



THE PRACTICALITY AND EFFECTIVENESS OF MOVANEWTON AS AN ANDROID-BASED VIRTUAL LABORATORY AND ANIMATION MODULE IN DEVELOPING STUDENTS' CRITICAL THINKING SKILLS

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Abstrak

Penelitian ini bertujuan untuk mengevaluasi kepraktisan dan keefektifan media pembelajaran MoVANewton (Modul Laboratorium Virtual dan Animasi Hukum Newton) dalam melatih keterampilan berpikir kritis peserta didik pada materi Hukum Newton. Penelitian ini menggunakan pendekatan kuantitatif dengan desain one-group pretest–posttest yang melibatkan 26 peserta didik kelas XI di SMA Ta'miriyah Surabaya. Kepraktisan media diukur melalui observasi keterlaksanaan pembelajaran dan angket respons peserta didik, sedangkan keefektifannya diukur menggunakan skor N-Gain dan penilaian keterampilan berpikir kritis berbasis proses melalui lembar kerja peserta didik (LKPD). Hasil penelitian menunjukkan bahwa MoVANewton memiliki tingkat kepraktisan yang sangat baik, dengan keterlaksanaan pembelajaran sebesar 96% dan respons peserta didik sebesar 85%. Selain itu, MoVANewton tergolong cukup efektif dalam melatih keterampilan berpikir kritis, yang ditunjukkan oleh nilai rata-rata N-Gain sebesar 0,43 (kategori sedang) dan persentase keterampilan berpikir kritis berbasis proses sebesar 83%. Dengan demikian, MoVANewton praktis digunakan dan cukup efektif dalam melatih keterampilan berpikir kritis peserta didik pada materi Hukum Newton.

Kata kunci: media pembelajaran, keterampilan berpikir kritis, Hukum Newton.

Abstract

This study aims to evaluate the practicality and effectiveness of the MoVANewton (Virtual Laboratory Module and Newton's Laws Animation) learning medium in developing students' critical thinking skills regarding Newton's laws. The study employed a quantitative approach using a one-group pretest–posttest design involving 26 eleventh-grade students at Ta'miriyah High School in Surabaya. The practicality of the medium was measured through observations of instructional implementation and student response questionnaires, while effectiveness was measured using N-Gain scores and process-based critical thinking skill assessments via worksheets. The results showed that MoVANewton demonstrated excellent practicality, with a 96% instructional implementation rate and an 85% student response rate. Furthermore, MoVANewton is quite effective in developing critical thinking skills, with an average N-Gain of 0.43 (moderate category) and a process-based critical thinking skills rate of 83%. Thus, MoVANewton is practical to use and quite effective in developing critical thinking skills regarding Newton's laws.

Keywords : educational media, critical thinking skills, Newton's laws.

INTRODUCTION

One of the key skills students need to master in physics is critical thinking (Panuluh, 2017). Critical thinking skills help students understand physics concepts more deeply by relating them to phenomena commonly encountered in daily life, so that learning is not merely focused on memorizing formulas (Viyanti et al., 2025). The results of a study conducted by Sunarti & Nurul Fadilah (2019) show that students with critical thinking skills achieved an average score of 78%, which is higher than that of students who participated in conventional learning, who achieved an average score of only 28% (Sunarti & Nurul Fadilah, 2019).

However, despite the importance of critical thinking skills in physics learning, students' critical thinking skills have yet to develop optimally, particularly when it comes to Newton's Laws (Motlhabane, 2025). One reason for this is that physics instruction still tends to rely on conventional methods, such as lectures, so students are rarely engaged in activities that involve analyzing and solving problems. This situation hinders the development of students' critical thinking skills (Hernandez-Sanchez et al., 2022). The results of a study conducted by Sari et al., (2017) indicate that students' critical thinking skills have not been optimally developed. This is evidenced by test results showing that students' critical thinking skills reached only 15.4%, resulting in a correspondingly low level of conceptual understanding of Newton's Laws at 24.2% (Sari et al., 2017).

One way to address students' low critical thinking skills and conceptual understanding of Newton's Laws is through the use of interactive learning media. Interactive learning media allow students to

actively engage in the learning process through concept visualization, simulations, and problem-solving activities that can foster analytical and evaluative skills. Research (Marlina et al., 2024) shows that the use of interactive learning media in physics instruction can improve students' critical and creative thinking skills. Additionally, virtual laboratories have also been shown to enhance students' conceptual understanding and critical thinking skills through independent and interactive concept exploration activities (Rahma et al., 2025). These findings are supported by a study by Khaliza et al. (2026), which shows that interactive learning media have a positive effect on students' critical thinking skills. Therefore, interactive learning media can be a highly effective solution for improving critical thinking skills while simultaneously strengthening students' conceptual understanding of Newton's laws.

Given students' low critical thinking skills regarding Newton's Laws, there is a need for learning media that can actively engage students in the processes of analysis and problem-solving during instruction. One such tool is MoVANewton (Virtual Laboratory and Animation Module for Newton's Laws), an Android-based learning application designed to develop critical thinking skills through the integration of electronic modules, interactive animations, and virtual laboratories. The results of the development study show that MoVANewton achieved a validity score of 97% in the areas of content, media, language, and learning, placing it in the "highly valid" category and deeming it suitable for use. However, the study was limited to the development phase and thus did not test the implementation of MoVANewton in the learning process. Therefore, further research

is needed to implement and evaluate the practicality and effectiveness of MoVANewton in developing students' critical thinking skills regarding Newton's Laws.

METODE

This study is a quantitative study using a one-group pretest–posttest design. At the beginning of the learning process, students took a pretest to assess their initial understanding of Newton's laws. Next, students participated in the learning process using the MoVANewton app as a learning medium. After the entire learning sequence was completed, students took a posttest to assess their understanding following the intervention. The research design is illustrated in Table 1.

Table 1. One-Group Pretest–Posttest Design

<i>Pre-test</i>		<i>Post-test</i>
O_1	X	O_2

Notes:

- O_1 : Students took a pretest before participating in the learning activity using the MoVANewton learning tool.
- X : The treatment involved using the MoVANewton app as a learning tool during the learning activity.
- O_2 : Students took a posttest after completing the learning activity using the MoVANewton learning tool.

This study has limitations because the effectiveness of the MoVANewton learning medium was tested using a one-group pretest–posttest design without involving a

control group. Therefore, the improvement in critical thinking skills observed cannot yet be directly compared with learning that uses other learning media or models. Thus, the results of this study indicate that the use of MoVANewton is effective in improving students' critical thinking skills.

The instruments used in this study included observation sheets, student response questionnaires, pretest and posttest sheets for critical thinking skills, modules, and Student Worksheets (LKPD). The observation sheets and student response questionnaires were used to measure the practicality of the MoVANewton learning media. Meanwhile, the pretest and posttest were used to measure the effectiveness of the MoVANewton learning media in developing students' critical thinking skills regarding Newton's laws.

Before being used in the study, all research instruments were first validated by experts in physics education to ensure the appropriateness of the indicators, the instrument design, the language used, and their relevance to the aspects of critical thinking skills being measured. The validation results were used as the basis for revising the instruments before they were administered to the students. The validation results showed that the research instruments had a very high level of validity, with an average of 97.3%, including the critical thinking skills pretest–posttest instrument at 97%, the student response questionnaire at 97%, and the learning implementation observation sheet at 98%. Based on these results, all research instruments were deemed highly valid and suitable for use in this study.

The practicality of the MoVANewton learning media was measured using a lesson implementation observation sheet completed

by a physics teacher and a student from the Physics Education Program acting as an observer. The lesson implementation observation sheet included several assessment aspects organized using a Likert scale for each indicator. The scores obtained were then calculated using the following equation.

$$\text{Percentage (\%)} = \frac{\text{Total score}}{\text{Maximum score}} \times 100\% \quad (1)$$

The resulting percentages are then categorized based on the implementation level criteria presented in Table 2.

Table 2. Implementation Level Criteria

Percentage (%)	Criteria
0-20	Not implemented well
21-40	Implemented poorly
41-60	Implemented fairly well
61-80	Implemented well
81-100	Implemented very well

In addition to the implementation observation sheet, the practicality of the MoVANewton learning media was also measured using a student response questionnaire completed by students at the end of the learning activity. The student response questionnaire included several aspects and assessment indicators organized using a Likert scale. The scores obtained were then calculated using the following equation.

$$\text{Percentage (\%)} = \frac{\text{Total score}}{\text{Maximum score}} \times 100\% \quad (2)$$

The percentage scores from the student response questionnaires were then categorized based on the criteria for the practicality of the MoVANewton learning media, as presented in Table 3.

Table 3. Criteria for Practicality

Percentage (%)	Criteria
0-20	Not Practical
21-40	Somewhat Impractical
41-60	Fairly Practical
61-80	Practical
81-100	Very Practical

To determine the effectiveness of the MoVANewton learning platform, pretest and posttest instruments measuring critical thinking skills were administered to students before and after the learning process. The scores obtained were then analyzed using the N-gain value to determine the improvement in students' critical thinking skills after participating in the learning process using the MoVANewton application. The N-gain value was calculated using the following equation.

$$N \text{ Gain} < g > = \frac{S_{\text{posttest}} - S_{\text{pretest}}}{S_{\text{max}} - S_{\text{pretest}}} \quad (3)$$

The N-gain values obtained were then categorized based on the criteria presented in Table 4.

Table 4. Criteria for Evaluating Test Score N-gain

Gain Score	Criteria
$g < 0,3$	Low
$0,3 \leq g < 0,7$	Moderate
$0,7 \leq g$	High

Based on these criteria, the MoVANewton learning media is considered effective if it achieves an N-gain score of ≥ 0.3 , which falls into the moderate or high category. Furthermore, the interpretation of the level of effectiveness based on the N-gain score refers to the criteria presented in Table 5.

Table 5. N-gain Interpretation

Percentage Interpretation (%)	Category
0 – 20	Ineffective
21 – 40	Somewhat Ineffective
41 – 60	Moderately Effective
61 – 80	Effective
82 – 100	Highly Effective

RESULTS AND DISCUSSION

1. Results of the Observation of the Implementation of the Learning Process

The MoVANewton learning media was implemented with 26 students in Class XI-2 at Ta'miriyah High School in Surabaya, utilizing modules and Student Worksheets (LKPD) to support the learning process. The pilot study was conducted using a One-Group Pretest-Posttest Design and involved two observers— a physics teacher and a student from the

Physics Education program—to observe the implementation of the learning process.

Before the learning process began, students were given a pretest to measure their initial critical thinking skills regarding Newton's laws.



Figure 1. The Learning Process Using the MoVANewton Learning Tool



Figure 2. Menu and Content Page Displays Featuring Animations in the MoVANewton App

Following the pretest, the session continued with a presentation on how to use the MoVANewton app, followed by the delivery of instructional content in accordance with the prepared modules and the Contextual

Teaching and Learning (CTL) instructional approach.



Figure 3. Screenshot of the MoVANewton Virtual Laboratory

At the end of the learning activity, students conducted a lab experiment using the virtual laboratory and completed the worksheet in accordance with the learning sequence of the Contextual Teaching and Learning (CTL) model.

After the entire learning sequence was completed, students took a posttest to measure improvements in critical thinking skills. Next, students filled out a response questionnaire to assess the practicality of the MoVANewton learning medium.

Two observers monitored the implementation of the learning activities throughout the pilot test. The observers were not directly involved in the learning activities but conducted independent observations by filling out an observation sheet on the implementation of the learning process. The aspects and indicators listed on the observation sheet were based on the syntax of the Contextual Teaching and Learning (CTL) model applied during the learning

process. The percentage of implementation for each learning component is presented in Table 6.

Table 6. Percentage of Implementation Scores for Each Component

Component	O 1	O 2	Total
Introduction	94%	94%	94%
Inquiry	92%	100%	96%
Asking	100%	100%	100%
Learning Community	92%	92%	92%
Modeling	100%	100%	100%
Reflection	88%	100%	94%
Authentic Assessment	100%	100%	100%
Conclusion	100%	100%	100%
Average			96%

Based on Table 6, the average percentage of learning implementation reached 96%, falling into the “very well implemented” category. This indicates that the implementation of the MoVANewton learning media proceeded in accordance with the planned learning stages.

2. Student Response Results

Student response results were obtained through a questionnaire completed after the learning process to determine the practicality of the MoVANewton learning media. Student responses were evaluated across four aspects: modules and visual presentation, language, learning, and critical thinking skills.

The evaluation results for each aspect are presented in Figure 4.

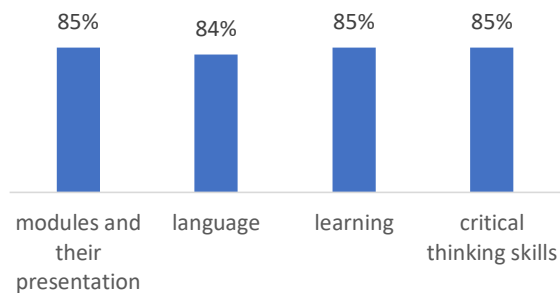


Figure 4. Percentage of Student Responses

Based on Figure 4, the learning aspect received the highest percentage at 86%, followed by the module and visual presentation aspects, as well as critical thinking skills, each of which received a percentage of 85%. Meanwhile, the linguistic aspect received the lowest percentage, at 84%. Overall, these results indicate that the MoVANewton learning medium falls into the “very practical” category based on student responses.

3. Results of the Analysis of Process-Based Critical Thinking Skills

Process-based critical thinking skills were analyzed based on the assessment results of the Student Worksheets (LKPD) completed in groups during the learning process using the MoVANewton learning medium. The assessment was conducted in accordance with the rubric provided in the instructional module and covered five aspects of critical thinking skills. The assessment results for each aspect are presented in Table 7.

Table 7. Percentage of Process-Based Critical Thinking Skills

Aspect	Percentage Score
Analyzing Arguments	84%
Observing and Considering Observations	83%
Making and Considering Decisions	83%
Defining Terms and Considering Definitions	81%
Determining Actions	86%
Average	83%

Based on Table 7, process-based critical thinking skills achieved an average percentage of 83%. All aspects of critical thinking skills showed percentages above 80%, with the highest percentage of 86% in the aspect of determining actions, while the lowest percentage of 81% was in the aspect of defining terms and considering definitions. In addition, the aspect of analyzing arguments achieved a percentage of 84%, while the aspects of observing and considering the results of observations, as well as formulating and evaluating decisions, each achieved a percentage of 83%.

4. Pretest–Posttest Results for Students’ Critical Thinking Skills

The pretest was administered before instruction using the MoVANewton learning medium, while the posttest was administered after the learning process was completed. The test instrument consisted of five items designed based on the critical thinking skill indicators according to Robert Ennis. The pretest and posttest results were then analyzed using N-Gain to determine the

improvement in students' critical thinking skills.

Based on the analysis results, the average N-Gain score was 0.43, which falls into the moderate category. These results indicate that the use of the MoVANewton learning medium was able to improve students' critical thinking skills. A summary of the N-Gain results categorized as high, moderate, and low is presented in Figure 5.

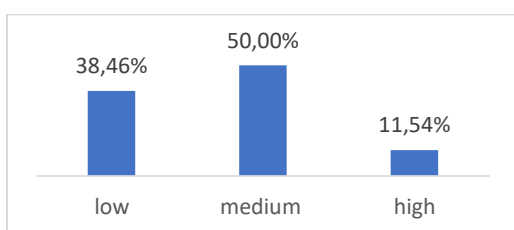


Figure 5. Percentage of N-Gain by Category

Based on Figure 5, 10 students (38.46%) achieved an N-Gain score in the low category, 13 students (50.00%) in the moderate category, and 3 students (11.54%) in the high category. These results indicate that the majority of students experienced a moderate improvement in critical thinking skills after participating in lessons using the MoVANewton learning media.

Table 8. Percentage of Improvement in Critical Thinking Skills by Indicator

Indicator		Percentage Increase
Indicator 1	Analyzing Arguments (Providing Simple Explanations)	7.69%
Indicator 2	Observing and Considering Observations	38.89%

Indicator		Percentage Increase
	(Building Basic Skills)	
Indicator 3	Making and Considering the Value of Decisions (Drawing Conclusions)	40.00%
Indicator 4	Defining Terms and Considering Definitions (Providing Further Explanations)	38.89%
Indicator 5	Defining Terms and Considering Definitions (Providing Further Explanations)	18.18%

Based on Table 8, all critical thinking skill indicators showed improvement after instruction using the MoVANewton learning medium. The highest increase was observed in indicator 3 making and evaluating decisions (drawing conclusions) at 40.00%, followed by indicator 2 observing and evaluating observations (building basic skills) and indicator 4 defining terms and evaluating definitions (providing further explanations) each of which increased by 38.89%. Meanwhile, Indicator 5 determining actions (strategies and tactics) showed an increase of 18.18%, while the lowest increase was observed in Indicator 1 analyzing arguments (providing simple explanations) at 7.69%.

5. Discussion

The improvement in students' critical thinking skills was influenced not only by the use of the MoVANewton app but also by the instructional design that guided students to observe phenomena, collect and analyze data, compare experimental results, and draw conclusions based on the evidence obtained. In this context, MoVANewton serves as a learning medium that provides an interactive learning environment to facilitate students in gradually developing critical thinking skills through a series of systematic learning activities.

The practicality of the MoVANewton learning medium was evaluated based on two aspects: the feasibility of the learning process and student responses. The research results indicate that both aspects meet the criteria for being highly practical, meaning that the MoVANewton learning medium is easy to use and can be effectively implemented in the learning process.

Regarding feasibility, the average percentage achieved was 96%, falling into the "very well implemented" category. These results indicate that the Contextual Teaching and Learning (CTL) instructional framework integrated into MoVANewton can be systematically applied in accordance with the instructional modules. Although there was a slight decline in several indicators such as the introductory phase, inquiry, learning community, and reflection all stages still received the "very well implemented" rating. This decline was primarily influenced by technical factors during implementation, such as limited learning time and the manual installation process for the application, as MoVANewton has not yet been distributed through an official platform. These findings

suggest that the challenges encountered stemmed not from the quality of the learning media but from on-site implementation conditions.

MoVANewton's practicality is also supported by student feedback, which rated it as "very practical" across all evaluation aspects, with percentages ranging from 84% to 86%. These results indicate that MoVANewton features an attractive interface, uses easy-to-understand language, supports the learning process, and facilitates the development of critical thinking skills. The relatively high percentages across all aspects suggest that students can use the learning medium easily without encountering significant obstacles during the learning process.

These findings align with the research by Roslina et al. (2024), which states that interactive learning media can increase student engagement during learning, as well as the research by Rahma et al. (2025), which shows that virtual laboratories provide a more active learning experience, thereby supporting conceptual understanding and critical thinking skills. Therefore, the results of this study reinforce the conclusion that the integration of electronic modules, animations, and virtual laboratories in MoVANewton not only meets validity criteria but also offers a high level of practicality for use in physics instruction on Newton's Laws.

The effectiveness of the MoVANewton learning media was assessed based on pretest-posttest results for critical thinking skills and process-based critical thinking skill assessments using worksheets. The research results indicate that MoVANewton is quite effective in developing critical thinking skills, as evidenced by an N-gain score of 0.43, or

43%, which places it in the “quite effective” category. This N-gain percentage category refers to Table 5, which was adapted from Riduwan’s (2018) interpretation of percentages. Additionally, the effectiveness of the learning medium, as determined by the process-based critical thinking skills assessment through worksheets, yielded an average score of 83%, indicating that students were able to apply critical thinking skills effectively during the learning process.

The effectiveness of the MoVANewton learning medium was evaluated based on pretest-posttest results for critical thinking skills, as well as process-based critical thinking skill assessments using worksheets. The research results indicate that MoVANewton is quite effective in developing critical thinking skills, as evidenced by an N-gain score of 0.43, or 43%, which places it in the “quite effective” category. This N-gain percentage category refers to Table 5, which was adapted from the percentage interpretation conducted by Riduwan (2018). In addition, the effectiveness of the learning media, as determined by the process-based critical thinking skills assessment through worksheets, yielded an average score of 83%, indicating that students were able to apply critical thinking skills effectively during the learning process.

The greatest improvement was observed in the indicators related to formulating and evaluating decision criteria. These results indicate that experimental activities using the virtual laboratory in MoVANewton are effective in training students to analyze experimental data, compare the results obtained, and make decisions based on available evidence. Through this process, students not only observe the phenomena

occurring but also interpret the experimental results to determine the most appropriate solution or conclusion based on Newton’s laws. Learning activities such as these provide students with the opportunity to develop higher-order thinking skills through a decision-making process based on experimental data. Additionally, the virtual laboratory environment allows students to repeat experiments, explore various scenarios, and evaluate the results obtained without being constrained by equipment limitations or the risks associated with in-person lab work, thereby making the decision-making process more focused and evidence-based. This is consistent with the findings of Potkonjak et al. (2016), who stated that virtual laboratories can enhance inquiry, data analysis, and problem-solving processes, as well as support the development of critical thinking skills through interactive experimental experiences. These findings are also supported by the research of Gunawan et al. (2019), who stated that data-based experimental activities can improve students’ ability to make critical decisions.

Conversely, the smallest improvement was observed in the “analyzing arguments” indicator. This is likely due to the fact that students already possessed prior knowledge of Newton’s laws, which are commonly encountered in everyday life; consequently, the improvement following instruction was not as significant as that observed for other indicators. These findings are consistent with the research by Asfa (2023), which states that experiences with real-world phenomena can foster prior knowledge that helps students understand concepts and solve problems.

Nevertheless, there are still some students who achieved low or even negative

N-Gain scores. This indicates that improvements in critical thinking skills are influenced not only by the quality of instructional materials but also by the level of student engagement during the learning process. Students who are less active tend to show lower improvement because they have not fully utilized activities such as exploration, analysis of experimental results, and reflection on their findings. In fact, active engagement in learning is a key factor in developing critical thinking skills. These findings align with the research by Fajra et al. (2023), which states that critical thinking skills develop optimally when students actively participate in every stage of learning. These results are also supported by the research by Ikhsan et al. (2020), which shows that interactive virtual laboratories can enhance critical thinking skills through students' active engagement in the processes of exploration and problem-solving.

The effectiveness of MoVANewton is also supported by the results of process-based critical thinking skill assessments conducted through worksheets, which achieved an average score of 93% and were rated "excellent." These results indicate that students were able to analyze data, make observations, draw conclusions, define concepts, and determine problem-solving steps during the virtual laboratory activities. Learning activities that integrate virtual experiments with worksheets provide students with the opportunity to build knowledge through independent inquiry and analysis, thereby fostering the development of critical thinking skills throughout the learning process.

Overall, the research results indicate that the MoVANewton learning medium is quite effective in developing students' critical thinking skills regarding Newton's laws. The

integration of electronic modules, interactive animations, virtual laboratories, and worksheets creates a learning experience that is more active, contextual, and student-centered, thereby supporting the development of critical thinking skills in physics instruction.

This study has limitations because it used a one-group pretest–posttest design without a control group; therefore, the improvement in students' critical thinking skills cannot yet be compared with learning outcomes from other media or conventional teaching methods. Consequently, future research is recommended to use a quasi-experimental design that includes a control group so that the effectiveness of MoVANewton can be compared more objectively.

CONCLUSION

Based on the results of the study on the implementation of the MoVANewton learning medium for Newton's Laws, it can be concluded that the MoVANewton learning medium meets the criteria of practicality and effectiveness in developing students' critical thinking skills. The practicality of the MoVANewton learning media falls into the "very practical" category, as indicated by an average learning implementation rate of 96% and an average student response rate of 85%. These results show that MoVANewton is easy to use and can be effectively implemented in the learning process.

The MoVANewton learning media has also proven to be quite effective in developing students' critical thinking skills regarding Newton's Laws. This effectiveness is demonstrated by an average N-Gain score of 0.43 which falls into the moderate category and an average percentage of process-based critical thinking skills measured through

worksheets of 83%. These results indicate that the use of MoVANewton is capable of enhancing students' critical thinking skills through learning activities that integrate electronic modules, interactive animations, and virtual laboratories.

REFERENCES

- Asfa, A. (2023). *Pengaruh Model Pembelajaran Berbasis Fenomena Terhadap Keterampilan Berpikir Kritis Peserta Didik SMA Negeri 1 Parigi Tengah* [Skripsi (Sarjana)]. Universitas Tadulako.
- Fajra, R. R., Syachruraji, A., & Rokmanah, S. (2023). Metode Pembelajaran Aktif Untuk Meningkatkan Keterampilan Berpikir Kritis Siswa Sekolah Dasar. *Jurnal Dunia Pendidikan*, 4(1), 122–129.
- Gunawan, G., Harjono, A., Hermansyah, H., & Herayanti, L. (2019). Guided Inquiry Model Through Virtual Laboratory to Enhance Students' Science Process Skills on Heat Concept. *Jurnal Cakrawala Pendidikan*, 259–268. <https://doi.org/10.21831/cp.v38i2.23345>
- Hernandez-Sanchez, M. D., Macias-Gonzalez, S., Iturbe-Sanchez, E., de Jesús Barragán-Cruz, A., & Carrasco, L. H. H. (2022). Physics Applications: Their Impact on Students' Motivation and Perspective of STEM. *ASEE Annual Conference and Exposition, Conference Proceedings*. <https://www.scopus.com/pages/publications/85138302302?origin=resultslist#>
- Ikhsan, J., Sugiyarto, K. H., & Astuti, T. N. (2020). Fostering student's critical thinking through a virtual reality laboratory. *International Journal of Interactive Mobile Technologies*, 14(8), 183–195. <https://doi.org/10.3991/IJIM.V14I08.13069>
- Khaliza, S. N., Verawati, N. N. S. P., & Susilawati, S. (2026). Pengaruh Model Problem Based Learning Berbantuan Media Pembelajaran Interaktif Canva untuk Meningkatkan Kemampuan Berpikir Kritis Fisika Peserta Didik. *Empiricism Journal*, 7(2), 858–866. <https://doi.org/10.36312/ej.v7i2.5439>
- Marlina, D., Sari, S. Y., & Rahim, F. R. (2024). Development of Interactive Learning Media Using the Lectora Application to Enhance Student's Critical and Creative Thinking Skills. *Journal of Innovative Physics Teaching*, 2(1), 23–36. <https://doi.org/10.24036/jipt.vol2-iss1/32>
- Motlhabane, A. (2025). The interplay between recall and understanding in physics: A case of Newton's laws. *Eurasia Journal of Mathematics, Science and Technology Education*, 21(12). <https://doi.org/10.29333/ejmste/17502>
- Panuluh, A. H. (2017). Improving the Science Process Skills of Physics Education Students by Using Guided Inquiry Practicum. *International Conference on Research in Education (ICRE 2017)*, 129–136.
- Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrović, V. M., & Jovanović, K. (2016). Virtual laboratories for education in science, technology, and engineering: A review. *Computers and Education*, 95, 309–327. <https://doi.org/10.1016/j.compedu.2016.02.002>

- Rahma, D. M., Yuliati, L., & Nasikhudin. (2025). Conceptual Understanding and Critical Thinking Skills Assisted by a Virtual Laboratory through Guided Inquiry Learning. *Kasuari: Physics Education Journal (KPEJ)*, 8(2), 477–486. <https://doi.org/10.1088/1742-6596/3132/1/012029>
- Riduwan. (2018). *Sekala pengukuran variabel-variabel penelitian*. Alfabeta.
- Roslina, R., Herpratiwi, H., & Firdaus, R. (2024). Media Pembelajaran Interaktif Berbasis Android untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Sekolah Dasar pada Mata Pelajaran IPA. *Didaktika*, 4(4), 426–437. <https://doi.org/10.17509/didaktika.v4i4.76880>
- Sari, S., Anjani, R., Farida, I., & Ramdhani, M. A. (2017). Using Android-Based Educational Game for Learning Colloid Material. In L. S. Riza, A. B. D. Nandiyanto, R. null, & A. G. Abdullah (Eds.), *Journal of Physics: Conference Series* (Vol. 895, Number 1). Institute of Physics Publishing. <https://doi.org/10.1088/1742-6596/895/1/012012>
- Sunarti, I., & Nurul Fadilah, D. N. (2019). Penerapan Model Pembelajaran Problem Based Learning (PBL) terhadap Kemampuan Berpikir Kritis Siswa. *Equilibrium: Jurnal Penelitian Pendidikan Dan Ekonomi*, 16(01), 15–25. <https://doi.org/10.25134/equi.v16i01.2014>
- Viyanti, Putri, R. A., & Rosidin, U. (2025). Can assessment for learning effectively measure critical thinking in physics education? *Journal of Physics: Conference Series*, 3132(1).