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Development of E-LKPD Integrated with BMKG Data in Thermodynamics Learning

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Abstract: This study aimed to develop an electronic student worksheet (E-LKPD) integrates real data from the Meteorology, Climatology, and Geophysics Agency (BMKG) for thermodynamics learning. The research employed the 4D development model (define, design, develop, and disseminate). At the define stage, the need for contextual learning media was identified, highlighting the importance of linking physics concepts with authentic climate data. The E-LKPD was designed with interactive and digital features to enhance student engagement. Validation by experts and teachers confirmed its validity and practicality. A classroom trial involving 35 students showed positive responses, improved conceptual understanding, and increased motivation. Observations further revealed that the integration of real climate data made physics learning more meaningful and engaging. In conclusion, the BMKG-based E-LKPD is a valid, practical, and effective learning resource that supports both conceptual mastery and student enthusiasm. Future research is recommended to examine its wider application in diverse classroom settings.

Keywords: BMKG; E-LKPD; Physics education; Thermodynamics

Introduction

Thermodynamics is one of the subjects in science that is commonly studied but is considered difficult to understand (Doyan et al., 2024). Its strong connection to real-world phenomena, particularly climate change, makes contextualized learning essential for fostering students' critical and analytical thinking skills. At the secondary school level, students are not only expected to master the concepts of heat and thermodynamics but also to apply them in analyzing everyday life and global issues (Bogador et al., 2024; Kemdikbudristek, 2024).

The learning objective "understanding the concepts of heat and thermodynamics and applying them to analyze climate change" can be examined through Bloom's revised taxonomy and Marzano's competency theory. Bloom emphasizes comprehension, interpretation, and analysis, while Marzano adds metacognitive skills such as reflection and evaluation. In addition, the 2024 curriculum emphasizes project-based and flexible learning, shifting the application of thermodynamics from analyzing heat engine efficiency to analyzing the impacts of climate change.

Interviews with teachers at SMAN 2 Bandung and SMAN 1 Tasikmalaya revealed that although media such as PowerPoint and simulations have been used, authentic secondary data such as BMKG climate records have not been utilized. This is consistent with previous studies showing that thermodynamics instruction in classrooms remains dominated by lectures and routine

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exercises, with limited use of interactive media and minimal connections to authentic phenomena (Lestari & Linuwih, 2014; Yulianci et al., 2021). As a result, students often struggle to see the relevance of physics concepts in addressing real-world problems such as climate change. Yet, rich and up-to-date data from the Meteorology, Climatology, and Geophysics Agency (BMKG) are available but have not been systematically integrated into physics learning media.

The lack of structured use of BMKG data reflects a gap between theoretical learning and practical application in thermodynamics education at the secondary level. To bridge this gap, this study developed an Inquiry-Based Learning (IBL) electronic student worksheet (E-LKPD) that integrates BMKG climate data (Siregar et al., 2023). The E-LKPD is designed to guide students in exploring thermodynamics concepts through authentic climate data, thereby fostering inquiry skills, analytical reasoning, and reflection. This study aims to produce learning media that are valid, practical, and effective in linking thermodynamic concepts with real-world environmental phenomena.

Method

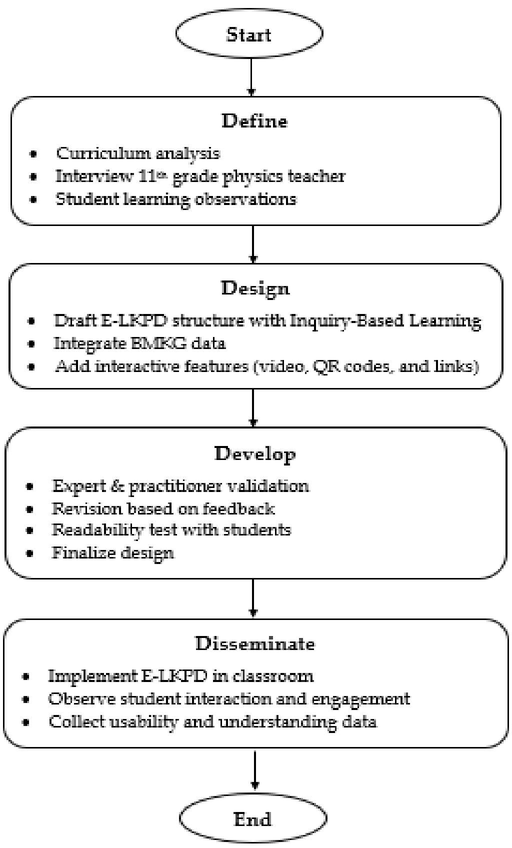

Figure 1. Research procedure of the 4D development model for the E-LKPD integrated with BMKG data

This study employed the Research and Development (R&D) method to produce a digital learning product in the form of an E-LKPD that integrates BMKG data into the concept of thermodynamics (Arkadiantika et al., 2020; Waruwu, 2024). The development model was adapted from Thiagarajan's 4D approach: Define, Design, Develop, Disseminate (Maulida et al., 2023).

Data were analyzed using both quantitative and descriptive approaches. Content validity was assessed using Aiken's V index, based on expert and practitioner evaluations (Aksari et al., 2021). The average V values obtained were used to classify the level of validity for each aspect, as presented in Table 1.

Table 1. Category classification of Aiken's V index

Aiken's V Index Interval	Classification
$0 \le \overline{V} \le 0.33$	Low
$0.34 \le \overline{V} \le 0.66$	Intermediate
$0.67 \le \overline{V} \le 1.00$	High

Descriptive statistics were used to analyze students' responses regarding the readability and usability of the E-LKPD. The analysis was carried out in three stages: the categorical responses from the questionnaire were converted into quantitative scores (Table 2); the scores were calculated in percentages to obtain the distribution of responses; and the resulting percentages were classified according to the criteria presented in Table 3 (Wardani & Suniasih, 2022).

Table 2. Conversion of response categories

Category Response	Score
Strongly agree	5
Agree	4
Neutral	3
Disagree	2
Strongly disagree	1

Table 3. Category classification of student response

Percentage Interval (%)	Classification
81.26–100	Very good
62.51–81.25	Good
43.76–62.50	Bad
25–43.75	Very Bad

Results and Discussion

The E-LKPD was developed using the 4D model and integrates BMKG climate data into thermodynamics learning. The final product consists of several components, including a cover, preface, table of contents, usage instructions, concept map, learning outcomes, two main activities, references, and an author profile. To support independent learning and engagement, interactive features such as QR codes, embedded videos, and Google Form–based answer sheets were also included.

Figure 2. Cover of the E-LKPD

Discovery learning is a scientific approach that enables students to construct concepts and principles through a series of stages, including active observation, problem formulation, hypothesis generation, data collection, conclusion drawing, and communication (Resmawati et al., 2018). The guided discovery learning model provides students with the experience of discovering concepts and principles contained in the learning material through various experimental activities (Ellianawati & Rahayu, 2024). Rizki et al. (2021) reinforced that the development of learning media using discovery learning has been shown to improve students' critical thinking skills. Meanwhile, research conducted by Khairunnisa et al. (2024) showed that the discovery learning-based module can improve students' science process skills. Activity 1, which applies a Discovery Learning approach, is presented in Figure 3. In this activity, students are guided to access the KLIMAKU website independently (BMKG, 2025), explore weather and climate data, and complete a post-test through an online form in Figure 4.

Activity 2 presented a Case Study Worksheet (Figure 5) that integrates thermodynamics concepts such as temperature conversion and heat transfer, which are then linked to BMKG data. Case-based learning is employed to encourage students to engage in higher-order critical thinking, enhance their collaborative skills, and deepen their understanding of the content (Fauzi et al., 2022; Lebang et al., 2024; Natalia et al., 2025). The worksheets are designed to make the learning process interactive and accommodate all elements of the scientific process (Asma et al., 2020). Students are guided through video tutorials on how to access and process real data, and the activity concludes with a discussion and interpretation of the results.

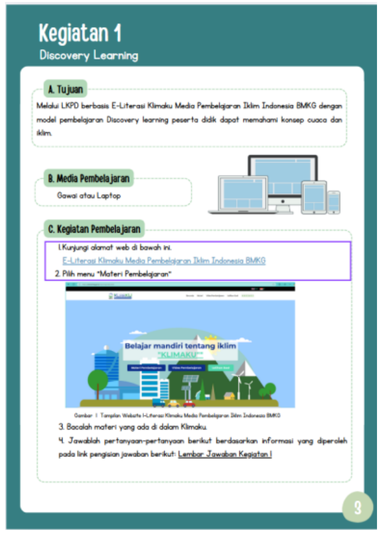

Figure 3. Display of activity 1

Figure 4. Activity 1 answer sheet using Google forms

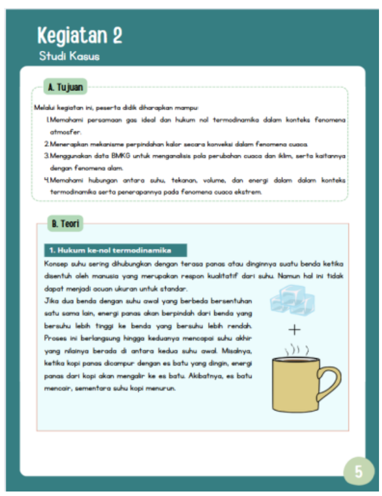

Figure 5. Display of activity 2 (case study worksheet)

The integration of QR codes and Google Forms offers paperless access, enhances assessment efficiency, and aligns with the demands of 21st-century learning (Ekayanti & Hariyono, 2020; Usman et al., 2022).

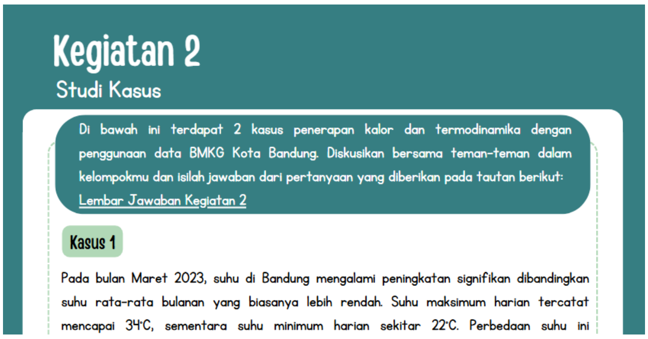

Figure 6. Activity 2 answer sheet using Google forms

Figure 7. The use of QR codes to access videos

Considering the essential role of teaching-learning materials in facilitating education (Minto, 2024), The E-LKPD underwent a comprehensive validation process conducted by two material experts, two media experts, and two experienced physics teachers. The validation covered content, practicality, linguistic quality, presentation, and graphical aspects. The results are shown in Tables 4 and 5.

Table 4. Validation result by the validator

Aspect	Total V Index	Classification
Linguistic	0.83	High
Content/Material	0.87	High
Presentation	0.92	High

Table 5. Validation results by teachers

Aspect	Total V Index	Classification
Content	0.93	High
Practicality	0.90	High
Linguistics	0.95	High
Presentations	0.95	High
Graphical	0.83	High

Overall, the product achieved an average validity of V = 0.91, classified as high. The strong scores in content and presentation indicate that the E-LKPD aligns well with learning objectives and is visually coherent. Minor improvements were suggested, particularly regarding terminology consistency and image resolution, which will be refined in future revisions. These findings confirm the suitability of the E-LKPD for classroom implementation. Similar studies also highlight that integrating technology and contextual data can increase product feasibility and student engagement (Hadiyastama et al., 2022; Siregar et al., 2024). In addition, high validity values have also been reported in previous developments of digital worksheets, supporting the view that technology-based instructional materials are increasingly suitable for modern classrooms (Ariatman et al., 2024).

The E-LKPD was tested on 35 students in grade XI who had learned thermodynamics concepts. Student responses were obtained through questionnaires and open-ended feedback.

Table 6. The results of the student response test

Aspect	Percentage (%)	Classification
Readability	84	Very Good
Presentation	90	Very Good
Usability	97	Very Good
Technological use	89	Very Good

The high usability score (97%) indicates that the integration of QR codes, interactive videos, and Google Forms in the E-LKPD was intuitive and easy for students to use. This finding aligns with previous studies, which showed that the use of QR Code media makes it more effective, efficient, and varied (Badriana et al., 2021; Handayani & Haryati, 2024). The strong presentation score (90%) also demonstrates visual coherence, consistent with validator assessments and earlier research, which show that clear design improves student engagement. Google Forms facilitated efficient assessment, increased learning motivation, and reduced cheating risks (Sef et al., 2025; Yuliana et al., 2021). Similarly, digital videos were shown to capture students' attention and simplify complex concepts, leading to improved learning outcomes (Firman & Bancong, 2024). Although the readability was slightly lower (84%), simplifying the content can facilitate learning and enhance students' understanding (Nurhuda et al., 2024). Overall, the findings confirm that technology-based media can enhance learning efficiency and motivation. The distinct contribution of this study lies in its explicit integration of BMKG climate data into thermodynamics learning, providing authentic contexts that not only strengthen conceptual understanding but also foster climate literacy in line with constructivist theory.

In addition to quantitative results from the student response questionnaire, qualitative data were also collected through open-ended responses. These responses provided deeper insights into students' perceptions of the E-LKPD, particularly regarding its effectiveness, practicality, and relevance. A summary of representative responses is presented in Table 7.

Table 7. Examples of student open-ended responses

Category	Responders	Sample Responses
Learning Effectiveness	14	"Learning is easy to understand and very interesting", "easy to understand", "makes it easy".
Practical Applications	10	"Thermodynamics relationship with everyday life", "using BMKG data".
Resource Efficiency	5	"No need to print", "paperless", "easy to access".
Material Understanding	8	"Become more knowledgeable about thermodynamics", "understand weather and climate".
Obstacles	1	"Learn a lot but not enough time"

Students also emphasized the eco-friendly, paperless nature of the product. These findings support earlier research that digital worksheets enhance both learning efficiency and environmental sustainability (Harisdianto et al., 2023; Romadoni & Akhsan, 2022).

Classroom observations (Figure 8) showed that students accessed the E-LKPD in groups using mobile phones and laptops. They appeared enthusiastic and actively engaged throughout the activities. The integration of BMKG data encouraged inquiry, discussion, and collaboration. Physics, often perceived as abstract and complex, has become more relatable and enjoyable, in line with studies showing that physics can become more relatable to real-life contexts (Sari et al., 2023) and more enjoyable to learn (Masril et al., 2018).

Figure 8. Observation documentation during implementation

This aligns with previous studies that real-data-based learning fosters higher student motivation and better conceptual understanding (Ariska et al., 2022). Overall, the high scores from validation and student responses demonstrate that the E-LKPD is feasible and practical for classroom implementation. The integration of authentic BMKG data was a key factor in driving its usability and practicality, as it provides concrete examples of abstract thermodynamic concepts. This aligns with constructivist learning theory, which emphasizes the importance of authentic contexts in knowledge construction (Herianto & Lestari, 2021).

Nevertheless, some limitations were identified. The readability score suggests that further refinement of terminology and activity pacing is needed. Additionally, the research was conducted in a limited sample of schools, which may limit its generalizability. Future studies should test the product in multiple institutions and explore additional interactive features, such as simulations or adaptive feedback systems.

Conclusion

This study successfully developed an E-LKPD integrating BMKG data into thermodynamics learning at the high school level. The product achieved high validity based on expert and teacher evaluations (average Aiken's V = 0.91) across content, language, presentation, and graphics aspects. Readability and student response tests also indicated very good feasibility (usability 97%; presentation 90%; readability 84%). These results confirm that the E-LKPD is practical, engaging, and effective in improving students' conceptual understanding of thermodynamics and climate change, while also fostering their 21st-century skills. The findings imply that incorporating authentic BMKG data into digital worksheets can enhance contextual physics learning and increase student motivation. Future research is recommended to extend the implementation to different schools, refine the textual clarity, and integrate additional interactive features, such as simulations, to maximize learning outcomes.

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Author Contributions

Conceptualisation: Y.F.A., N.M.S., H.R.P., B.Y.P., W., and T.; Methodology: Y.F.A., N.M.S., and H.W.S.; Validation: Y.F.A., N.M.S., H.W.S., and B.Y.P.; Formal analysis: Y.F.A. and H.R.P.; Investigation: Y.F.A., N.M.S., H.R.P., and W.; Resources, supervision: W. and T.; Data management: N.M.S. and H.R.P.; Writing—initial draft: Y.F.A., H.R.P., and B.Y.P; Writing—review and editing: N.M.S., H.R.P., B.Y.P., W., and T.; Visualization: H.R.P. and B.Y.P.; Research administration: N.M.S. and W.; Funding: Y.F.A., N.M.S., H.R.P., and B.Y.P. All authors have read and approved the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

References

Aksari, V., Budhi, W., & Hasanah, D. (2021). Pengembangan E-LKPD Fisika Berbasis Inkuiri Terbimbing pada Materi Gerak Lurus untuk Peserta Didik Kelas X SMA. *Jurnal Riset dan Kajian Pendidikan Fisika*, *8*(1), 43. https://doi.org/10.12928/jrkpf.v8i1.20210

Ariatman, R., Arifin, S., & Musari, M. (2024). Mengembangkan Kecerdasan Majemuk: Strategi Memaksimalkan Potensi Siswa di Era Society 5.0. *Journal of Classroom Action Research*, *6*(3), 608–616. https://doi.org/10.29303/jcar.v6i3.7680

Ariska, M., Akhsan, H., Muslim, M., Romadoni, M., & Putriyani, F. S. (2022). Prediksi Perubahan Iklim Ekstrem di Kota Palembang dan Kaitannya dengan Fenomena El Niño-Southern Oscillation (ENSO) Berbasis Machine Learning. *JIPFRI (Jurnal Inovasi Pendidikan Fisika dan Riset Ilmiah)*, *6*(2), 79–86. https://doi.org/10.30599/jipfri.v6i2.1611

Arkadiantika, I., Ramansyah, W., Effindi, M. A., & Dellia, P. (2020). Pengembangan Media Pembelajaran Virtual Reality pada Materi Pengenalan Termination dan Splicing Fiber Optic. *Jurnal Dimensi Pendidikan dan Pembelajaran*, *8*(1), 29. https://doi.org/10.24269/dpp.v0i0.2298

Asma, R., Asrial, A., & Maison, M. (2020). Development of Interaction Electronics Student Worksheets on Electromagnetic Induction Based on Scientific Approaches. *Jurnal Penelitian Pendidikan IPA*, *6*(2), 136–143. https://doi.org/10.29303/jppipa.v6i2.387

Badriana, S., Apriani, H., & Marito, M. (2021). Pengembangan Modul Fisika Berbasis QR-CODE pada Pokok Bahasan Fisika Inti Kelas XII SMA. *Schrodinger Jurnal Ilmiah Mahasiswa Pendidikan Fisika*, *2*(2), 124–132. https://doi.org/10.30998/sch.v2i2.4363

BMKG. (2025). *Manfaat Iklim dan Cuaca dalam Kehidupan*. Jakarta: Kedeputian Bidang Klimatologi BMKG. E-Literasi Klimaku Media Pembelajaran Iklim Indonesia BMKG. Retrieved from https://cews.bmkg.go.id/elearning/index.html

Bogador, C. J., Camarao, M. K. G., Matunding, C. G., & Sombria, K. J. F. (2024). Challenges and Benefits of Inquiry-Based Learning in Physics. *International Journal of Multidisciplinary: Applied Business and Education Research*, *5*(7), 2716–2732. https://doi.org/10.11594/ijmaber.05.07.26

Doyan, A., Wahyudi, W., Ayub, S., Harjono, A., & Susilawati, S. (2024). Effectiveness of Thermodynamics Textbooks Assisted by Heyzine Flipbook to Improve Students' Generic Science, Critical Thinking and Conceptual Understanding. *Jurnal Penelitian Pendidikan IPA*, *10*(10), 7839–7844. https://doi.org/10.29303/jppipa.v10i10.9091

Ekayanti, N., & Hariyono, E. (2020). Sets Vision: How to Develop Students' Climate Literacy Through Physics Learning. *Inovasi Pendidikan Fisika*, *9*(2), 215-222. Retrieved from https://ejournal.unesa.ac.id/index.php/inovasi-pendidikan-fisika/article/view/34546/30719

Ellianawati, E., & Rahayu, T. (2024). Development of Physics Teaching Material: Guided Discovery Learning with Liveworksheet to Improve Work and Energy Problem Solving. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *9*(1), 24. https://doi.org/10.26737/jipf.v9i1.4442

Fauzi, A., Ermiana, I., Rosyidah, A. N. K., & Sobri, M. (2022). Implementasi Case Method (Pembelajaran Berbasis Pemecahan Kasus) Ditinjau dari Kemampuan Kolaboratif Mahasiswa. *Jurnal Eduscience (JES)*, *9*(3), 809–817. https://doi.org/10.36987/jes.v9i3.3446

Firman, S., & Bancong, H. (2024). Studi Literatur: Analisis Penggunaan Media Video pada Mata Pelajaran IPA di SD. *Jurnal Pendidikan IPA*, *13*(1), 42. https://doi.org/10.20961/inkuiri.v13i1.80643

Hadiyastama, M. F., Nurwahidin, M., & Yulianti, D. (2022). Peran Teknologi Pendidikan dalam Pembelajaran Abad 21. *Jurnal Pengembangan Profesi Pendidikan Indonesia*, *1*(1), 11–18. Retrieved from https://jurnal.fkip.unila.ac.id/index.php/JPPPI/article/view/26081

Handayani, F. A., & Haryati, T. (2024). Pemanfaatan Media Pembelajaran QR-Code sebagai Upaya Implementasi Pendidikan Sesuai Kodrat Zaman KHD di SMP Negeri 6 Semarang. *Jurnal Ilmiah*

Profesi Pendidikan, *9*(2), 809–815. https://doi.org/10.29303/jipp.v9i2.2180

Harisdianto, H., Affandi, A. K., Ariani, M., & Suhadi, S. (2023). Downscaling Spasial Data Curah Hujan TRMM di Wilayah Sumatera Selatan dengan Algoritma Artificial Neural Network dan Random Forest Regression. *Jurnal Penelitian Sains*, *25*(3), 283. https://doi.org/10.56064/jps.v25i3.906

Herianto, H., & Lestari, D. P. (2021). Implementasi Teori Konstruktivisme dalam Pembelajaran IPA Melalui Pemanfaatan Bahan Ajar Elektronik. *Jurnal Pembangunan Pendidikan: Fondasi dan Aplikasi*, *9*(1). https://doi.org/10.21831/jppfa.v9i1.38024

Kemdikbudristek. (2024). *Capaian Pembelajaran Pendidikan*. Jakarta: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.

Khairunnisa, M., Sutarno, S., & Harlita, H. (2024). Development of E-Modules Based on Discovery Learning to Improve Science Process Skills on The Material of Interactions Between Living Things. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 7067–7075. https://doi.org/10.29303/jppipa.v10i9.7729

Lebang, M. P., Nurhayati, N., & Saleh, M. (2024). Penerapan Pembelajaran Fisika Berbasis Kasus (Case Method) Terhadap Kemampuan Menyelesaikan Soal HOTS Peserta Didik Kelas XI MIPA SMA Negeri 16 Makasar. *Jurnal Sains dan Pendidikan Fisika*, *20*(2), 197–204. https://doi.org/10.35580/jspf.v20i2.3692

Lestari, P. P., & Linuwih, S. (2014). Analisis Konsepsi dan Perubahan Konseptual Suhu dan Kalor pada Siswa SMA Kelas Unggulan. *Unnes Physics Educational Journal*, *3*(2), 62–67.

Masril, M., Hidayati, H., & Darvina, Y. (2018). Penerapan Discovery Learning Berbantuan Virtual Laboratory untuk Meningkatkan Kompetensi Fisika Siswa SMA. *Jurnal Penelitian Pendidikan IPA*, *5*(1). https://doi.org/10.29303/jppipa.v5i1.160

Maulida, L., Murtinugraha, R. E., & Arthur, R. (2023). Model Four-D sebagai Implementasi untuk Pengembangan Bahan Ajar Elektronik Modul Mata Kuliah K3. *Jurnal Pendidikan West Science*, *1*(7), 433-440. https://doi.org/10.58812/jpdws.v1i07.532

Minto, T. L. (2024). Material Development in ELT: Principles and Procedures. *Research Journal of English Language and Literature (RJELAL)*, *12*(1), 316–323. https://doi.org/10.33329/rjelal.12.1.316

Natalia, D., Aswan, D. M., & Aina, M. (2025). Feasibility Test of Case Study Oriented Textbooks in Educational Digital Psychology Courses. *Jurnal Penelitian Pendidikan IPA*, *11*(2), 124–130. https://doi.org/10.29303/jpipa.v11i2.9857

Nurhuda, P., Megawati, R., Sudirman, S., & Agustin, R. (2024). Mind Map-Assisted STEM Integration to Enhance Students' Science Skills in the 21st Century: A Literature Review. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 960–967. https://doi.org/10.29303/jppipa.v10i12.9480

Resmawati, F. S., Prabowo, P., & Munasir, M. (2018). The Discovery Learning Model with A Scientific Approach to Increase Science Learning Achievement of Students. *Proceedings of the Mathematics, Informatics, Science, and Education International Conference (MISEIC 2018)*. Surabaya, Indonesia. https://doi.org/10.2991/miseic-18.2018.48

Rizki, A., Khaldun, I., & Pada, A. U. T. (2021). Development of Discovery Learning Student Worksheets to Improve Students' Critical Thinking Skills in Chemical Balance Materials. *Jurnal Penelitian Pendidikan IPA*, *7*(4), 707–711. https://doi.org/10.29303/jppipa.v7i4.829

Romadoni, M., & Akhsan, H. (2022). Karakteristik Iklim di Kota Palembang serta Implikasinya Terhadap Bencana Kabut Asap. *JIPFRI (Jurnal Inovasi Pendidikan Fisika dan Riset Ilmiah)*, *6*(2), 60–66. https://doi.org/10.30599/jipfri.v6i2.1541

Sari, I. P. M., Jatmiko, B., & Suprapto, N. (2023). Students' Physics Problem-Solving Skills in Daily Life Context: Between Confession and Fact. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 231–241. https://doi.org/10.29303/jppipa.v9i1.2561

Sef, W., Hamdani, A. S., & Soraya, I. (2025). Efektivitas Penggunaan Media Evaluasi Berbasis Google Form pada Pembelajaran PAI dalam Penilaian Akhir Semester (PAS). *Journal for Islamic Studies*, *8*(2). https://doi.org/10.31943/afkarjournal.v8i2.1399

Siregar, A. N., Prasetyo, Z. K., Jumadi, J., & Paramitha, D. (2023). Effectiveness of Using Guided Inquiry-Based E-LKPD on Global Warming Material to Increasing Students' Understanding of Concepts. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9156–9161. https://doi.org/10.29303/jppipa.v9i11.5166

Siregar, T., Wijaya, A., Rangkuti, A. N., Nasution, M., & Sungkono, J. (2024). Keterampilan dan Kecakapan Abad 21: Kompetensi Digital Pendidik Masa Depan. *Journal of Islamic and Scientific Education Research*, *01*(02), 1–11. Retrieved from https://jurnal.uinsyahada.ac.id/index.php/SJPAI/article/view/10942

Usman, U., Fakhruddin, Z., Hardiyanti, H., Zam, Z., & Qadaruddin, Q. (2022). *Literasi Digital dan Mobile Learning*. IAIN Parepare Nusantara Press.

Wardani, W. P., & Suniasih, N. W. (2022). E-LKPD Interaktif Berbasis Kearifan Lokal pada Materi Aksara Bali Kelas V Sekolah Dasar. *Mimbar Ilmu*, *27*(1), 173–182. https://doi.org/10.23887/mi.v27i1.44586

Waruwu, M. (2024). Metode Penelitian dan Pengembangan (R&D): Konsep, Jenis, Tahapan dan Kelebihan. *Jurnal Ilmiah Profesi Pendidikan*, *9*(2), 1220–1230. https://doi.org/10.29303/jipp.v9i2.2141

Yuliana, B., Gummah, S., & Sukroyanti, B. A. (2021). Penggunaan Google Form sebagai Alat Evaluasi Pelajaran Fisika Kelas X. *Lensa: Jurnal Kependidikan Fisika*, *9*(2), 178. https://doi.org/10.33394/j-lkf.v9i2.4691

Yulianci, S., Nurjumiati, N., Asriyadin, A., & Adiansha, A. A. (2021). The Effect of Interactive Multimedia and Learning Styles on Students' Physics Creative Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *7*(1), 87–91. https://doi.org/10.29303/jppipa.v7i1.529