Schrödinger:Journal of Physics Education
Vol. 6, No. 1, March 2025, pp. 34~42
ISSN: 2716-1587, DOI: 10.37251/sjpe.v6i1.1469

Qualitative Analysis of the Implementation of Inquiry-Based Physics Learning Tools on Strengthening Character and Improving Learning Outcomes

Silvina Anjar Sari[1], Nirawit Kunanta[2], Mohamed A Oransa[3]
[1]Physics Education Study Program, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia
[2]School of Physics, Institute of Science, Suranaree University of Technology, Nakhon Ratchasima, Thailand
[3]Department of Engineering Math and Physics, Faculty of Engineering Cairo University, Giza, Egypt

Article Info

Article history:

Received Jan 3, 2025
Revised Feb 8, 2025
Accepted Mar 16, 2025
Online First Mar 17, 2025

Keywords:

Character Development
Inquiry-Based Learning
Learning Outcomes
Physics Education

ABSTRACT

Purpose of the study: This study aims to analyze the implementation of inquiry-based physics learning devices to support character strengthening and improve student learning outcomes.

Methodology: This study uses a qualitative approach with a case study design. The subjects of the study were students and teachers of grade XI majoring in natural sciences 2 of Sleman 2 State Senior High School, selected using purposive sampling technique. Data were collected through observation, interviews, and document analysis. Data analysis used the Miles and Huberman model with data reduction, data display, and drawing conclusions through triangulation.

Main Findings: Inquiry-based learning increases students' active engagement, understanding of physics concepts, and critical thinking skills. Students are more independent, creative, and demonstrate positive character traits such as honesty, discipline, and cooperation. Test results show significant improvements in academic achievement. This approach is effective in supporting character building and the development of 21st-century skills according to the Merdeka Curriculum.

Novelty/Originality of this study: This study reveals the effectiveness of inquiry-based physics learning devices not only in improving learning outcomes, but also in building students' character. This study provides new insights into the integration of character building in physics learning, in line with the Merdeka Curriculum, and shows how the inquiry approach can develop 21st century skills more holistically.

Corresponding Author:
Silvina Anjar Sari,
Physics Education Study Program, Universitas Negeri Yogyakarta,
Colombo Street, Karangmalang, Yogyakarta, 55281, Indonesia
Email: silviaanjar@gmail.com

1. INTRODUCTION

Physics is one of the subjects that plays an important role in developing critical thinking, analytical, and problem-solving skills. In learning physics, students are not only required to understand basic concepts, but also to be able to apply the principles of physics in everyday life [1]-[3]. However, physics learning is often considered difficult by students because it is abstract and requires a strong conceptual understanding [4]-[6]. Therefore, an effective learning approach is needed to improve student understanding and encourage them to be more active in exploring physics concepts [7]-[9]. One approach that can be used is inquiry-based learning, which emphasizes

direct student involvement in the learning process through exploration, investigation, and reflection on physics phenomena [10]-[12].

In addition to understanding concepts, character education is also an important aspect of the education system in Indonesia. Character education aims to shape students' personalities who have integrity, are independent, and are responsible in their daily lives [13]-[15]. The government, through the Merdeka Curriculum, emphasizes the importance of learning that is not only oriented towards academic achievement, but also builds positive student character [16]-[18]. In the context of physics learning, characters such as curiosity, perseverance, cooperation, and scientific attitudes are essential so that students can develop critical and innovative thinking [19]-[21]. Therefore, the implementation of learning devices that are able to integrate character building in physics learning is crucial.

Physics learning devices that are in accordance with the Independent Curriculum must be designed to provide flexibility for teachers and students in carrying out the teaching and learning process. This device consists of a Learning Implementation Plan, student modules or books, teacher handbooks, and student activity sheets that are oriented towards exploration-based learning [22]-[24]. The Independent Curriculum emphasizes project-based learning and differentiation, where learning devices must be able to adapt to students' needs and abilities [25]-[27]. Therefore, the physics learning devices that are developed must contain interactive and contextual activities, and provide space for students to actively participate in discovering physics concepts.

One model of learning devices that can be applied in physics learning is inquiry-based learning devices. This model encourages students to explore concepts through direct experience by conducting experiments, observations, and discussions based on investigative questions [28]-[30]. In inquiry learning, students are given the freedom to design and test their own hypotheses, so that they can develop critical thinking and problem-solving skills [31]-[33]. By using inquiry-based learning tools, it is expected that students will not only understand physics concepts more deeply, but also be able to develop scientific attitudes and collaborative skills that are essential in academic and professional life [34]-[36].

Thus, the implementation of inquiry-based physics learning tools has an important role in improving student learning outcomes while strengthening their character. Improvement in learning outcomes is not only measured from the cognitive aspect, but also from the affective and psychomotor aspects that reflect students' scientific thinking skills and attitudes [37]-[39]. Therefore, this study aims to analyze the implementation of inquiry-based physics learning tools in supporting character strengthening and improving student learning outcomes. The results of this study are expected to contribute to the development of more effective and contextual physics learning strategies, in accordance with the principles of the Independent Curriculum.

Previous research has explored the effectiveness of inquiry-based learning in improving students' understanding of scientific concepts and views about the nature of science. For example, one study found that a technology-supported inquiry-based learning approach can improve elementary school students' understanding of the nature of science through engagement in exploration and reflection activities [40]. Previous studies have explored the effectiveness of inquiry-based learning in improving students' understanding of physics concepts and character development. For example, a study developed an inquiry-based physics science comic integrated with character education, which showed that this approach could improve students' understanding of concepts and character development [41]. In addition, another study developed an inquiry-based physics learning module on linear motion material for high school students, which showed that the module was effective in improving students' conceptual understanding [42].

However, most of these studies have not explicitly emphasized the integration of character education in the context of physics learning. Most studies focus on improving conceptual understanding without linking it to students' character development. Therefore, there is a research gap on how inquiry-based physics learning tools can be designed not only to improve cognitive learning outcomes, but also to strengthen students' characters in accordance with the principles of the Merdeka Curriculum which emphasizes character education. The current study aims to fill this gap by analyzing the implementation of inquiry-based physics learning tools in supporting character strengthening and improving student learning outcomes, so that it can contribute to the development of more effective and contextual physics learning strategies..

Effective physics learning not only aims to improve conceptual understanding, but also to shape students' character so that they have critical thinking skills, scientific attitudes, and problem-solving abilities. However, many students still have difficulty understanding physics because the learning approach does not actively involve them. In addition, character strengthening in physics learning is often not the main focus, even though the Independent Curriculum emphasizes the importance of character education integrated with exploration-based learning. Therefore, research is needed that analyzes the implementation of inquiry-based learning devices to determine their effectiveness in improving learning outcomes and strengthening student character, so that they can be a reference in developing more contextual and meaningful physics learning strategies. This study aims to analyze the implementation of inquiry-based physics learning devices in supporting character strengthening and improving student learning outcomes.

2. RESEARCH METHOD

This study uses a qualitative research approach with a case study design to analyze the implementation of inquiry-based physics learning devices in strengthening student character and improving learning outcomes. The research process includes classroom observations, interviews with teachers and students, and document analysis such as lesson plans and student worksheets [43], [44]. This study uses a descriptive qualitative design to explore how students engage in learning, how students' character develops, and how students' academic performance improves through inquiry-based learning activities [45], [46].

The research procedure consists of several stages. The preparation stage involves a literature review on inquiry-based learning, character education, and physics learning outcomes, the design of research instruments such as observation sheets, interview guidelines, and student assessment tools, and validation of the instruments with experts. In the implementation stage, classroom observations were conducted to examine student engagement, discussions, and problem-solving approaches during inquiry-based learning activities. Structured interviews with teachers and students were conducted to gain insight into the experiences and perceptions of teachers and students. In addition, document analysis was conducted by reviewing lesson plans, student worksheets, and assessment results to evaluate the effectiveness of the learning devices. The subjects of this study were students and teachers of class XI mathematics and natural sciences department of Sleman 2 State Senior High School who were selected using a purposive sampling technique.

Data collection involved three main methods: observation, which focused on students' active participation and character development during the learning process; interviews, which captured teachers' and students' perspectives on the impact of inquiry-based learning; and document analysis, which examined learning materials and students' responses. The data analysis process followed Miles and Huberman's model, consisting of data reduction, data display, and conclusion drawing, to ensure systematic interpretation. Thematic analysis was applied to identify recurring themes related to student engagement, character development, and learning outcomes, while triangulation was used to validate findings by comparing multiple data sources. To enhance the validity and reliability of the study, data triangulation was applied by comparing information from multiple sources, member checking was conducted by involving teachers to verify interpretations, and peer debriefing with other researchers ensured objectivity. Through this approach, this study aims to provide valuable insights into the effectiveness of inquiry-based physics learning tools in improving students' conceptual understanding and character development, in accordance with the principles of the Independent Curriculum.

3. RESULTS AND DISCUSSION

This study analyzes the implementation of inquiry-based physics learning devices in strengthening student character and improving learning outcomes through classroom observations, interviews with teachers and students, and document analysis. Based on the findings of the data obtained, several important aspects were revealed regarding the effectiveness of inquiry-based learning in achieving the desired goals. The results of classroom observations show that inquiry-based learning increases students' active involvement. Students appear more enthusiastic in conducting experiments, asking questions, and discussing in groups. The inquiry process that gives students the freedom to design and test their own hypotheses allows students to delve deeper into physics material, as well as develop critical thinking and problem-solving skills. Students are also more actively involved in finding solutions to the physics problems they face, both through experiments and class discussions. The table of results for student character development is presented in table 1 below:

Table 1. Results of data analysis on student character development in physics learning

No.	Character	Character Description	Teacher Perception	Student Perception	Observation and Interview Evidence
1.	Religious	Attitude and behavior that is obedient in carrying out the teachings of the religion that is believed.	The teacher saw that students performed their religious duties well and had a religious attitude in every learning activity.	Students feel that religious teachings influence the way they complete tasks well and responsibly.	Students always start and end activities with prayer, and show mutual respect in the group.
2.	Honest	Behavior that is based on efforts to make oneself a person who can always be trusted	The teacher observed that students never reduced their grades on assignments and were always honest	Students feel that honesty is a principle that they apply in	Students never cheat on exams and always try to answer

		in words, actions, and work.	in answering exam questions.	completing tasks and group work.	questions to the best of their ability.
3.	Tolerance	Attitude and actions that respect differences in religion, tribe, ethnicity, opinions, attitudes, and actions of others that are different from oneself.	The teacher noted that students highly respected friends of different religions or ethnicities and always supported diversity.	Students feel comfortable working with friends who have differences and there is no discrimination in the group.	Group discussions always run smoothly without any differences of opinion that cause conflict between students.
4.	Discipline	Actions that demonstrate orderly behavior and obey various provisions and regulations.	The teacher observed that students were always on time for class and disciplined in completing assignments.	Students admit that discipline really helps them in achieving good results in learning.	Students always arrive on time, complete assignments on time, and follow class rules well.
5.	Hard Work	Behavior that shows serious efforts in overcoming various obstacles to learning and assignments, and completing tasks as well as possible.	The teacher noted that students showed improvement in their efforts to overcome difficulties in experiments and physics problems.	Students feel more enthusiastic in trying various ways to solve difficult problems.	Some students work extra hard to complete experiments even though they initially fail, until they finally succeed.
6.	Creative	Thinking and doing something to produce new ways or results from something that has been owned.	The teacher observed that students began to use different methods in experiments to achieve better results.	Students feel they can find new ideas in experiments and feel satisfied with the results they create themselves.	Students create new methods in experiments to test their hypotheses and innovate in how to experiment.
7.	Independent	Attitude and behavior that is not easily dependent on others in completing tasks.	The teacher observed that students were increasingly independent in finding solutions to problems without always relying on the teacher's help.	Students feel more confident and able to complete individual tasks without the help of others.	Many students work on physics assignments independently and are responsible for the tasks given.
8.	Democratic	A way of thinking, behaving, and acting that assesses the rights and obligations of oneself and others equally, and respects the rights and obligations of others.	The teacher noted that students showed an attitude of respecting and honoring the opinions of friends in group discussions.	Students feel more appreciated and involved in every decision made in the group.	Class and group discussions are always based on discussions that listen to each other and respect the opinions

					of all members.
9.	Curiosity	Attitude and action that always tries to know more deeply and broadly from something that is learned.	The teacher observed that students were more enthusiastic in asking questions and exploring more deeply about the physics concepts they were learning.	Students feel curious and always want to know more about the physics concepts they are learning.	Many students actively ask questions and look for additional references to deepen their knowledge of the subject matter.
10.	National Spirit and Love for the Country	A way of thinking, acting, and having insight that places the interests of the nation and state above the interests of oneself and one's group.	The teacher noted that students better understood the importance of maintaining the good name of the country through academic achievement.	Students feel proud to be able to learn and contribute positively to the progress of the nation through education.	Students show pride in the results of experiments and record results that are useful for the advancement of science.
11.	Appreciating Achievement	Attitudes and actions that encourage him to produce something useful for society, and acknowledge and respect the success of others.	The teacher observed that students gave each other appreciation for their friends' achievements in learning activities.	Students feel proud when they appreciate their friends' achievements and feel motivated to perform better.	Students give praise to friends who have successfully completed assignments or experiments.
12.	Friendly/	Actions that show a sense of pleasure in talking, socializing, and working together with others.	The teacher noted that students actively discussed in groups and always tried to maintain good relationships with their friends.	Students feel happy to work together with friends and have close relationships in study groups.	Students are active in speaking and sharing ideas during group discussions.
13.	Communicative	Attitudes, words, and actions that cause others to feel happy and safe with his presence.	The teacher observed that students always tried to keep the classroom atmosphere harmonious and avoid conflict.	Students feel comfortable in a peaceful and cooperative learning environment.	Students calm friends who are experiencing tension and always try to create a peaceful atmosphere during discussions.
14.	Peace-loving	The habit of making time to read various readings that provide virtue for him.	The teacher observed that some students showed great interest in physics books and other learning resources.	Students feel interested in reading more references to understand the material more deeply.	Students bring additional books on physics and many actively read articles to deepen their understanding

					of the subject matter.
15.	Like to Read	Attitudes and actions that always try to prevent damage to the natural environment around him, and develop efforts to repair the damage to nature that has occurred.	The teacher observed that students participated in activities to keep the classroom and school clean.	Students feel responsible for the cleanliness and sustainability of the surrounding environment.	Students actively participate in cleaning activities and always remind their friends to maintain cleanliness.
16.	Care for the Environment	Attitudes and actions that always want to provide assistance to others and communities in need.	The teacher observed that students were often involved in social activities outside of school, such as helping orphans or disaster victims.	Students feel happy to be able to help others, both at school and outside of school.	Students organize charity events and help friends who need help studying.
17.	Social Care	A person's attitude and behavior to carry out his duties and obligations, which he should do, towards himself, others, and the environment.	The teacher observed that students always tried to complete assignments well and on time.	Students feel that responsibility is important to achieve the best results in every task given.	Students complete group assignments independently and ensure that all members contribute to the work given.

Thus, the results of this analysis indicate that the characters developed during inquiry-based learning are not only focused on academics, but also pay attention to moral and social aspects that support students' personal development. Improvements in students' physics learning outcomes are also observed from the evaluation of learning outcomes and analysis of student worksheets. The documents analyzed show that most students experienced an increase in their understanding of physics concepts, especially in topics that require problem solving and application of concepts in real situations. The test results showed a significant improvement in the class average score after the implementation of inquiry-based learning, especially in the aspect of applying physics concepts to everyday life.

Inquiry-based learning is in accordance with the principles contained in the Independent Curriculum, which emphasizes the development of 21st century skills, such as critical thinking, creativity, and problem-solving skills. This study found that inquiry-based learning tools support students in developing these skills effectively, by giving them the freedom to explore materials and design their own experiments. This is in line with the objectives of the Independent Curriculum which prioritizes learning that is oriented towards strengthening character and developing skills that are relevant to the needs of the times.

Overall, the implementation of inquiry-based physics learning tools not only improves students' learning outcomes in understanding physics concepts, but also strengthens their character. Inquiry-based learning has been proven effective in developing critical thinking, problem-solving, and collaboration skills. In addition, through data triangulation and member checking, the findings of this study obtained strong validity, indicating that inquiry-based learning is an effective and relevant approach in the context of physics learning in secondary schools, in accordance with the principles of the Independent Curriculum.

This finding is in line with previous research that emphasizes the effectiveness of constructivist learning in science education. For example, the shared knowledge construction model (CKCM) based on cognitive constructivist theory has been shown to improve students' academic achievement and their views on the nature of science. Research published in the International Journal of Science and Mathematics Education shows that CKCM-based instruction improves students' academic achievement levels and ensures the sustainability of the knowledge learned [47]. In addition, the concept of discovery learning introduced by Jerome Bruner, which is also rooted in cognitive constructivism, emphasizes the importance of students in finding information themselves through the inquiry process. This approach has been recognized as effective in improving students' conceptual understanding

and critical thinking skills in science learning [48]. Thus, the findings of this study are consistent with existing literature, which shows that inquiry-based and constructivist learning approaches are effective in increasing student engagement, character development, and learning outcomes in science education.

Then the results of the research on the implementation of inquiry-based physics learning devices show that this approach increases student active engagement, strengthens character, and improves learning outcomes. These findings are in line with previous studies that emphasize the effectiveness of inquiry learning in science education. One of them, a study published in the Journal of Science Education and Technology explored how elementary school students' views on the nature of science changed when they were involved in a technology-enhanced scientific inquiry curriculum. The results showed that student engagement in technology-supported inquiry activities can improve their understanding of the nature of science [40]. In addition, the Handbook of Research on Student Engagement highlights that student engagement through effective academic instruction and classroom management can improve their motivation and academic achievement. Inquiry approaches that actively involve students in the learning process can improve student engagement and learning outcomes [49]. Thus, the findings of this study are consistent with existing literature, which suggests that inquiry-based learning approaches are effective in enhancing student engagement, character development, and learning outcomes in science education.

This study makes a new contribution to the field of physics education by revealing the effectiveness of inquiry-based learning tools not only in improving students' learning outcomes, but also in strengthening their characters in accordance with the principles of the Independent Curriculum, making it a more holistic approach to 21st century learning. The results of this study indicate that the application of inquiry-based learning can increase students' active involvement, understanding of physics concepts, and strengthening characters such as independence, honesty, and cooperation.

The implication of this finding is that teachers can further optimize the inquiry method in physics learning to support students' cognitive and affective development simultaneously. However, this study has several limitations, including the limitation in the scope of the sample which only involved one school, so that the generalization of the results needs to be done carefully. In addition, external factors such as differences in student backgrounds and learning infrastructure support can also affect the effectiveness of the implementation of this method. Further research with a wider scope and technology integration can be conducted to enrich the results and application of inquiry-based learning in more diverse contexts.

4. CONCLUSION

Based on the research results, the implementation of inquiry-based physics learning devices has proven effective in strengthening students' character and improving their learning outcomes. Inquiry-based learning encourages students to be actively involved in experiments, discussions, and problem solving, which strengthens their critical thinking skills and scientific attitudes. The development of students' character, such as honesty, hard work, creativity, and curiosity, was also seen significantly through observations and interviews with teachers and students. In addition, the results of the learning evaluation showed an increase in students' academic performance in understanding physics concepts. Thus, inquiry-based learning not only improves students' academic understanding but also supports character development that is essential for the formation of a better personality in accordance with the principles of the Independent Curriculum. Further research can explore the effect of inquiry-based learning on other aspects of students' character and integrate technology to enrich the learning experience. Research with a wider and more diverse sample is also needed to see if these findings are consistent across contexts.

ACKNOWLEDGEMENTS

Thanks are given to all parties who have participated in this research, for the support and assistance given in this research. Thanks are also given to the parties who have provided very significant financial support in the implementation of this research.

REFERENCES

[1] M. Chekour, Y. Z. Seghroucheni, M. A. Tadlaoui, and M. M. Hafid, "Blended Learning and Simulation for Teaching Electrical Concepts to High School Pupils," *J. Turkish Sci. Educ.*, vol. 19, no. 4, pp. 1119–1134, 2022, doi: 10.36681/tused.2022.165.

[2] W. T. Wulandari, "Contextual learning approach : development of worksheet in physics subjects," *Schrödinger J. Phys. Educ.*, vol. 4, no. 2, 2023, doi: 10.37251/sjpe.v4i2.506.

[3] M. M. Zeidan and D. Young, "Enhancing classroom engagement : investigating student motivation towards learning physics," *SchrödingerJournal Phys. Educ.*, vol. 5, no. 4, pp. 150–159, 2024, doi: 10.37251/sjpe.v5i4.1288.

[4] T. Bouchée, L. de Putter - Smits, M. Thurlings, and B. Pepin, "Towards a better understanding of conceptual difficulties in introductory quantum physics courses," *Stud. Sci. Educ.*, vol. 58, no. 2, pp. 183–202, 2022, doi: 10.1080/03057267.2021.1963579.

[5] C. Hankeln, U. Kroehne, L. Voss, and S. Gross, "Developing digital formative assessment for deep conceptual learning goals : Which topic - specific research gaps need to be closed ?," *Educ. Technol. Res. Dev.*, no. 0123456789, 2025, doi: 10.1007/s11423-025-10486-x.

[6] R. Rizaldi, U. H. S, S. Fitriana, and T. A. Mardiana, "Effectiveness of Cooperative Problem Solving (CPS) learning with the science process skills approach on the subject of simple harmonic motion," *SchrödingerJournal Phys. Educ.*, vol. 5, no. 4, pp. 174–179, 2024, doi: 10.37251/sjpe.v5i4.1377.

[7] A. Marougkas, C. Troussas, A. Krouska, and C. Sgouropoulou, "Virtual reality in education: a review of learning theories, approaches and methodologies for the last decade," *Electron.*, vol. 12, no. 13, 2023, doi: 10.3390/electronics12132832.

[8] H. J. Cho, K. Zhao, C. R. Lee, D. Runshe, and C. Krousgrill, "Active learning through flipped classroom in mechanical engineering: improving students' perception of learning and performance," *Int. J. STEM Educ.*, vol. 8, no. 1, 2021, doi: 10.1186/s40594-021-00302-2.

[9] I. Furqon, M. W. Afgani, J. K. Putri, and F. Mabruroh, "Development of computer-based learning media on collision lesson using the context of traditional marbles game," *SchrödingerJournal Phys. Educ.*, vol. 5, no. 4, pp. 124–134, 2024.

[10] E. G. A. Tolba and A. M. Al-Osaimi, "The effectiveness of using the model-based thinking strategy in developing first-grade high school students' physical concepts and inquiry thinking skills," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 19, no. 4, 2023, doi: 10.29333/EJMSTE/13111.

[11] A. N. Fauziyah, M. Ramadan, P. R. Gumede, and I. N. Udosen, "Development of digital book bilingual physics learning media using kvisoft flipbook for high school class X semester 1 subject of newton's law," *J. Educ. Technol. Learn. Creat.*, vol. 1, no. 1, pp. 7–15, 2023, doi: 10.37251/jetlc.v1i1.618.

[12] C. J. Bogador, M. K. G. Camarao, C. G. Matunding, and K. J. F. Sombria, "Challenges and benefits of inquiry-based learning in physics," *Int. J. Multidiscip. Appl. Bus. Educ. Res.*, vol. 5, no. 7, pp. 2716–2732, 2024, doi: 10.11594/ijmaber.05.07.26.

[13] Lukman *et al.*, "Effective teachers' personality in strengthening character education," *Int. J. Eval. Res. Educ.*, vol. 10, no. 2, pp. 512–521, 2021, doi: 10.11591/ijere.v10i2.21629.

[14] V. Lungu, L. CretuTa, M. Munteanu, and L. Sadovei, "The place of social and moral values in the high school curriculum from the republic of moldova," *J. Ilm. Ilmu Terap. Univ. Jambi*, vol. 9, no. 1, pp. 87–103, 2025, doi: 10.22437/jiituj.v9i1.38082.

[15] K. A. A. Gamage, D. M. S. C. P. K. Dehideniya, and S. Y. Ekanayake, "The role of personal values in learning approaches and student achievements," *Behav. Sci. (Basel).*, vol. 11, no. 7, 2021, doi: 10.3390/bs11070102.

[16] M. Sulaiman, Y. Latifah, Y. Deneri, and J. R. Gonzales, "Exploring character dynamics : unveiling dominant values in physics education," *SchrödingerJournal Phys. Educ.*, vol. 5, no. 2, pp. 46–52, 2024, doi: 10.37251/sjpe.v5i2.964.

[17] D. R. Rizaldi, E. Nurhayati, and Z. Fatimah, "The correlation of digital literation and STEM integration to improve indonesian students' skills in 21st century," *Int. J. Asian Educ.*, vol. 1, no. 2, pp. 73–80, 2020, doi: 10.46966/ijae.v1i2.36.

[18] N. Yunaini, M. Prabowo, N. Hassan, and A. Kichi, "The concept of the independent learning curriculum (merdeka belajar) in elementary schools in view progressivism educational philosophy," *JIP (Jurnal Ilm. PGMI)*, vol. 8, no. 2, pp. 95–105, 22AD.

[19] S. Sukarno, K. T. Win, and D. A. C. Hong, "Teachers' views regarding the character of students' perseverance in science learning," *Integr. Sci. Educ. J.*, vol. 5, no. 1, pp. 59–64, 2024, doi: 10.37251/isej.v5i1.806.

[20] I. A. Rizki *et al.*, "Cooperative model, digital game, and augmented reality-based learning to enhance students' critical thinking skills and learning motivation," *J. Pedagog. Res.*, vol. 8, no. 1, pp. 339–355, 2024, doi: 10.33902/JPR.202423825.

[21] J. Watters, "Why Is It So? Interest and Curiosity in Supporting Students Gifted in Science BT - Handbook of Giftedness and Talent Development in the Asia-Pacific," S. R. Smith, Ed., Singapore: Springer Singapore, 2021, pp. 761–786. doi: 10.1007/978-981-13-3041-4_34.

[22] J. M. P. Sanchez, "Teaching motion concepts through pokémon unite : atudents ' acceptance and experiences," *SchrödingerJournal Phys. Educ.*, vol. 5, no. 3, pp. 98–106, 2024, doi: 10.37251/sjpe.v5i3.1076.

[23] Q.-F. Yang, H. Lin, G.-J. Hwang, P.-Y. Su, and J.-H. Zhao, "An exploration-based SVVR approach to promote students' chemistry learning effectiveness," *Interact. Learn. Environ.*, vol. 32, no. 5, pp. 2003–2027, May 2024, doi: 10.1080/10494820.2022.2135106.

[24] E. Triani, Maison, and Nazarudin, "Diagnosing students ' misconceptions of direct current electrical circuits using a five-tier isomorphic instrument," *J. Ilm. Ilmu Terap. Univ. Jambi*, vol. 9, no. 1, pp. 71–86, 2025, doi: 10.22437/jiituj.v9i1.40469.

[25] A. Žerovnik and I. Nančovska Šerbec, "Project-Based Learning in Higher Education BT - Technology Supported Active Learning: Student-Centered Approaches," C. Vaz de Carvalho and M. Bauters, Eds., Singapore: Springer Singapore, 2021, pp. 31–57. doi: 10.1007/978-981-16-2082-9_3.

[26] E. Wati, J. Kigo, and K. Inthaud, "Positive impact of the local wisdom module on the canang kayu musical instrument : building the character of love for the homeland," *SchrödingerJournal Phys. Educ.*, vol. 5, no. 1, 2024, doi: 10.37251/sjpe.v5i1.905.

[27] T. P. Socrates, R. Afrizon, H. Hidayati, and R. Hidayat, "The Needs Analysis for an Educational Physics Game with Scientific Literacy and Ethnoscientific Content," *J. Pendidik. Fis. dan Teknol.*, vol. 9, no. 1, pp. 151–162, 2023, doi: 10.29303/jpft.v9i1.5079.

[28] M. S. Bolger, J. B. Osness, J. S. Gouvea, and A. C. Cooper, "Supporting scientific practice through model-based inquiry: A students'-eye view of grappling with data, uncertainty, and community in a laboratory experience," *CBE Life Sci. Educ.*, vol. 20, no. 4, pp. 1–22, 2021, doi: 10.1187/cbe.21-05-0128.

[29] T. de Jong *et al.*, "Let's talk evidence – the case for combining inquiry-based and direct instruction," *Educ. Res. Rev.*, vol. 39, no. November 2022, p. 100536, 2023, doi: 10.1016/j.edurev.2023.100536.

[30] F. Özer and D. Sarıbaş, *Exploring Pre-service Science Teachers' Understanding of Scientific Inquiry and Scientific*

Practices Through a Laboratory Course, vol. 32, no. 3. Springer Netherlands, 2023. doi: 10.1007/s11191-022-00325-3.
[31] Y. Wen *et al.*, "Integrating augmented reality into inquiry-based learning approach in primary science classrooms," *Educ. Technol. Res. Dev.*, vol. 71, no. 4, pp. 1631–1651, 2023, doi: 10.1007/s11423-023-10235-y.
[32] D. K. Dewi, W. Ardhana, Irtadji, T. Chusniyah, and A. Sulianti, "Inquiry-based learning implementation to improve critical thinking of prospective teachers," *Int. J. Inf. Educ. Technol.*, vol. 11, no. 12, pp. 638–645, 2021, doi: 10.18178/IJIET.2021.11.12.1575.
[33] T. D. Nur, A. D. Corebima, S. Zubaidah, I. Ibrohim, and M. Saefi, "Biology through thinking empowerment by questioning: the effect on conceptual knowledge and critical thinking," *Particip. Educ. Res.*, vol. 10, no. 1, pp. 122–139, 2023, doi: 10.17275/per.23.7.10.1.
[34] K. Ay and G. Dağhan, "The effect of the flipped learning approach designed with community of inquiry model to the development of students' critical thinking strategies and social, teaching and cognitive presences," *Educ. Inf. Technol.*, vol. 28, no. 11, pp. 15267–15299, 2023, doi: 10.1007/s10639-023-11809-2.
[35] X. Yang, M. Zhang, Y. Zhao, Q. Wang, and J.-C. Hong, "Relationship between creative thinking and experimental design thinking in science education: Independent or related," *Think. Ski. Creat.*, vol. 46, p. 101183, 2022, doi: https://doi.org/10.1016/j.tsc.2022.101183.
[36] A. A. Ogegbo and U. Ramnarain, "Teaching and learning Physics using interactive simulation: A guided inquiry practice," *South African J. Educ.*, vol. 42, no. 1, pp. 1–9, 2022, doi: 10.15700/saje.v42n1a1997.
[37] I. M. Astra, A. Henukh, and Algiranto, "Implementation of think pair share model in physics learning to determine cognitive, affective and psychomotor learning outcomes and student responses," *J. Phys. Conf. Ser.*, vol. 1876, no. 1, 2021, doi: 10.1088/1742-6596/1876/1/012064.
[38] V. J. Owan *et al.*, "Innate ability, health, motivation, and social capital as predictors of students' cognitive, affective and psychomotor learning outcomes in secondary schools," *Front. Psychol.*, vol. 13, no. October, 2022, doi: 10.3389/fpsyg.2022.1024017.
[39] M. Abbasi, M. Shirazi, H. Torkmandi, S. Homayoon, and M. Abdi, "Impact of teaching, learning, and assessment of medical law on cognitive, affective and psychomotor skills of medical students: a systematic review," *BMC Med. Educ.*, vol. 23, no. 1, pp. 1–15, 2023, doi: 10.1186/s12909-023-04695-2.
[40] J. Schellinger, A. Mendenhall, N. Alemanne, S. A. Southerland, V. Sampson, and P. Marty, "Using Technology-Enhanced Inquiry-Based Instruction to Foster the Development of Elementary Students' Views on the Nature of Science," *J. Sci. Educ. Technol.*, vol. 28, no. 4, pp. 341–352, 2019, doi: 10.1007/s10956-019-09771-1.
[41] D. Yulianti, S. Khanafiyah, and S. Sulistyorini, "Inquiry-based science comic physics series integrated with character education," *J. Pendidik. IPA Indones.*, vol. 5, no. 1, pp. 38–44, 2016, doi: 10.15294/jpii.v5i1.5787.
[42] N. A. Arisa, L. Hakim, and L. Lefudin, "Development of inquiry-based physics learning modules on linear motion materials for senior high school students," *Phys. Educ. Res. J.*, vol. 4, no. 1, pp. 41–50, 2022, doi: 10.21580/perj.2022.4.2.11188.
[43] L. Hatch and S. K. Clark, "A study of the instructional decisions and lesson planning strategies of highly effective rural elementary school teachers," *Teach. Teach. Educ.*, vol. 108, p. 103505, 2021, doi: https://doi.org/10.1016/j.tate.2021.103505.
[44] G. M. Geletu and D. M. Mihiretie, "Professional accountability and responsibility of learning communities of practice in professional development versus curriculum practice in classrooms: Possibilities and pathways," *Int. J. Educ. Res. Open*, vol. 4, no. December 2022, p. 100223, 2023, doi: 10.1016/j.ijedro.2022.100223.
[45] P. Guo, N. Saab, L. Wu, and W. Admiraal, "The Community of Inquiry perspective on students' social presence, cognitive presence, and academic performance in online project-based learning," *J. Comput. Assist. Learn.*, vol. 37, no. 5, pp. 1479–1493, 2021, doi: 10.1111/jcal.12586.
[46] N. Adhami and M. Taghizadeh, "Integrating inquiry-based learning and computer supported collaborative learning into flipped classroom: effects on academic writing performance and perceptions of students of railway engineering," *Comput. Assist. Lang. Learn.*, vol. 37, no. 3, pp. 521–557, 2024, doi: 10.1080/09588221.2022.2046107.
[47] B. Caymaz and A. Aydin, "The Effect of Common Knowledge Construction Model-Based Instruction on 7th Grade Students' Academic Achievement and Their Views about the Nature of Science in the Electrical Energy Unit at Schools of Different Socio-economic Levels," *Int. J. Sci. Math. Educ.*, vol. 19, no. 2, pp. 233–265, 2021, doi: 10.1007/s10763-020-10054-0.
[48] Y. Ozdem-Yilmaz and K. Bilican, "Discovery Learning—Jerome Bruner BT - Science Education in Theory and Practice: An Introductory Guide to Learning Theory," B. Akpan and T. J. Kennedy, Eds., Cham: Springer International Publishing, 2020, pp. 177–190. doi: 10.1007/978-3-030-43620-9_13.
[49] A. L. Reschly and S. L. Christenson, *Handbook of Research on Student Engagement*. Switzerland: Springer Cham, 2022. doi: 10.1007/978-3-031-07853-8.