Berkala Ilmiah Pendidikan Fisika
https://ppjp.ulm.ac.id/journal/index.php/bipf
e-ISSN: 2549-2764 p-ISSN: 2337-604X
Vol 13 No 3 2025
DOI: 10.20527/bipf.v13i3.23558

Exploring the Interplay Between Research Skills and Decision Making in Project-Based STEM Learning on Household Electricity Issues

Susilawati[1*], Haibah Wijayanti[1], Sheilla Rully Anggita[1], and Siti Norsaila Alias[2]
[1]Physics Education Department, Faculty of Science & Technology,
Universitas Islam Negeri Walisongo Semarang, Indonesia
[2]Physics Education Department, Faculty of Science & Technology,
Universiti Pendidikan Sultan Idris, Malaysia
*susilawati@walisongo.ac.id

Article Info

Article history:
Received: August 5, 2025
Accepted: October 30, 2025
Published: November 13, 2025

Keywords:
Decision-making
Household electricity issues
Project-based STEM learning
Research skills

This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License

© 2025 Berkala ilmiah Pendidikan Fisika

Abstract

This study investigates project-based STEM learning applied to explore the interaction between research skills and decision-making in addressing household electricity issues. The need for an understanding of household electricity is crucial to include in learning to equip students to meet their daily needs. This study used a quasi-experimental design, specifically a non-equivalent control group design. The sample consisted of 37 students, selected using a purposeful sample, with a focus on household electricity. The MANCOVA test results revealed a significant effect of project-based STEM learning. In the experimental group, the p-values for research skills and decision-making were 0.001 and 0.000, respectively, indicating the effect of STEM-based learning on both abilities. Students' research skills are linked to their decision-making abilities. In this learning context, issues of household electricity needs and applications are discussed. Project-based STEM learning, implemented in the classroom, guides students in exploring electricity issues relevant to household needs. This learning provides a complex understanding of how to meet everyday needs in society.

To cite this article: Susilawati, S., Wijayanti, H., Anggita, S. R., & Alias, S. N. (2025). Exploring the interplay between research skills and decision making in project-based stem learning on household electricity issues. *Berkala Ilmiah Pendidikan Fisika*, *13*(3), 424-433.

INTRODUCTION

Mastery of concepts, high-level thinking skills, and the ability to create are part of 21st-century skills that can be developed from the habit of conducting research, solving problems, and making decisions (Adnan, 2025; Ram et al., 2025). Mastery and scientific skills are essential in life. When students are accustomed to conducting research, it requires them to be able to choose and make decisions that are part of a scientific procedure. Issues related to household electricity needs and applications are essential to this study. Students explore electricity issues and their applications in households, followed by the implementation of project-based STEM learning. STEM learning is expected to provide a comprehensive understanding of community needs, particularly in the context of electricity.

The approach allows students to be actively involved in designing, researching, and solving real problems that are complex and contextual, such as household electricity issues. This problem is closely related to the student experience and requires a systematic thought process and responsible decision-making (Dauer et al., 2016; Wahono et al., 2025a).

Understanding the relationship between research skills and problem-solving is very important to designing learning strategies that are more effective and meaningful.

One of the fundamental problems that is closely related to student life is the issue of household electricity, which not only requires an understanding of physics concepts but also the skills to identify problems, design data-driven solutions, and make appropriate and responsible decisions. STEM integration in learning through projects effectively increases critical thinking skills, problem-solving, and student motivation. Students' problems have increased in direct current electric material that uses project-based STEM models (Asilevi et al., 2024; Muangchan et al., 2024).

Research skills support students' ability to analyze data, while decision-making skills help them select the best solution from available alternatives in project-based STEM learning. The urgency of this exploration is reinforced by the need for physics learning that is not only concept-oriented but also applicable to real-world problems. Field conditions indicate that learning opportunities are rare for students to conduct research and make decisions on contextual issues, such as household electricity efficiency, making this study both relevant and important to conduct.

Project-based learning requires students to complete the investigative process, which includes identification, data collection, analysis, and decision-making based on the findings. Students can determine projects/lessons that show an increase in self-directed learning skills, but students have not been able to select projects. General energy issues in the context of schools are not explored, especially in the specific context of households, such as understanding the house circuit system, electricity security, and local cultural context (Cheerapakorn et al., 2024; Yang et al., 2024; Yulianti, 2024).

This study aims to explore the interaction between the skills of researching and making informed decisions in the context of project-based STEM learning, particularly in relation to household electricity problems. The findings of this study are expected to contribute to the development of learning models that can equip students with skills relevant to real-life challenges and the world of future work.

METHODS

This study employed a non-equivalent control group design, involving one experimental group and one control group, which were selected directly without a randomization process (Sugiyono, 2016.). Although both groups studied the same material, which focused on the context of household electricity, they received different instructional approaches. The experimental group used the project-based STEM learning approach, while the control group applied the discovery learning model.

This study involved 37 students from a higher education institution, 18 in the experimental group and 19 in the control group. Students in both classes had prior knowledge of household electricity cases and problems used in the study.

Data in this study were collected through assessments in the form of pretests and post-tests. The indicators of research skills and decision-making are presented in Table 1.

Table 1 Outlines the indicators used to assess students' research and decision-making skills

Point of Indicator	Students' Research Skills	Decision-making Skills
1	Formulate the problem clearly and focus	Identify the main problem requiring a decision.
2	Develop research objectives and directions	Collect relevant information for decision-making
3	Design data collection methods and techniques	Generate several alternative solutions
4	Collect and record data systematically	Evaluate the advantages and disadvantages of each alternative
5	Analyze and interpret data logically	Choose the best solution rationally

Point of Indicator	Students' Research Skills	Decision-making Skills
6	Draw conclusions based on the results of data analysis	Evaluate the results of decisions and reflect on them

The data used in this study were obtained through a pretest and post-test that measured students' research and decision-making skills. Differences in research and decision-making skills between the experimental and control groups were subjected to comparative statistical analysis using pretest and post-test scores. Each correct answer was awarded 15 points to each participant. The results of the MANCOVA test for both research and decision-making skills indicated whether there were statistically significant differences (Parsad & Bhar, 1997).

The experimental group applied the project-based STEM learning approach, while the control group applied the discovery learning model. The steps of STEM-based learning integrated with project-based learning refer to the National Research Council (2012), as illustrated in Figure 1.

Figure 1 Project-based STEM learning implementation

RESULTS AND DISCUSSION

The Effect of STEM Learning on Students' Research and Decision-Making Skills

The average N-Gain score for STEM learning, as measured by students' research and decision-making skills, is shown in Figure 2.

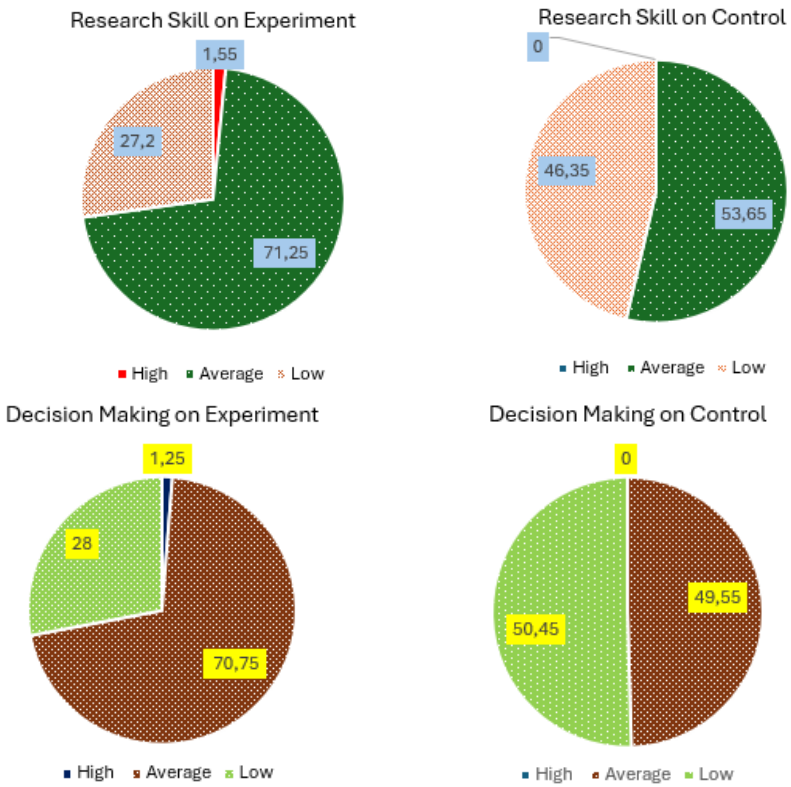
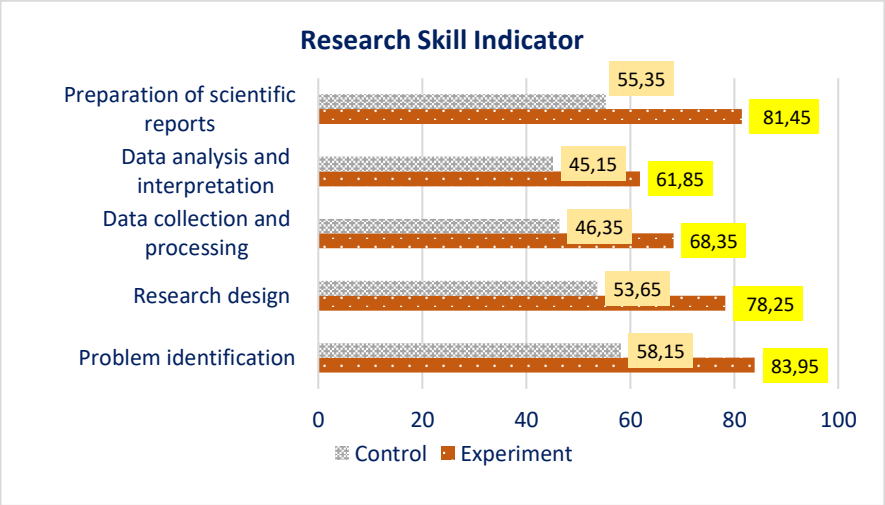
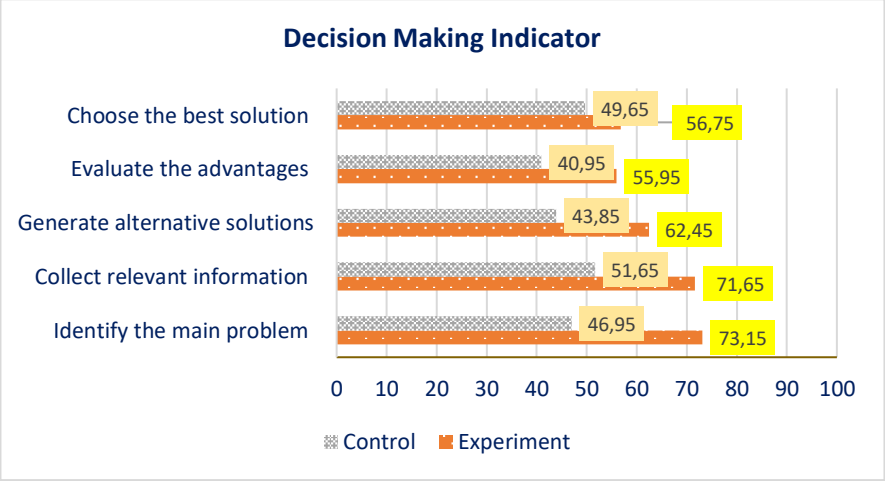


Figure 2 Results of the n-gain score

Figure 2 presents the results of the N-Gain score calculation for students' research and decision-making skills. The N-Gain scores were obtained from the pretest and post-test data of the control and experimental groups. Research skills in the experimental class, which received project-based STEM learning treatment, were average, while the control class had a lower average. The N-Gain scores for the research skill indicator and the decision-making indicator are shown in Figure 3.



(a)



(b)

Figure 3 (a) N-Gain Score of the research skill indicator and (b) N-Gain Score of decision-making indicators

Research skills were measured using five indicators: problem identification, research design, data collection and processing, data analysis and interpretation, and preparation of scientific reports. Decision-making skills consisted of five indicators: identifying the main problem requiring a decision, collecting relevant information for decision-making, generating several alternative solutions, evaluating the advantages and disadvantages of each alternative, choosing the best solution rationally, and assessing the results of decisions and reflecting on them. MANCOVA analysis results of research and decision-making skills are presented in Table 2.

Table 2 MANCOVA analysis result of research skill and decision making

Data	Variable	df	Sig.	Category
Project-based STEM	Research skill	1	0.001	Significant
	Decision-making	1	0.000	Significant

The MANCOVA analysis showed a significant difference in students' research and decision-making skills between the experimental and control groups. The p-value was below the 0.05 threshold, indicating that the applied learning approach, namely project-based STEM learning, had a significant impact on both variables simultaneously. This multivariate analysis also showed a mutually related contribution between research skills and decision-making abilities.

The relationship between research skills and decision-making

Pearson's correlation analysis illustrates the relationship between research skills and decision-making in the control and experimental classes. The results of the correlation analysis for the control class showed a strong correlation, with a value of 0.733 between research skills and decision-making. The relationship between research skills and decision-making in the control classes is shown in Table 3.

Table 3 Pearson correlation output in the control class

Pearson Correlations Output			
		Research Skill	Decision-Making
Research Skill	Correlation	1	0.733
	Sig. (2-tailed)		0.000
	N	19	19
Decision-Making	Correlation	0.733	1
	Sig. (2-tailed)	0.000	
	N	19	19

The results of the correlation analysis for the experimental classes showed a value of 0.841, indicating a strong correlation between research skills and decision-making. The relationship between research skills and decision-making in the control and experimental classes is shown in Table 4.

Table 4 Pearson correlation output in the experiment class

Pearson Correlations Output			
		Research Skill	Decision Making
Research Skill	Correlation	1	0.841
	Sig. (2-tailed)		0.000
	N	18	18
Decision-Making	Correlation	0.841	1
	Sig. (2-tailed)	0.000	
	N	18	18

Table 3 shows a MANCOVA analysis to evaluate the effect of project-based STEM learning on household electricity issues on research skills. The results of calculating students' research skills on household electricity issues and usage through project-based STEM learning showed a significant impact, with a p-value of 0.01. This study found that research-based STEM learning effectively improved students' research skills, particularly in relation to household electricity issues and usage. Project-based STEM learning effectively and significantly enhanced students' research abilities. Each STEM learning activity stimulated curiosity and encouraged students to prove and find solutions to problems.

The scientific approach of scientists in studying concepts and applications was implemented in STEM learning and projects. Information technology integration was also employed to address problems related to electricity issues in this project-based STEM learning initiative (Wandira, & Anwar, 2023; Wright & Delgado, 2023). Research skills foster student activeness, creativity, and collaboration. Interaction and collaboration in project completion, as part of the learning process, led students to focus and innovate toward problem-solving and decision-making (Jituafua, 2024; Sihombing et al., 2024).

Students' abilities in formulating and proposing hypotheses, as well as collecting and analyzing data, demonstrate the results of project-based learning (STEM) that trains research skills. These skills relate to household electricity problems, needs, and usage. Students are also given the opportunity to determine problem-solving with various alternatives. Students' research skills also require decision-making skills. This reinforces the importance of project-based learning (STEM) that involves understanding physics concepts. In addition to conceptual understanding, this learning equips students with critical, collaborative, and creative thinking skills to address everyday problems. The results of this study emphasize the interaction between research skills and decision-making as a combination that produces innovative, sustainable, and relevant solutions for students' daily lives.

This study demonstrates the role of project-based STEM in enhancing students' conceptual understanding and creativity. Relevantly, it also emphasizes the direct relationship between research and decision-making skills. This study differs in that it specifically explores the interaction between the two and connects it to real-world household electrical problems, which are rarely discussed in physics instruction. Thus, this study presents a new perspective: mastery of science and students' ability to research, analyze data, and make decisions applicable to everyday life.

Students' data analysis and interpretation skills are still low when analyzing research results (Bottia et al., 2023). Data collection and data tabulation skills still need improvement in research skills. Students' exploration and creativity in determining solutions and making decisions are essential for improving research skills (Ashidiq et al., 2024; Nastiti et al., 2024). Active student engagement and interaction in STEM project learning activities combine learning strategies, innovation, and creativity to challenge students. Project-based STEM learning analyzes household electricity problems and issues (Susilawati et al., 2025).

The MANCOVA calculation results for the experimental class showed a p-value of 0.00, as shown in Table 4. This indicates that project-based STEM learning has a significant impact on students' decision-making skills. Project-based STEM learning on household electricity issues is more effective in improving decision-making skills. Project-based STEM learning develops scientific decision-making skills and provides solutions to everyday problems (Bottia et al., 2023; King et al., 2021). The observed improvement in decision-making skills can be attributed to the familiarization with activities and opportunities provided in project-based STEM learning related to household electricity issues. Furthermore, students acquire appropriate decision-making and solution-solving skills (Chamrat & Suyamoon, 2024; Nastiti et al., 2024).

The highest score in the experimental class was obtained on the indicator "identifying key problems and gathering relevant information." Similarly, the control class scored highest on the indicator "identifying key problems and gathering relevant information." This decision-making indicator aligns with the stages of project-based STEM learning on household electricity issues, which supports students' decision-making skills (Chamrat & Suyamoon, 2024; Wahono et al., 2025b). Project-based STEM learning on household electricity issues encourages students to choose alternative courses of action, innovate creatively, make informed decisions, and conduct evaluations. This STEM learning, in

developing students' research skills, can help them formulate effective and informed decisions (Susilawati et al., 2022).

Project-based STEM learning fosters students' independence and confidence in making informed decisions based on hands-on experience and scientific investigation. This is relevant to previous research, which suggests that the relationship between problem-solving and decision-making skills is due to the activities and interactions that occur during the stages involved in project-based learning activities (Palian et al., 2025). Research skills are developed through a series of scientific phases that require step-by-step learning activities to complete projects and make informed decisions. Students' research skills and decision-making are closely related. However, individuals with strong research skills do not necessarily possess the courage, independence, and ability to make decisions (Ekasari & Algiranto, 2025). Decision-making is more often found to be based on students' research skills through systematic research procedures. Individuals often fail to consider the various phases involved in making decisions. This results in less effective decision-making outcomes (Prasetyaningsih et al., 2025; Rahm, 2025; Thi Phuong Dung et al., 2024). Correlation analysis results indicate that improving research skills and abilities can have a positive impact on other abilities, including decision-making.

CONCLUSION

The results of this study indicate that project-based STEM learning can impact students' research skills and decision-making abilities. The improvement in students' research skills was evident in the post-test results after participating in the project-based STEM learning approach. This study also found a relationship between research skills and decision-making. However, one limitation of this study is that most student projects were simulations illustrating household electricity problems. Therefore, future research is recommended to design and implement real, hands-on kits related to common electricity issues in household usage, with more comprehensive engineering designs.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

The authors contributed to the implementation and completion of this manuscript. The first author conducted the overall research. The second and third authors validated the research instruments and reviewed the manuscript, as well as assisted in the analysis and review to complete the substance of this manuscript.

ACKNOWLEDGMENTS

We would like to express our gratitude to all parties for their support in conducting this research. We would like to thank the experts and validators who provided input and suggestions for improvements in the instrument development. We would also like to thank the Research and Community Service Institute (LPPM) of UIN Walisongo Semarang.

REFERENCES

Adnan, Ö, C. K. A. (2025). Basic skills of 21st century teachers. *Australian Journal of Teacher Education*, *50*.

Ashidiq, R. M., Winarno, N., Prima, E. C., Widodo, A., & Chang, C.-Y. (2024). Investigating the impact of stem learning on students' critical thinking skills through hand-made projector activity. *Journal of Science Learning*, *7*(2), 187–203. https://doi.org/10.17509/jsl.v7i2.61549

Asilevi, M. N., Havu-Nuutinen, S., & Kang, J. (2024). Secondary school teachers' interest and self-efficacy in implementing STEM education in the science curriculum. *European*

Journal of Science and Mathematics Education, *12*(2), 297–311. https://doi.org/10.30935/scimath/14383

Bottia, M. C., Mickelson, R. A., & Stearns, E. (2023). Racially diverse educational pathways and STEM college outcomes: A quantitative analysis of students in North Carolina. *Science Education*, *107*(4), 964–998. https://doi.org/https://doi.org/10.1002/sce.21797

Chamrat, S., & Suyamoon, P. (2024). The development of teacher interns' development of teacher interns' competencies of science instructionaldesign and implementation using stem activity based on diy, tinker and maker frameworks. *Journal of Technology and Science Education*, *14*(4), 990–1010. https://doi.org/10.3926/JOTSE.2225

Cheerapakorn, P., Hinon, K., & Wannapiroon, P. (2024). Hybrid project-based learning model on metaverse to enhance collaboration. *International Education Studies*, *17*(6), 65. https://doi.org/10.5539/ies.v17n6p65

Dauer, J. M., Lute, M., & Straka, O. (2016). Indicators of informal and formal decision-making about a socioscientific issue. *International Journal of Education in Mathematics, Science and Technology*, *5*(1), 124. https://doi.org/10.18404/ijemst.05787

Ekasari, A., & Algiranto, A. (2025). Critical thinking ability in a stem-based problem-based learning model: A focus on temperature and heat. *Berkala Ilmiah Pendidikan Fisika*, *13*(1), 12. https://doi.org/10.20527/bipf.v13i1.20182

Jituafua, A. (2024). A professional development programme based on biomimicry to improve stem project creativity of science student teachers. *Journal of Turkish Science Education*, *21*(4), 705–722. https://doi.org/10.36681/tused.2024.038

King, N. S., Collier, Z., Johnson, B. G., Acosta, M., & Southwell, C. N. (2021). Determinants of Black families' access to a community-based STEM program: A latent class analysis. *Science Education*, *105*(6), 1100–1125. https://doi.org/https://doi.org/10.1002/sce.21669

Muangchan, S., Sukkamart, A., Pimdee, P., Ployduangrat, J., & Thongkaw, A. (2024). Upper secondary school student digital information fluency: a second-order confirmatory factor analysis. *International Journal of Technology in Education*, *7*(4), 719–734. https://doi.org/10.46328/ijte.792

Nastiti, L. R., Sunarno, W., Sukarmin, S., Saputro, S., & Baehaqi, L. (2024). Improving STEM literacy through project-based geoscience learning (PjBGL) model. *Journal of Baltic Science Education*, *23*(4), 694–709. https://doi.org/10.33225/jbse/24.23.694

Palian, Y. O., Efwinda, S., & Damayanti, P. (2025). Development of STEM-based worksheets on global warming to improve students' scientific reasoning ability. *Berkala Ilmiah Pendidikan Fisika*, *13*(1), 63. https://doi.org/10.20527/bipf.v13i1.19864

Parsad, R., & Bhar, L. (1997). *Multivariate Analysis of Variance*. *34*.

Prasetyaningsih, P., Kaniawati, I., Septem Riza, L., & Aria Utama, J. (2025). A content analysis of digital edutainment for disaster literacy in higher education. *Jurnal Penelitian Dan Pembelajaran IPA Prasetyaningsih*, *11*(1), 38–59. https://doi.org/10.30870/jppi.v11i1.29857

Rahm, J. (2025). Restorying belonging in stem by unpacking affective politics at work in higher education and beyond: A response to el halwany and adams. *Science Education*, *n/a*(n/a). https://doi.org/https://doi.org/10.1002/sce.21987

Ram, I., Rosenberg-Kima, R., Lewin, D. R., Barzilai, A., Chumtonov, O., & Roll, I. (2025). Active learning and the development of 21st century skills in online stem education: A large-scale survey. *Online Learning Journal*, *29*(1), 4–31. https://doi.org/10.24059/olj.v29i1.3533

Sihombing, R. A., Muslim, M., Rahman, T., & Winarno, N. (2024). Enhancing quality education in indonesia: A literature review of stem-esd landscape contributions. *Journal of Science Learning*, *7*(3), 213–226. https://doi.org/10.17509/jsl.v7i3.69046

Sugiyono, S. (2016). *Metode penelitian kuantitatif, kualitatif, dan R&D (Edisi Revisi)*. Alfabeta.

Susilawati, S., Fadllan, A., Mareta, M. P., Masturi, M., & Xaphakdy, S. (2025). The role of engagement, content, and understanding of numeracy literacy in physics creativity projects. *Momentum: Physics Education Journal*, *9*(2), 187–199. https://doi.org/10.21067/mpej.v9i2.11544

Susilawati, S., Rusdiana, D., Kaniawati, I., & Ramalis, T. R. (2022). Pre-service physics teacher conceptions and visual literacy to observe sky maps throught heaven view media. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *7*(1), 18. https://doi.org/10.26737/jipf.v7i1.2179

Thi Phuong Dung, T., Thuy Xuan Thao, T., Vinh, T., Tang Phuc Khang, L., & Chi, H. (2024). Design a framework on teaching experimental practice competencies in primary science education. *Jurnal Penelitian dan Pembelajaran IPA*, *10*(2), 190–209. https://doi.org/10.30870/jppi.v10i2.28720

Wahono, B., Purmanna, A., Ramadhani, R., & Manalu, M. S. (2025a). Strengthens the student collaboration and decision-making skills through integrated stem education: A research and development study. *Science Education International*, *36*(1), 86–93. https://doi.org/10.33828/sei.v36.i1.9

Wahono, B., Purmanna, A., Ramadhani, R., & Manalu, M. S. (2025b). Strengthens the student collaboration and decision-making skills through integrated stem education: A research and development study. *Science Education International*, *36*(1), 86–93. https://doi.org/10.33828/sei.v36.i1.9

Wandira, A., & Daenuri Anwar, E. (2023). Fluidmistar media in inquiry to improve the creative thinking skills of senior high school students. *Phenomenon : Jurnal Pendidikan MIPA*, *13*(1), 78–95.

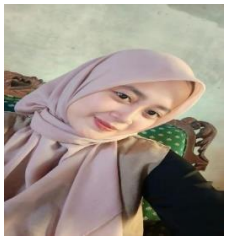
Wright, G. W., & Delgado, C. (2023). Generating a framework for gender and sexual diversity-inclusive STEM education. *Science Education*, *107*(3), 713–740. https://doi.org/10.1002/sce.21786

Yang, H., Zhang, Q., & Shen, M. (2024). The practice and research of junior high school information technology project-based learning based on stem education concept. *International Journal of Technology in Education and Science*, *8*(1), 63–74. https://doi.org/10.46328/ijtes.537

Yulianti, K. (2024). Promoting students' soft skills through project-based learning in character building pancasila course: A study in a higher education institution in Indonesia. *International Society for Technology, Education, and Science*.

AUTHOR PROFILES

Dr.Susilawati, M.Pd., was born in Muara Enim on Mei 12, 1986, and currently serves as a lecturer at UIN walisongo Semarang. Her expertise and research interests include conceptions and physics learning.
https://scholar.google.com/citations?user=8Hf3d1YAAAAJ&hl=id
https://sinta.kemdiktisaintek.go.id/authors/profile/6723164
https://orcid.org/0000-0001-9977-7730
https://www.scopus.com/authid/detail.uri?authorId=57226730188



Habibah Wijayanti, currently serves as a student at UIN walisongo Semarang. Her expertise and research interests include learning method and practicum.

Sheilla Rully Anggita, currently serves as a student at UIN walisongo Semarang. Her expertise and research interests include learning method and practicum.
https://scholar.google.com/citations?user=1IuvWBQAAAAJ&hl=id&oi=ao
https://sinta.kemdiktisaintek.go.id/authors/profile/6649469
https://orcid.org/0000-0003-4346-2275
https://www.scopus.com/authid/detail.uri?authorId=57222615842

Dr. Siti Norsaila Alias, currently serves as a student at UPSI Malaysia. Her expertise and research interests include physics learning and assesment.
https://scholar.google.com/citations?user=9AYC87oAAAAJ&hl=id
https://orcid.org/0000-0001-6889-3691