 21st-century scientific literacy (OECD, 2023).

CONCLUSION

Based on the research results and discussion, it can be concluded that the use of microhydro power plant (MHP) demonstration equipment is effective in improving the science process skills of Physics Education students. This effectiveness is reflected not only in the improvement in science process skills achievement but also in the quality of the learning process, which emphasizes active student involvement in scientific activities. MHP-based learning allows students to connect abstract concepts of electromagnetism with real-world phenomena through observation, measurement, data analysis, and conclusion drawing, thereby making physics learning more meaningful.

The results of this study demonstrate a alignment between the learning objectives formulated in the introduction and the findings in the results and discussion sections. The use of MHP demonstration equipment has proven effective in bridging the gap between theory and practice in electromagnetism learning, while simultaneously supporting the development of science process skills, a key competency in physics education. Thus, MHP demonstration equipment functions not only as a practical aid but also as a learning tool that supports the development of a comprehensive scientific experience for students.

Based on the results of this study, the use of MPP teaching aids has the prospect for further development, both in terms of teaching aid design and its application to other physics materials related to energy and electricity. In addition, further research can examine the effect of the use of MPP teaching aids on other aspects, such as critical thinking skills, in-depth understanding of concepts, or students' attitudes towards the use of renewable energy. With this development, MPP teaching aids have the potential to become an alternative medium for learning physics that is sustainable and relevant to the needs of today's science education.

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