



# Validation of Phyleb-VIV Media for Training Middle School Students' Physics Problem-Solving Skills

I Made Hermanto<sup>1\*</sup>, Dewi Diana Paramata<sup>1</sup>, Rahim Tolingguhu<sup>1</sup>

<sup>1</sup>Department of Science Education, Universitas Negeri Gorontalo, Gorontalo, Indonesia.

Received: October 15, 2025  
Revised: January 25, 2026  
Accepted: February 25, 2026  
Published: February 28, 2026

Corresponding Author:  
I Made Hermanto  
[imadehermanto@ung.ac.id](mailto:imadehermanto@ung.ac.id)

DOI: [10.29303/jppipa.v12i2.13139](https://doi.org/10.29303/jppipa.v12i2.13139)

 Open Access

© 2026 The Authors. This article is distributed under a (CC-BY License)



**Abstract:** This study aimed to validate Phyleb-VIV, a web-based learning medium that integrates a virtual laboratory, interactive simulations, and video-based instruction to train junior high school students' problem-solving skills in direct-current electricity. The development research followed the ADDIE model, and this report focuses on the implementation outcomes and formative expert evaluation. Expert validation was conducted by three validators using a 1-5 Likert-type instrument across four aspects, namely Content, Appearance and Design, Language and Communication, and Interactivity and Engagement. Data were analyzed descriptively using mean Likert scores (P) and validity criteria. The results indicated that all aspects fell into the Highly Valid category, namely Content (P = 4.80), Appearance and Design (P = 5.00), Language and Communication (P = 5.00), and Interactivity and Engagement (P = 4.75). These findings confirm that Phyleb-VIV is suitable for classroom try-outs to examine its practicality and effectiveness. Recurrent qualitative feedback from validators emphasized the need for more diagnostic, topic-specific automated feedback and regular content updates to maintain relevance. In conclusion, Phyleb-VIV demonstrates excellent validity in terms of content, interface, communication, and interactivity, and is ready for further testing to evaluate its impact on improving students' conceptual understanding and problem-solving skills in direct-current electricity.

**Keywords:** Direct-current electricity; Expert validation; Interactive simulations; Problem-solving skills; Virtual laboratory; Web-based learning

## Introduction

Physics learning at the middle school (junior high school) level faces complex challenges, particularly in helping students grasp abstract concepts and apply them to real-world problem solving. One topic that often causes conceptual difficulties is direct current (DC) electricity, which requires logical thinking, mathematical reasoning, and an understanding of relationships among physical variables. Prior work indicates that many students still hold misconceptions about Ohm's law, current, voltage, and electric circuits due to instruction dominated by memorization and limited laboratory experience (Marcelina & Hartanto, 2021; Prastyaningrum & Pratama, 2019). Consequently, higher-order thinking skills, including problem-solving

skills, have not developed optimally among middle school students. Problem-solving is a key 21st-century competence that equips students to tackle contextual, everyday problems. In physics learning, it relates not only to cognitive outcomes but also to critical, analytical, and reflective thinking when addressing scientific problems. Studies show that problem-solving-oriented education strengthens these skills (Abeden & Siew, 2022; Alberida et al., 2022). However, efforts to cultivate problem-solving are often hindered by limited laboratory facilities, a lack of interactive media, and suboptimal technology integration in science classes. Adequate laboratory provision enhances practical experiences that foster problem-solving (Alberida et al., 2022). Interactive media—such as simulations or educational software—can better attract students'

## How to Cite:

Hermanto, I. M., Paramata, D. D., & Tolingguhu, R. Validation of Phyleb-VIV Media for Training Middle School Students' Physics Problem-Solving Skills. *Jurnal Penelitian Pendidikan IPA*, 12(2), 217-227. <https://doi.org/10.29303/jppipa.v12i2.13139>

interest and improve conceptual understanding (Abeden & Siew, 2022; Asri et al., 2024). Technology integration also enables more flexible learning and broader access to resources to support analytic skill development (Wenno et al., 2021). Interactive environments like virtual laboratories can reinforce cognitive and collaborative skills, thereby facilitating better problem-solving (Gunawan et al., 2018; Ratnaningsih & Hertanti, 2020). These approaches are relevant to unlocking students' potential in physics learning and in everyday life (Susetyo et al., 2021). This situation calls for innovative media that visualize abstract concepts, offer interactivity, and provide virtual experimental experiences to support scientific reasoning.

Several studies have developed technology-based media—virtual laboratories, interactive simulations, and video-based instruction—that effectively increase motivation and understanding of physics concepts. For example, videoscribe-based instructional videos have improved physics conceptual understanding and demonstrated media effectiveness (Listari et al., 2023). Android-based learning media have been shown to make physics learning more effective with positive impacts on understanding (Nyemas, 2020). PhET simulations have significant effects on concept mastery and help students grasp physics content more deeply (Yunita et al., 2020). Through such tools, teachers can more successfully facilitate effective and engaging learning (Aswara et al., 2022; Kamil, 2023). Previous studies have documented the benefits of virtual laboratories, interactive simulations, and video-based instruction in electricity learning. Several web-based learning platforms have also integrated more than one of these approaches; however, empirical validation of web-based media that coherently combine all three within a single integrated environment remains very limited. Virtual laboratories are proven to support process skills and experimental activities, yet they are often not accompanied by sustained, diagnostic problem-solving feedback. Video-based instruction facilitates concept visualization, but it tends to be one-way and provides limited opportunities for interactive exploration. Interactive simulations, on the other hand, are effective for manipulating variables, but they are not always supported by systematic conceptual narratives and structured practical tasks. These conditions indicate a research opportunity for the development and, importantly, the validation of integrated learning media that bring the three approaches together in a coherent web-based platform. Further research is needed to provide robust evidence of validity and design feasibility for such integrated media.

Development research in educational media should not stop at product design; it also requires

comprehensive validation by content and media experts. The importance of expert validation lies in ensuring that media are not only visually appealing but also aligned with the curriculum and intended learning goals (Alberida et al., 2022). Expert review is crucial to evaluate content quality and the feasibility of classroom use (Abeden & Siew, 2022). Without proper validation, products may contain misinformation or be misaligned with students' needs, adversely affecting their understanding. Validation is therefore key to ensuring media are fit for use from the perspectives of content accuracy, clarity of presentation, language effectiveness, and interactivity. A validation-focused study is thus necessary before wide-scale classroom implementation.

This study develops and validates Phyleb-VIV (Physics Learning Web-Based on Virtual Laboratory, Interactive Simulation, and Video-Based Instruction). Phyleb-VIV is a web-based integrated medium designed to improve students' problem-solving skills in DC electricity. It combines a virtual laboratory for digital experimental experiences, interactive simulations that let students manipulate variables and observe real-time outcomes, and video-based instruction that explains foundational concepts contextually. This integration is relatively novel in media development for lower-secondary science.

Accordingly, this study aims to develop and validate Phyleb-VIV as a web-based learning medium for direct-current electricity to train junior high school students' physics problem-solving skills, and to establish its feasibility prior to practicality and effectiveness testing. Practically, the findings are expected to inform teachers and instructional media developers in designing technology-enhanced learning that is contextual, interactive, and meaningful. Theoretically, this study contributes to physics learning media research by presenting a coherent web-integrated platform that combines a virtual laboratory, interactive simulations, and instructional videos within a single validated and feasible digital learning ecosystem for secondary education.

## Method

The study employed a Research and Development (R&D) approach using the ADDIE development model (Analyze, Design, Develop, Implement, and Evaluate), as illustrated in Figure 1 (Branch, 2009). In the Analyze stage, the research identified learning problems that need to be addressed in direct-current electricity instruction, reviewed and analyzed existing learning materials in terms of their shortcomings and potential for improvement, and examined learning needs as well as the instructional goals and objectives to be achieved. In the Design stage, the study formulated and produced

a development plan for Phyleb-VIV as a learning medium for direct-current electricity, designed the learning scenarios to be implemented within the medium, and prepared learning evaluation strategies aligned with the objectives established during the Analyze stage. In the Develop stage, Phyleb-VIV was produced based on the prior design as a direct-current electricity learning medium, including the analysis and integration of a virtual laboratory, interactive simulations, and video-based instruction within the platform. In the Implement stage, the developed Phyleb-VIV was subjected to formative expert validation by three specialists with extensive experience in instructional media development. Finally, in the Evaluate stage, the expert validation results were analyzed and the product was revised in accordance with the feedback provided.

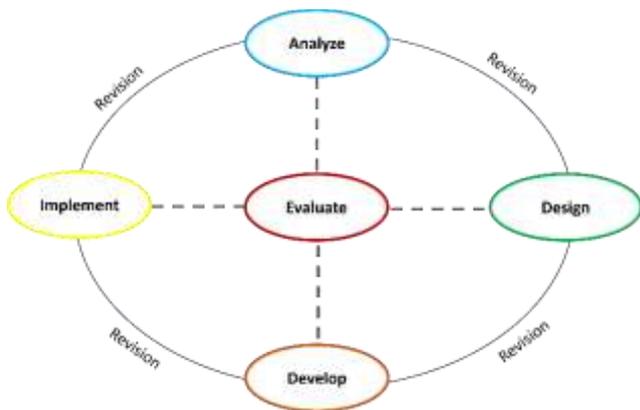


Figure 1. Flow chart of the ADDIE model

A high-quality learning medium must meet validity requirements. Therefore, this study used validation sheets covering four aspects: content, appearance & design, language & communication, and interactivity & engagement. Data were analyzed using quantitative descriptive analysis.

Expert validation of Phyleb-VIV was carried out using validation sheets. The analysis applied a descriptive qualitative interpretation of average validator scores (P), which were converted to validity criteria as shown in Table 1.

Table 1. Validity criteria for learning devices

Score Interval (P)	Criterion	Description
4.21 ≤ P ≤ 5.00	Highly Valid	Fit for use without revision
3.41 ≤ P < 4.21	Valid	Usable with minor revisions
2.61 ≤ P < 3.41	Less Valid	Usable with major revisions
1.00 ≤ P < 2.61	Not Valid	Requires comprehensive improvement

## Result and Discussion

### Expert Validation Results

Expert validation covered four aspects, namely content feasibility, appearance and design, language and communication, and interactivity and engagement. Scores were assigned using a Likert scale of 1–5 (1 = very unfit to 5 = highly fit). The ratings for each aspect were summarized into a mean score (P). The results are presented in Table 2.

Table 2. Phyleb-VIV validation results

Aspect	P (Mean)	Category
Content	4.80	Highly Valid
Appearance and Design	5.00	Highly Valid
Language and Communication	5.00	Highly Valid
Interactivity	4.75	Highly Valid

All aspects met the Highly Valid category; therefore Phyleb-VIV was deemed feasible to proceed to classroom implementation. Consistency across validators was high, indicating stable judgments on all four aspects. Recurrent qualitative suggestions emphasized strengthening topic-specific automated feedback and updating materials so that content remains relevant to daily-life contexts.

### Discussion by Aspect

#### Content Feasibility (P = 4.80, Highly Valid)

The validation results indicate that the Content Feasibility aspect obtained an average score of P = 4.8 (very valid category). Three core indicators achieved the maximum score (P = 5.0), while two other indicators received relatively lower scores (P = 4.7 and P = 4.3). The score of P = 5.0 on the indicator assessing the alignment between media content, basic competencies, and learning objectives confirms that the media content is perceived as fully aligned with the intended learning outcomes. Conceptually, this reflects the practice of constructive alignment, in which materials, learning activities, and objectives are systematically designed to ensure that instruction remains focused on targeted competencies (McLoughlin, 2001; Wilhelm et al., 2019). The same maximum score (P = 5.0) on the indicator of conceptual accuracy and correctness of information demonstrates that validators considered the material to meet the scientific rigor required for science learning. Conceptual accuracy is a prerequisite for preventing misconceptions and for supporting the development of stable scientific understanding (Awila et al., 2025; Eljinsa & Zamhari, 2024; Fikriana et al., 2023; Pacaci et al., 2024). Furthermore, the score of P = 5.0 on the indicator concerning the depth and breadth of content appropriate to students' developmental level suggests

that the material complexity is well-suited to the target users. This is essential because developmentally appropriate instructional design tends to reduce irrelevant cognitive load and helps learners allocate their mental resources toward understanding core concepts (Arsyad & Adnan, 2024; Fahlevi et al., 2022).



Figure 2. Display of material content in Phyleb-VIP

On the indicator of integration between content, examples, and exercises ( $P = 4.7$ ), validators still rated the quality highly; however, this score suggests that the integration of concepts-examples-exercises could be further enriched to become more “instructional” rather than merely “informational.” Instruction employing contextual examples typically presents structured illustrations that reinforce conceptual understanding and train higher-order thinking skills to strengthen knowledge transfer (Afriwardani et al., 2023; Izzah & Desnita, 2023). This finding offers opportunities for improvement in exercise design, such as adding tiered question variations, clarifying the linkage between examples and subtopic objectives, or incorporating brief prompts that encourage self-explanation so that learners understand the reasoning behind each step or answer provided (Abdul et al., 2024; Fajri et al., 2024; Wittwer & Renkl, 2010). The lowest score within this aspect was found in the indicator assessing content currency and relevance to real-life contexts ( $P = 4.3$ ). Although still categorized as highly valid, this score indicates a need to strengthen the “contextual” and “authentic” dimensions so that the material becomes more closely connected to students’ real-life experiences. Educational literature emphasizes that incorporating everyday-life contexts and authentic tasks helps learners recognize the relevance of science, enhances meaningfulness, and strengthens motivation as well as transfer of conceptual application (Cheung & Kulasegaram, 2022; Kamila et al., 2024; Kuhn & Müller, 2014). Therefore, updating examples and case studies with more current phenomena is recommended.

The high validation score for the content aspect indicates that Phyleb-VIP’s materials are aligned with the competencies of direct-current electricity (current, voltage, resistance, power, energy) and that they successfully describe relationships among physical variables as well as connections across concepts. Designing physics learning materials that are comprehensive and cover the full breadth of content fosters a more structured and goal-directed learning trajectory and improves students’ understanding through conceptual cohesion across topics. Such an approach is supported by the notion of concept connectivity, which emphasizes how physical phenomena can be understood from multiple perspectives and how concepts are interlinked within a single learning framework (Dingel et al., 2023). Likewise, integrated sequencing of content within science curricula positions physics principles as components of an interconnected conceptual chain, including Disciplinary Core Ideas and Crosscutting Concepts, so that content does not stand in isolation but forms a sustained learning network (Langbeheim et al., 2023). This integrated placement also aligns with the benefits of visualization and topic mapping in physics education to identify interrelated ideas, enabling students to recognize both visual and conceptual bridges between topics (Marrone & Linnenluecke, 2020).

From an evaluation and validation standpoint, a comprehensive design should be accompanied by expert review by both media and subject-matter specialists to ensure content quality and curricular relevance, so that integration across concepts proceeds without informational distortion or conceptual error. This practice is consistent with holistic, structure-oriented design principles and with literature emphasizing expert validation to secure alignment of content with learning goals and curricula (Ispal & Ishak, 2022), as well as sensitivity to learners’ contexts to optimize conceptual understanding (Chhabra & Das, 2023). In sum, comprehensive, integrated, and connectivity-oriented physics materials play a pivotal role in shaping a structured and navigable learning pathway; this approach enables students not merely to memorize but to understand real-world applications of physics concepts and their links to subsequent topics, thereby strengthening higher-order thinking and problem-solving skills.

*Appearance & Design (P = 5.00, Highly Valid)*

Validation results for the Media Appearance and Design Aspect demonstrate very strong and consistent quality, with an average score of  $P = 5.0$  (very valid category). This score indicates that validators perceived the media design not only as visually appealing but also as functionally effective as a learning interface that

minimizes confusion and supports information processing. The maximum score ( $P = 5.0$ ) for the indicator assessing an attractive, proportional, and non-confusing layout suggests that the arrangement of content elements effectively helps users map the information flow clearly, thereby reducing unnecessary cognitive load. This aligns with multimedia design principles emphasizing the reduction of extraneous cognitive load so that learners can focus on core learning ideas (Ismawati et al., 2023; Skulmowski & Xu, 2022). Similarly, the maximum score for the indicator evaluating the combination of colors, images, and text in supporting readability and aesthetics ( $P = 5.0$ ) indicates that color selection and typography were considered capable of maintaining readability while enhancing the visual experience. Appropriate text-background color contrast influences readability, retention, and users' aesthetic perception; thus, effective visual design contributes not only to appearance but also to learning quality (Aini & Mufit, 2022; Hall & Hanna, 2004; Istyadji et al., 2022).



**Figure 3.** Phyleb-VIV interface view

The score of  $P = 5.0$  on the indicator assessing ease of navigation confirms that the menu/button structure and transitions between sections are intuitive. Ease of navigation constitutes a core element of usability as an interaction outcome, reflected in effectiveness, efficiency, and user satisfaction within a specific context of use. Simple and consistent navigation enables users to achieve learning goals without interface-related disruptions (Cook & Dupras, 2004; Li & Luximon, 2020). The maximum score ( $P = 5.0$ ) for the clarity and relevance of images, audio, and video indicates that the media met validators' expectations regarding the necessity of clear and relevant visual learning resources. Theoretically, the quality and relevance of multimedia elements contribute to learning when they clarify concepts rather than introduce distractions. Multimedia assets function as reinforcements of conceptual representation rather than mere ornaments (Çeken & Taşkın, 2022; Mayer, 2017). Finally, the score of  $P = 5.0$  on the indicator of consistent visual design supporting

material comprehension reflects stylistic consistency in icon patterns, typography, heading hierarchy, and information presentation. In digital learning media, aesthetics and visual consistency are associated with perceived usability—interfaces perceived as visually pleasing and well-organized are also perceived as easier to use—which enhances learning comfort and reduces interaction barriers (Gan et al., 2015).

The maximum score on this aspect indicates a consistent interface, clear navigation, and visual affordances that effectively support learning. Design quality plays a strategic role in facilitating the understanding of abstract concepts and minimizing cognitive load when students interact with simulations and virtual experiments. In physics learning media, a consistent interface, clear navigation, and learning-oriented visual affordances are core design functions that enable structured, goal-directed, and readily comprehensible learning. Interface consistency helps students recognize interaction patterns and reduces cognitive load when moving across topics, allowing them to focus on conceptual understanding rather than on how to operate the medium (Faudzi et al., 2023). Moreover, a clear and visually consistent graphical interface eases access to interrelated content, thereby maintaining cohesion between prior and new materials. In mobile-learning and digital environments, standardized interface design frameworks have been shown to increase instructional effectiveness by lowering cognitive barriers and simplifying navigation across integrated sequences of materials.

#### *Language & Communication (P = 5.00, Highly Valid)*

Validation results for the language and communication aspect demonstrate very strong and consistent performance, with maximum scores across all indicators ( $P = 5.0$ ; average  $P = 5.0$ ; very valid category). This indicates that validators perceived the language used in the Phyleb-VIV media not only as grammatically correct but also as functioning effectively as an instructional communication tool that reduces misinterpretation and minimizes irrelevant processing load. The maximum score on the indicator assessing language compliance with standard conventions and clarity ( $P = 5.0$ ) suggests that diction, spelling, and sentence structure were well organized, thereby enhancing readability and comprehension fluency. Presenting material in simpler and more accessible language supports improved student understanding compared to more complex standard formats (Maulida et al., 2024; Munfaridah et al., 2021). The indicator evaluating effective, communicative, and age-appropriate sentences also achieved  $P = 5.0$ . From an instructional perspective, effective sentences appropriate to learners' developmental levels help focus

attention on core ideas. This aligns with cognitive load theory, which emphasizes reducing extraneous load caused by inefficient presentation so that working memory capacity can be allocated to constructing understanding (Kirschner, 2002; Sweller, 2023). Concise and structured presentation enhances meaningful learning compared to lengthy and less-directed text.

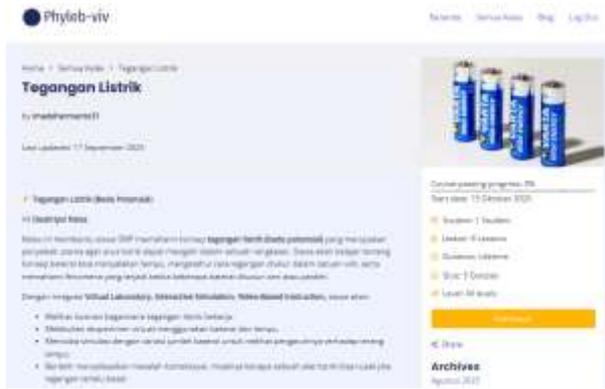


Figure 4. Class description view in Phyleb-VIP

The maximum score ( $P = 5.0$ ) for the indicator assessing clarity and correctness of technical terminology indicates that the Phyleb-VIV media anticipates terminological barriers often associated with misconceptions in science learning. Clear explanations of key terms (names, functions, characteristics) before or during conceptual use help learners build more stable understanding (Chiu & Churchill, 2016; Lubis et al., 2023). Furthermore, emphasizing key terms through headings, visual markers, and signaling/cueing techniques enhances learning outcomes by directing attention to essential information (Schneider et al., 2018; Gog, 2021). Finally, the maximum score ( $P = 5.0$ ) for the indicator assessing clarity of instructions confirms that the instructional language is operational and unambiguous, enabling users to follow usage steps smoothly. Conceptually, ease of following instructions is part of usability quality, encompassing effectiveness, efficiency, and satisfaction in achieving learning objectives (Gunasekera et al., 2019; Jahnke, 2022). Overall, Phyleb-VIV fulfills instructional communication quality standards through standard and accessible language, effective age-appropriate sentences, clear technical terminology, and operationally clear instructions, all contributing to a smoother learning experience and potentially enhanced conceptual understanding.

*Interactivity & Engagement (P = 4.75, Highly Valid)*

Validation results for the Interactivity and user engagement aspect indicate very high quality, with an average score of  $P = 4.75$ . The maximum score ( $P = 5.0$ )

for the indicator assessing support for active learner participation suggests that, according to validators, the interaction design effectively shifts learners from passive information recipients to active participants (e.g., through exploration, responses to tasks/questions, or manipulation of interactive elements). Active engagement increases the likelihood of meaningful processing and strengthens conceptual understanding, particularly when activities direct attention to relevant information and minimize distractions. The maximum score ( $P = 5.0$ ) on the self-paced learning indicator indicates that the media supports learners in regulating their learning pace (e.g., revisiting content, progressing according to readiness, and organizing their learning sequence). Self-paced design is a crucial feature of digital learning environments for accommodating differences in ability and learning rhythm. Research on self-directed learning design emphasizes the importance of adequate structure and support to ensure effectiveness without causing cognitive confusion (Ebbini, 2023; Englmeier, 2025).

The score of  $P = 5.0$  for the motivation and curiosity indicator confirms that interactive elements contribute meaningfully to engaging learning experiences. Literature on interactive digital environments demonstrates that well-designed interactivity enhances engagement and motivation by fostering a sense of control, appropriate challenge, and an immersive learning experience (Li et al., 2024; Shadiev et al., 2025). However, the feedback indicator received the lowest score ( $P = 4.0$ ; valid category), consistent with validators' comments recommending the addition of feedback on students' quiz results at the end of each subtopic session. This suggests that while feedback features are present, they have not yet achieved optimal quality compared to other interactivity components.

Feedback effectiveness depends largely on the informational quality provided—not merely indicating correct or incorrect answers, but helping learners understand performance gaps, refine strategies, and identify next improvement steps. Influential feedback models emphasize task-, process-, and self-regulation-oriented feedback (e.g., explanations of why answers are incorrect, cues to key concepts, and suggestions for corrective steps), as superficial feedback often fails to produce meaningful learning improvement (Adarkwah, 2021; Ada et al., 2017; Mandouit & Hattie, 2023).

Therefore, a key recommendation derived from this validation finding is to develop subtopic-based quiz feedback that includes confirmation of results (correct/incorrect), brief scientific or conceptual explanations, hints or references to relevant material sections, and opportunities for retry or short remediation before proceeding. In online learning contexts, well-designed informative and relevant

feedback—including automated feedback—has been shown to contribute positively to learning outcomes when aligned with learners’ needs.

The high score on interactivity confirms that Phyleb-VIV enables active exploration through interactive simulations and a virtual laboratory (e.g., PhET), while also providing feedback on student learning outcomes. These findings are consistent with literature reporting that simulation media such as PhET can enhance learning motivation, opportunities for independent practice, and conceptual understanding in science education. In particular, web-integrated PhET has been associated with gains in conceptual understanding and motivation in electricity learning (Balasubramani et al., 2025), and PhET as a game-based learning tool has been linked to significant improvements in conceptual understanding and motivation in physics (Fanshawe et al., 2020).



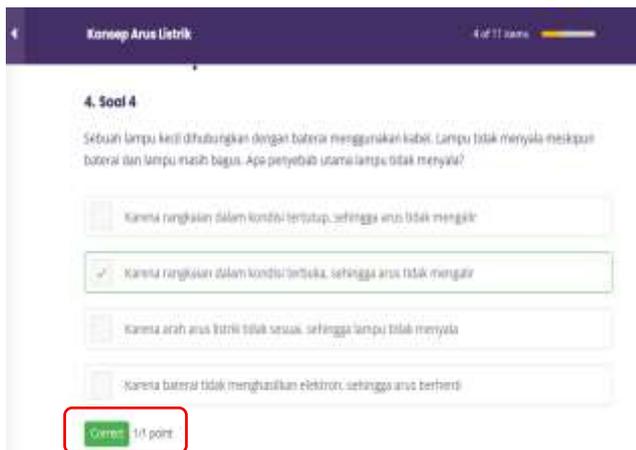
Figure 6. Interactive learning display on the Phyleb-VIV

More broadly, research on interactive learning environments emphasizes that responsive, interactive media increase learner engagement and support more self-directed, sustained learning (Anthonysamy, 2022; Patrick et al., 2025). Within a wider instructional-design perspective, adaptive and interactive models that incorporate real-time feedback are also associated with heightened engagement, and work on self-regulated learning (SRL) supported by smart technologies indicates that interactivity can scaffold pathways responsive to individual needs (Setiawan, 2025).

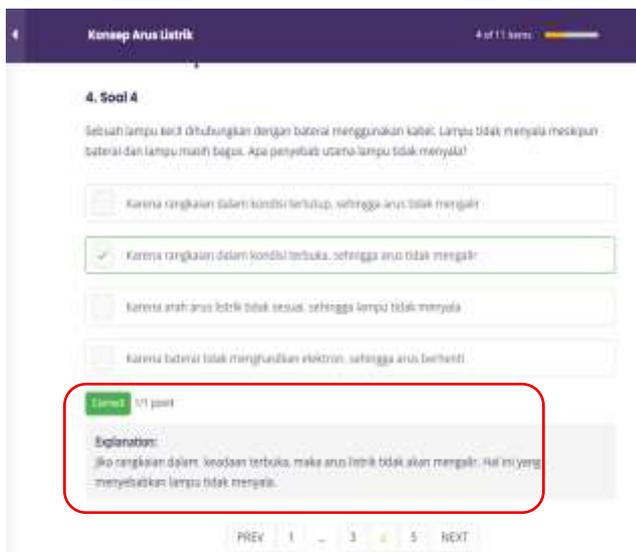
Overall, the very high validity profile across all aspects indicates that Phyleb-VIV is ready for classroom trials of practicality and effectiveness. Its contribution resides in the integration of three approaches—a virtual laboratory, an interactive simulation, and video-based instruction—within a single web platform. By uniting these components, Phyleb-VIV can maximize synergies among concept visualization, variable-manipulation-based exploration, and contextual worked examples to address misconceptions and improve problem-solving readiness. Current findings are based on expert validation; empirical evidence of effectiveness for improving students’ problem-solving performance has yet to be measured. The next phase should therefore involve field testing (pretest–posttest) to estimate N-Gain in conceptual understanding and problem-solving performance, accompanied by process data (interaction logs, and the quality of reflective responses). Evaluation may be conducted within a cognitive–metacognitive assessment framework and include analyses of teachers’ and students’ perceptions of usability. Finally, the small validator sample and relatively homogeneous school context constitute limitations that warrant multi-site replication.

**Conclusion**

Phyleb-VIV—a web-based learning medium integrating a virtual laboratory, interactive simulation, and video-based instruction for direct-current electricity—achieved a very high level of expert validity



(a)



(b)

Figure 5. Feedback in the quiz: (a) before validation and (b) after validation

(overall  $P \approx 4.89$ ), indicating that the product is suitable to proceed to the next evaluation stage. Aspect-level validation scores were consistently strong for Content Feasibility ( $P=4.80$ ), Appearance & Design ( $P=5.00$ ), Language & Communication ( $P=5.00$ ), and Interactivity & Engagement ( $P=4.75$ ). The key refinement identified by validators concerns the feedback component (relative to other indicators): the next iteration should add diagnostic, topic-specific automated feedback for students' responses in the end-of-subtopic quizzes, explicitly linked to common error patterns and core concepts. With this targeted improvement, subsequent studies should focus on classroom implementation to examine usability with teachers and students and to quantify learning outcomes (e.g., N-gain for conceptual understanding and improvements in physics problem-solving performance).

#### Acknowledgments

The authors gratefully acknowledge the participating schools and partner institutions for their collaboration, particularly the teachers and students who contributed to classroom needs analysis and piloting activities, as well as the expert validators for their constructive reviews of the content, interface, language, and interactivity of Phyleb-VIV. This work was supported by Lembaga Penelitian dan Pengabdian Kepada Masyarakat (LPPM) Universitas Negeri Gorontalo under the Riset Akselerasi Publikasi Nasional (RAPN) 2025, Contract No. 573/UN47.D1/PT.01.03/2025. The funder had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript. Any opinions, findings, and conclusions expressed in this article are those of the authors and do not necessarily reflect the views of the sponsor.

#### Author Contributions

Conceptualization, methodology, formal analysis, writing – reviewing and editing, obtaining funding, I.M.H. and D.D.P.; software, visualization, I.M.H. and R.T.; validation, investigation, I.M.H., D.D.P., and R.T.; resources, writing – preparation of original draft, supervision, project administration, I.M.H.; data curation, D.D.P. and R.T. All authors have read and approved the published version of the manuscript.

#### Funding

This research was supported by Universitas Negeri Gorontalo under the Riset Akselerasi Publikasi Nasional (RAPN) 2025, Contract No. 573/UN47.D1/PT.01.03/2025.

#### Conflicts of Interest

The authors declare no conflict of interest.

#### References

- Abdjul, T., Odja, A. H., & Nurhayati, N. (2024). Effectiveness of Virtual Laboratory-Based Interactive Learning Media Through a Differentiated Approach to Students' Scientific Literacy. *Jurnal Penelitian Pendidikan IPA*, 10(11), 9838–9838. <https://doi.org/10.29303/jppipa.v10i11.9253>
- Abeden, N. A. M., & Siew, N. M. (2022). Assessing Students' Critical Thinking and Physics Problem-Solving Skills in Secondary Schools. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 7(6), e001584. <https://doi.org/10.47405/mjssh.v7i6.1584>
- Ada, M. B., Stansfield, M., & Baxter, G. (2017). Using Mobile Learning and Social Media to Enhance Learner Feedback: Some Empirical Evidence. *Journal of Applied Research in Higher Education*, 9(1), 70–90. <https://doi.org/10.1108/JARHE-07-2015-0060>
- Adarkwah, M. A. (2021). The Power of Assessment Feedback in Teaching and Learning: A Narrative Review and Synthesis of the Literature. *SN Social Sciences*, 1(3), 75. <https://doi.org/10.1007/s43545-021-00086-w>
- Afriwardani, P., Jumadi, J., & Pribadi, F. O. (2023). Development of Interactive Physics E-Book to Reduce Student Misconception. *Jurnal Penelitian Pendidikan IPA*, 9(4), 2018–2024. <https://doi.org/10.29303/jppipa.v9i4.1854>
- Aini, S., & Mufit, F. (2022). Using Adobe Animate CC Software in Designing Interactive Multimedia Based on Cognitive Conflict in Straight Motion. *Jurnal Penelitian Pendidikan IPA*, 8(5), 2350–2361. <https://doi.org/10.29303/jppipa.v8i5.2048>
- Alberida, H., Sari, M., Razak, A., Syamsuriza, S., & Rahmi, Y. L. (2022). Problem Solving: A Learning Model to Foster Argumentation and Critical Thinking Ability for Students with Different Academic Abilities. *Jurnal Penelitian Pendidikan IPA*, 8(3), 1393–1400. <https://doi.org/10.29303/jppipa.v8i3.1208>
- Anthonymsamy, L. (2022). Formulation of Self-Regulated Learning Strategies Framework for Digital Learning for Lifelong Learning. (2022). *Asian Journal of Research in Education and Social Sciences*, 4(1), 24–32. <https://doi.org/10.55057/ajress.2022.4.1.4>
- Arsyad, W., & Adnan, A. (2024). Implikasi Penggunaan Media Pembelajaran Digital Terhadap Perkembangan Kognitif Siswa Ditinjau dari Teori Jean Piaget. *JIP-Jurnal Ilmiah Ilmu Pendidikan*, 7(12), 13557–13561. <https://doi.org/10.54371/jiip.v7i12.6357>
- Asri, I. H., Jampel, I. N., Arnyana, I. B. P., Suastra, I. W., & Nitiasih, P. K. (2024). Profile of Problem Based Learning (PBL) Model in Improving Students' Problem Solving and Critical Thinking Ability. *KNE Social Sciences*, 9(2). <https://doi.org/10.18502/kss.v9i2.14898>

- Aswara, S., Amanda, F. D., & Fitriani, R. (2022). Pengaruh Media Pembelajaran Fisika Berbasis Video untuk Meningkatkan Minat dan Pemahaman Konsep Materi Tekanan Siswa SMAN 2 Sungai Penuh. *Integrated Science Education Journal*, 3(1), 16–23. <https://doi.org/10.37251/isej.v3i1.173>
- Awila, A. A., Abdjul, T., Yusuf, M., Odja, A. H., Mursalin, M., & Supartin, S. (2025). Effectiveness of Interactive Learning Media Based on Virtual Laboratory on Scientific Literacy and Concept Mastery in Dynamic Electricity. *Jurnal Penelitian Pendidikan IPA*, 11(12), 1–10. <https://doi.org/10.29303/jppipa.v11i12.13530>
- Balasubramani, M., Jose, P. D., Rajakumar, M. P., Devi, S. I., Navaneetha, K. M., & Robinson, J. G. (2025). Methods for Promoting Students' Active Engagement in Digital Environments. In Book: *Digital Tools and Platforms for Effective and Personalized Learning* (pp.375-402). <https://doi.org/10.4018/979-8-3373-6013-3.ch014>
- Branch, R. M. (2009). *Instructional Design: The ADDIE Approach* (Vol. 722). Springer. <https://doi.org/10.1007/978-0-387-09506-6>
- Çeken, B., & Taşkın, N. (2022). Multimedia Learning Principles in Different Learning Environments: A Systematic Review. *Smart Learning Environments*, 9(1), 19. <https://doi.org/10.1186/s40561-022-00200-2>
- Cheung, J. J. H., & Kulasegaram, K. M. (2022). Beyond the Tensions within Transfer Theories: Implications for Adaptive Expertise in the Health Professions. *Advances in Health Sciences Education*, 27(5), 1293–1315. <https://doi.org/10.1007/s10459-022-10174-y>
- Chhabra, M., & Das, R. (2023). Students' Understanding of Electrostatic Force as a Vector Quantity at the Undergraduate Level. *Physics Education*, 58(3), 035016. <https://doi.org/10.1088/1361-6552/acc0c2>
- Chiu, T. K. F., & Churchill, D. (2016). Design of Learning Objects for Concept Learning: Effects of Multimedia Learning Principles and an Instructional Approach. *Interactive Learning Environments*, 24(6), 1355–1370. <https://doi.org/10.1080/10494820.2015.1006237>
- Cook, D. A., & Dupras, D. M. (2004). A Practical Guide to Developing Effective Web-Based Learning. *Journal of General Internal Medicine*, 19(6), 698–707. <https://doi.org/10.1111/j.1525-1497.2004.30029.x>
- Dingel, B. B., Rivera, J. G. C., Palabrica, F. d. G., & Bennett, C. D. (2023). Concept Connectivity: An Educational and Research Framework for Scientific Learning in Optics, Photonics, and Electronic Education. *Seventeenth Conference on Education and Training in Optics and Photonics: ETOP 2023*, 76. <https://doi.org/10.1117/12.2670640>
- Ebbini, E. (2023). Enhancing Collaborative and Self-Paced Learning in Traditional and Distance Education Settings. In A. Badran, E. Baydoun, S. Hillman, & J. Mesmar (Eds.), *Higher Education in the Arab World: E-Learning and Distance Education* (pp. 223–245). Springer Nature Switzerland. [https://doi.org/10.1007/978-3-031-33568-6\\_12](https://doi.org/10.1007/978-3-031-33568-6_12)
- Eljinsa, S. M., & Zamhari, M. (2024). A Powtoon Animation Video Development Utilizing a Scientific Approach for Teaching Electrolyte and Non-Electrolyte Solutions. *Jurnal Penelitian Pendidikan IPA*, 10(11), 8985–8995. <https://doi.org/10.29303/jppipa.v10i11.9545>
- Englmeier, K. (2025). The Design of Self-Paced Learning for Structured Learning Environments. *Procedia Computer Science*, 256, 71–77. <https://doi.org/10.1016/j.procs.2025.02.097>
- Fahlevi, A., Jumadi, J., Dewi, A. N., & Sari, F. P. (2022). Development of Electronic Student Worksheet Based on Guided Inquiry on the Topic of Photosynthesis. *Jurnal Penelitian Pendidikan IPA*, 8(3), 1408–1415. <https://doi.org/10.29303/jppipa.v8i3.1674>
- Fajri, N., Sriyati, S., & Rochintaniawati, D. (2024). Global Research Trends of Digital Learning Media in Science Education: A Bibliometric Analysis. *Jurnal Penelitian Pendidikan IPA*, 10(1), 1–11. <https://doi.org/10.29303/jppipa.v10i1.6248>
- Fanshawe, M., Delaney, N., & Powell, A. (2020). Utilizing Instantaneous Feedback to Promote Self-Regulated Learning in Online Higher Education Courses. In Book: *Technology-Enhanced Formative Assessment Practices in Higher Education* (pp.41-59). <https://doi.org/10.4018/978-1-7998-0426-0.ch003>
- Faudzi, M. A., Cob, Z. C., Omar, R., Sharudin, S. A., & Ghazali, M. (2023). Investigating the User Interface Design Frameworks of Current Mobile Learning Applications: A Systematic Review. *Education Sciences*, 13(1), 94. <https://doi.org/10.3390/educsci13010094>
- Fikriana, M. F., Wiyanto, W., & Haryani, S. (2023). Development of the Diary Book of Science with the STEM Approach of Discovery in Improving Students' Concept Understanding and Scientific Communication Skills. *Jurnal Penelitian Pendidikan IPA*, 9(4), 1641–1649. <https://doi.org/10.29303/jppipa.v9i4.3032>
- Gan, B., Menkhoff, T., & Smith, R. (2015). Enhancing Students' Learning Process Through Interactive Digital Media: New Opportunities for Collaborative Learning. *Computers in Human Behavior*, 51, 652–663. <https://doi.org/10.1016/j.chb.2014.12.048>

- Gog, T. V. (2021). The Signaling (or Cueing) Principle in Multimedia Learning. In *The Cambridge Handbook of Multimedia Learning* (pp. 221–230). Cambridge University Press. <https://doi.org/10.1017/9781108894333.022>
- Gunawan, G., Suranti, N. M. Y., Nisrina, N., & Herayanti, L. (2018). Students' Problem-Solving Skill in Physics Teaching with Virtual Labs. *IJPT International Journal of Pedagogy and Teacher Education*, 2, 10. <https://doi.org/10.20961/ijpte.v2i0.24952>
- Gunesequera, A. I., Bao, Y., & Kibelloh, M. (2019). The Role of Usability on E-Learning User Interactions and Satisfaction: A Literature Review. *Journal of Systems and Information Technology*, 21(3), 368–394. <https://doi.org/10.1108/JSIT-02-2019-0024>
- Hall, R. H., & Hanna, P. (2004). The Impact of Web Page Text-Background Colour Combinations on Readability, Retention, Aesthetics and Behavioural Intention. *Behaviour & Information Technology*, 23(3), 183–195. <https://doi.org/10.1080/01449290410001669932>
- Ismawati, R., Widiyatmoko, A., & Cahyono, A. N. (2023). Literature Review of Online Learning Technology in Chemistry Lab Activities. *Jurnal Penelitian Pendidikan IPA*, 9(10), 751–759. <https://doi.org/10.29303/jppipa.v9i10.3635>
- Ispal, A., & Ishak, M. Z. (2022). Transforming Physics Content into Content Physics for Instruction Through the Model of Educational Reconstruction (MER). *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 7(8), e001660. <https://doi.org/10.47405/mjssh.v7i8.1660>
- Istyadji, M., Yulinda, R., Amalina, D., & Fahmi, F. (2022). Validity and Practicality of Articulate Storyline Learning Media on Environmental Pollution Materials for Junior High School Students. *Jurnal Penelitian Pendidikan IPA*, 8(6), 2599–2604. <https://doi.org/10.29303/jppipa.v8i6.1639>
- Izzah, N., & Desnita, D. (2023). Effectiveness of Tornado Physics Enrichment Book to Increase Science Literacy of High School Students. *Jurnal Penelitian Pendidikan IPA*, 9(9), 7740–7748. <https://doi.org/10.29303/jppipa.v9i9.5076>
- Jahnke, I. (2022). Quality of Digital Learning Experiences – Effective, Efficient, and Appealing Designs? *International Journal of Information and Learning Technology*, 40(1), 17–30. <https://doi.org/10.1108/IJILT-05-2022-0105>
- Kamil, F. (2023). Matematika sebagai Fondasi Kritis dalam Menaklukkan Tantangan Soal Fisika. *JEAS*, 1(1), 1–6. <https://doi.org/10.30739/jeas.v1i1.2486>
- Kamila, K., Wilujeng, I., Jumadi, J., & Ungirwalu, S. Y. (2024). Analysis of Integrating Local Potential in Science Learning and Its Effect on 21st Century Skills and Student Cultural Awareness: Literature Review. *Jurnal Penelitian Pendidikan IPA*, 10(5), 223–233. <https://doi.org/10.29303/jppipa.v10i5.6485>
- Kirschner, P. A. (2002). Cognitive Load Theory: Implications of Cognitive Load Theory on the Design of Learning. *Learning and Instruction*, 12(1), 1–10. [https://doi.org/10.1016/S0959-4752\(01\)00014-7](https://doi.org/10.1016/S0959-4752(01)00014-7)
- Kuhn, J., & Müller, A. (2014). Context-Based Science Education by Newspaper Story Problems: A Study on Motivation and Learning Effects. *Perspectives in Science*, 2(1), 5–21. <https://doi.org/10.1016/j.pisc.2014.06.001>
- Langbeheim, E., Lehavi, Y., & Merzel, A. (2023). Physics in K-12 Integrated Science Curricula. In Taşar, M. F., & Heron, P. R. L. eds. *The International Handbook of Physics Education Research: Learning Physics*. [https://doi.org/10.1063/9780735425477\\_021](https://doi.org/10.1063/9780735425477_021)
- Li, Q., & Luximon, Y. (2020). Older Adults' Use of Mobile Device: Usability Challenges While Navigating Various Interfaces. *Behaviour & Information Technology*, 39(8), 837–861. <https://doi.org/10.1080/0144929X.2019.1622786>
- Li, Y., Chen, D., & Deng, X. (2024). The Impact of Digital Educational Games on Student's Motivation for Learning: The Mediating Effect of Learning Engagement and the Moderating Effect of the Digital Environment. *PLOS ONE*, 19(1), e0294350. <https://doi.org/10.1371/journal.pone.0294350>
- Listari, A., Doyan, A., Ayub, S., & Hikmawati, H. (2023). Pengembangan Media Pembelajaran Fisika Berbasis Videoscribe pada Materi Momentum dan Impuls untuk Meningkatkan Pemahaman Konsep. *Jurnal Ilmiah Profesi Pendidikan*, 8(1), 22–28. <https://doi.org/10.29303/jipp.v8i1.1140>
- Lubis, L. H., Febriani, B., Yana, R. F., Azhar, A., & Darajat, M. (2023). The Use of Learning Media and Its Effect on Improving the Quality of Student Learning Outcomes. *International Journal of Education, Social Studies, and Management (IJESSM)*, 3(2), 7–14. <https://doi.org/10.52121/ijessm.v3i2.148>
- Mandouit, L., & Hattie, J. (2023). Revisiting “The Power of Feedback” from the Perspective of the Learner. *Learning and Instruction*, 84, 101718. <https://doi.org/10.1016/j.learninstruc.2022.101718>
- Marcelina, S., & Hartanto, T. J. (2021). Correcting Students' Understanding About Simple Direct Current (DC) Circuits Through Scientific Approach. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, 7(2), 153–160. <https://doi.org/10.21009/1.07207>
- Marrone, M., & Linnenluecke, M. K. (2020). Interdisciplinary Research Maps: A New

- Technique for Visualizing Research Topics. *Plos One*, 15(11), e0242283. <https://doi.org/10.1371/journal.pone.0242283>
- Maulida, Q., Rosyida, Z. L., & Jariyah, I. A. (2024). Tinjauan Literatur Terhadap Media Pembelajaran Berbasis E-book Interaktif dalam Pembelajaran IPA. *Inspirasi: Jurnal Pendidikan dan Kebudayaan*, 1(2), 145-155. <https://doi.org/10.69836/inspirasi-jpk.v1i2.163>
- Mayer, R. E. (2017). Using Multimedia for E-Learning. *Journal of Computer Assisted Learning*, 33(5), 403-423. <https://doi.org/10.1111/jcal.12197>
- McLoughlin, C. (2001). Inclusivity and Alignment: Principles of Pedagogy, Task and Assessment Design for Effective Cross-Cultural Online Learning. *Distance Education*, 22(1), 7-29. <https://doi.org/10.1080/0158791010220102>
- Munfaridah, N., Avraamidou, L., & Goedhart, M. (2021). The Use of Multiple Representations in Undergraduate Physics Education: What Do We Know and Where Do We Go from Here? *Eurasia Journal of Mathematics, Science and Technology Education*, 17(1), em1934. <https://doi.org/10.29333/ejmste/9577>
- Nyemas, W. (2020). Pengembangan Media Pembelajaran Fisika Berbasis Android di SMA Negeri 3 Ngabang. *Jurnal Pendidikan Informatika dan Sains*, 9(1), 21-27. <https://doi.org/10.31571/saintek.v9i1.1296>
- Pacaci, C., Ustun, U., & Ozdemir, O. F. (2024). Effectiveness of Conceptual Change Strategies in Science Education: A Meta-Analysis. *Journal of Research in Science Teaching*, 61(6), 1263-1325. <https://doi.org/10.1002/tea.21887>
- Patrick, S. M., Nicholas, N. J., Maritz, M., & Wolvaardt, L. (2025). Enhancing Public Health Education Through Smart Learning Environments: Integrating Technology and Pedagogy. *Medical Science Educator*. <https://doi.org/10.1007/s40670-025-02408-6>
- Prastyaningrum, I., & Pratama, H. A. (2019). Student Conception of Ohm's Law. *Journal of Physics Conference Series*, 1321(2), 022028. <https://doi.org/10.1088/1742-6596/1321/2/022028>
- Ratnaningsih, S., & Hertanti, E. (2020). The Effect of Interactive Multimedia Base Problem Solving on Students' Critical Thinking Skills in Equilibrium and Rotational Dynamics Concept. *Proceedings of the 5th International Conference on Education in Muslim Society, ICEMS 2019*. 30 September-01 October 2019, Jakarta, Indonesia. <https://doi.org/10.4108/eai.30-9-2019.2291192>
- Schneider, S., Beege, M., Nebel, S., & Rey, G. D. (2018). A Meta-Analysis of How Signaling Affects Learning with Media. *Educational Research Review*, 23, 1-24. <https://doi.org/10.1016/j.edurev.2017.11.001>
- Setiawan, B. (2025). The Implementation of STEM Robotic Development with Mobile Application Control to Train Students' Collaborative Skills. *E3s Web of Conferences*, 640, 02012. <https://doi.org/10.1051/e3sconf/202564002012>
- Shadiev, R., Wang, X., & Shen, S. (2025). Effects of Immersion and Interactive Strategies on Students' Intercultural Competence in Virtual Learning Environments. *Education and Information Technologies*, 30(5), 5883-5919. <https://doi.org/10.1007/s10639-024-13030-1>
- Skulmowski, A., & Xu, K. M. (2022). Understanding Cognitive Load in Digital and Online Learning: A New Perspective on Extraneous Cognitive Load. *Educational Psychology Review*, 34(1), 171-196. <https://doi.org/10.1007/s10648-021-09624-7>
- Susetyo, B., Siswaningsih, W., & Oktavi, F. R. (2021). Development of Critical Thinking Test Instruments with Problem Solving Context on the Salt Hydrolysis Material. *Jurnal Pendidikan Sains Indonesia*, 9(2), 243-255. <https://doi.org/10.24815/jpsi.v9i2.19862>
- Sweller, J. (2023). Discussion of the Special Issue on Cognitive Load Theory. *British Journal of Educational Psychology*, 93(S2), 402-410. <https://doi.org/10.1111/bjep.12606>
- Wenno, I. H., Jamaludin, J., & Batlolona, J. R. (2021). The Effect of Problem Based Learning Model on Creative and Critical Thinking Skills in Static Fluid Topics. *Jurnal Pendidikan Sains Indonesia*, 9(3), 498-511. <https://doi.org/10.24815/jpsi.v9i3.20829>
- Wilhelm, S., Förster, R., & Zimmermann, A. B. (2019). Implementing Competence Orientation: Towards Constructively Aligned Education for Sustainable Development in University-Level Teaching-and-Learning. *Sustainability*, 11(7), 1891. <https://doi.org/10.3390/su11071891>
- Wittwer, J., & Renkl, A. (2010). How Effective are Instructional Explanations in Example-Based Learning? A Meta-Analytic Review. *Educational Psychology Review*, 22(4), 393-409. <https://doi.org/10.1007/s10648-010-9136-5>
- Yunita, Y., Halim, A., & Safitri, R. (2020). Meningkatkan Penguasaan Konsep Mahasiswa dengan Simulasi Physics Education and Technology (PhET). *Jurnal Pendidikan Sains Indonesia*, 7(1), 16-22. <https://doi.org/10.24815/jpsi.v7i1.13492>