

Development of E-LKPD with Problem Based Learning (PBL) Learning Model in Informatics Subject at High School

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Abstract: This study aims to develop and examine the validity and practicality of an Electronic Student Worksheet (E-LKPD) based on the Problem-Based Learning (PBL) model to enhance student engagement and understanding in Informatics at the secondary school level. The research employed a Research and Development (R&D) approach using the 4D model (Define, Design, Develop, Disseminate) proposed by Thiagarajan, Semmel, and Semmel. The E-LKPD was validated by material and media experts and tested for practicality by students and teachers. Validation results indicated an average score of 95.15% from material experts and 96.64% from media experts, both categorized as very high. Practicality tests yielded an average of 96.28% from students and 96.84% from teachers and students combined. These findings confirm that the developed E-LKPD is highly valid and practical for use in Informatics learning. Moreover, its implementation shows potential to foster student engagement and understanding, aligning with the intended objectives of the development.

Keywords: E-LKPD; Model 4D; Problem-based learning; Research and development

Introduction

Education plays a strategic role in the progress of a nation, as the quality of human resources is shaped by the effectiveness of learning processes. Careful planning is therefore essential to ensure that every learner experiences relevant and effective education. In the era of the Fourth Industrial Revolution, the integration of digital technology into education has become a necessity to create innovative and engaging learning systems that align with the characteristics of today's learners (Montuori et al., 2024). Despite rapid global advancements in technology, Indonesia continues to face significant challenges in education. Findings from the Programme for International Student Assessment (PISA) 2022 placed Indonesia below the OECD average in reading, mathematics, and science, indicating persistent gaps in students' critical thinking and

problem-solving abilities. This highlights the urgent need to strengthen both the quality of teaching and the use of technology-based learning innovations to equip students with 21st-century competencies (Akbar & Zahrotun, 2024; Natalia & Muhtarom, 2024; Pambudi et al., 2024; Wahyuni et al., 2024).

One promising solution is the development of interactive, technology-based learning media that promote active engagement and problem-solving. The Electronic Student Worksheet (E-LKPD) represents a digital innovation designed to provide dynamic, flexible, and easily accessible instructional resources (Moreno-Palma et al., 2024). When combined with the Problem-Based Learning (PBL) model, E-LKPD has the potential to encourage independent, creative, and critical learning, shifting students from passive recipients of knowledge to active problem solvers (Amron et al., 2025; Gitakarma & Tjahyanti, 2020).

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The context of SMAN 1 Siberut Barat Daya illustrates the urgency of such an innovation. Although stable internet access has only recently become available, many students still struggle with digital literacy. Most are familiar only with basic smartphone functions and lack the ability to use productivity applications, spreadsheets, or online collaboration platforms. Furthermore, while laptops and personal computers are largely unavailable, nearly all students own smartphones, and the school provides tablets for those without personal devices. This situation emphasizes the importance of designing E-LKPDs that are fully compatible with mobile devices. Teachers also face barriers in implementing PBL effectively (Rich et al., 2020). Developing problem scenarios that are locally relevant and feasible with the available devices presents considerable challenges. Limited instructional time two 45-minute sessions per week further restricts the opportunities for in-depth exploration and discussion, which are central to PBL. These limitations often result in Informatics lessons that remain highly theoretical and less engaging, leading to low student motivation and minimal connection between classroom concepts and real-world applications (Hidayah et al., 2025; Nengsih, 2020; Syaddad, 2020).

Beyond these classroom-level issues, broader challenges relate to aligning the goals of national educational reforms with practical realities. The Merdeka Curriculum, introduced to promote flexibility, creativity, and problem-solving, requires supportive tools to be implemented effectively. Without adequate digital resources particularly those that can be accessed via smartphones the curriculum's objectives risk remaining aspirational rather than actionable (Weintrop et al., 2019). Against this backdrop, the development of a PBL-based E-LKPD tailored for mobile access becomes both timely and necessary. Such innovation has the potential to not only address gaps in digital literacy and learning engagement but also to support teachers in overcoming constraints of time, resources, and pedagogy. By focusing on Informatics education, the study also contributes to strengthening a subject that is increasingly central in preparing students for participation in a digital society (Fitriyah & Ghofur, 2018; Ismawati et al., 2023; Rizkika et al., 2022).

Previous studies have shown that E-LKPDs can enhance critical thinking, problem-solving, and engagement across different learning contexts. However, most research has focused on urban or resource-rich environments, while limited attention has been given to rural schools with restricted infrastructure and low digital skills. Moreover, although PBL is widely recognized as an effective pedagogical model, its integration into mobile-friendly E-LKPDs aligned with

the Merdeka Curriculum remains underexplored. This study addresses that gap by developing and validating a PBL-based E-LKPD specifically designed for mobile use in rural secondary schools (Rich et al., 2021). In doing so, it provides both theoretical contributions expanding the literature on PBL integration into digital worksheets – and practical outcomes offering a scalable and context-sensitive solution for enhancing engagement and understanding in Informatics learning (Risamasu & Pieter, 2023; Sari & Purwaningsih, 2023; Zhalila et al., 2024).

Method

This study adopted a research and development (R&D) approach as outlined by Sugiyono (2017). The R&D method was selected because it is specifically designed to produce educational products and to evaluate their quality in terms of validity and practicality (Zhang et al., 2024). In this study, the product developed was an Electronic Student Worksheet (E-LKPD) based on the Problem-Based Learning (PBL) model for Informatics learning at the secondary school level. Development research is inherently iterative, requiring systematic evaluation at each stage to ensure that the resulting product meets the expected standards of quality (Syahputra & Abil, 2023; Khoerunnisa et al., 2023; Hidar & Indana, 2025).

The development followed the Four-D Model (4D model) proposed by Thiagarajan, Semmel, and Semmel (1974) (Fitrah et al., 2025). This model consists of four sequential stages: Define, Design, Develop, and Disseminate. It was chosen because of its structured and systematic nature, which has been widely applied in the development of instructional media and teaching materials. The stages of the 4D model were adapted to the context of this study as described below (Putu & Jan, 2024; Zikri & Handayani, 2024).

Defining Stage

In the Define stage, the initial problems in Informatics learning were identified. The analysis included five steps: initial-final analysis to recognize student difficulties in understanding Informatics concepts, student analysis to explore the characteristics and prior knowledge of tenth-grade students at SMAN 1 Siberut Barat Daya, task analysis to outline the skills expected to be mastered, concept analysis to determine the relevant subject matter, and the formulation of learning objectives. Additional data were collected through teacher interviews and a review of previous studies to strengthen the foundation for product development (Ghaisani & Setyasto, 2023; Silfiyani et al., 2024).

Design Stage

The Design stage was carried out to create a blueprint of the E-LKPD. This involved preparing assessment instruments to measure students' computational thinking skills, particularly through problem scenarios related to the social impact of informatics (Yulanda et al., 2023). Media selection was conducted to ensure compatibility with student conditions, resulting in the use of the wizer.me platform, which is accessible via mobile devices. The format of the E-LKPD was then defined as a digital worksheet integrating the PBL model. Finally, an initial prototype was created, including a storyboard, video-based instructional materials, comprehension exercises, and problem-based tasks (Fahrizy & Fathurrahman, 2024; Rianda et al., 2025).

Development Stage

The Develop stage implemented the prototype design and focused on expert validation and field

testing. Material experts and media experts evaluated the E-LKPD and provided feedback for revisions. Afterward, a developmental trial was conducted with 50 students to gather responses and assess the practicality of the E-LKPD in classroom practice (Dewitasari & Rusmini, 2023; Sajidi & Parmin, 2025).

Deployment Stage

The Disseminate stage extended the implementation of the E-LKPD to a wider context. A field validation was conducted with tenth-grade students at SMAN 1 Silaut to examine its practicality in real classroom conditions. Following this, the product was finalized and packaged with a user manual to facilitate wider adoption by teachers and students (Angeli & Giannakos, 2020; Wardhani et al., 2025).

The overall research procedure following the 4D model is presented in Figure 1.

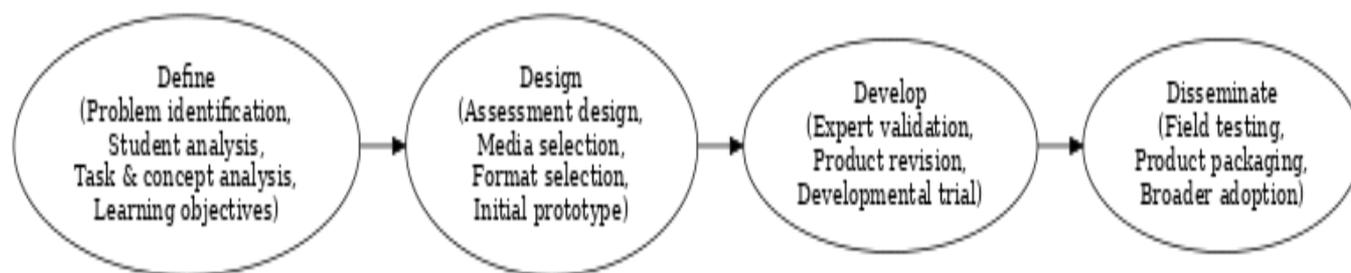


Figure 1. Research Procedures Using the 4D Model

As shown in Figure 1, the research followed a structured sequence beginning with problem identification and analysis, followed by the design of the digital worksheet, expert validation and developmental trials, and finally broader dissemination (Saputra et al., 2024). This systematic process ensured that the developed PBL-based E-LKPD met the required criteria of validity and practicality, while also aligning with the specific needs of Informatics learning in secondary schools (Grover & Pea, 2020; Liu et al., 2024).

Result and Discussion

The development of the E-LKPD followed the four stages of the 4D model: Define, Design, Develop, and Disseminate. In the Define stage, preliminary analysis was carried out to identify students' learning difficulties in Informatics and to understand their prior knowledge, digital skills, and learning needs. This stage provided the foundation for selecting relevant concepts and formulating learning objectives aligned with the Merdeka Curriculum. The findings confirmed that

students required learning tools that were mobile-friendly and capable of fostering computational thinking and problem-solving skills.

In the Design stage, the initial prototype of the E-LKPD was created. Assessment instruments were prepared to measure computational thinking, media and formats were selected, and the E-LKPD was designed using wizer.me. This platform allowed the integration of video-based materials, comprehension tasks, and problem-based activities. The design aimed to make the learning process more interactive and engaging while ensuring accessibility through smartphones, which are widely used by students in rural schools.

The Develop stage focused on validation and refinement. Expert validation showed that the E-LKPD met very high standards in both content and media quality. Material experts rated content feasibility, language, and usefulness highly, with an overall score of 95.15%. Similarly, media experts highlighted the display, ease of use, and consistency, with an overall score of 96.64%. These results confirm that the E-LKPD was theoretically valid and technically well designed.

Table 1. Material expert validation results

Aspect	Percentage (%)
Content Appropriateness	96.50
Language	95.90
Presentation	94.70
Usability	93.50
Average	95.15

Table 2. Media expert validation results

Display	Percentage (%)
Ease of use	96.50
Consistency	97.40
Format	98.30
Graphics	96.50
Average	94.50

The Disseminate stage evaluated the practicality of the E-LKPD through trials with students and teachers. The results demonstrated that the E-LKPD was highly practical. Students found it easy to use, attractive, and supportive of independent learning, while teachers emphasized its convenience and its alignment with instructional objectives. The average practicality score from students was 96.28%, and from both students and teachers 96.84%, both within the “very high” category.

Table 3. Practicality results from students

Aspect	Percentage (%)
Ease of use of the job sheet	97.30
Ease of understanding the material	94.60
Attractiveness of Job sheet	95.70
Learning Independent	97.20
Achievement of Learning goals	96.60
Average	96.28

Table 4. Practicality results from teachers and students

Aspect	Percentage (%)
Ease of use	96.10
Ease of understanding	95.50
Student Independence	95.60
Learning Independent	98.80
Teacher convenience	98.50
Average	96.84

These results align with earlier research that emphasizes the effectiveness of validated and user-friendly digital worksheets in fostering engagement and learning autonomy. In rural contexts like SMAN 1 Siberut Barat Daya, where digital literacy and infrastructure remain limited, the practicality of mobile-accessible E-LKPD is particularly valuable. The findings highlight that this innovation supports students' independent learning and motivation while assisting teachers in implementing PBL effectively within limited instructional time.

Overall, this study demonstrates that the integration of PBL into a mobile-friendly E-LKPD is both valid and practical for Informatics learning. The novelty

of this research lies in its adaptation of digital worksheets for rural school contexts, focusing on smartphone accessibility and PBL integration. This approach provides a theoretical contribution by expanding the literature on PBL-based digital learning tools and a practical contribution by offering a scalable solution that bridges the gap between curriculum reforms and classroom realities in Indonesia.

Conclusion

This study successfully developed an Electronic Student Worksheet (E-LKPD) based on Problem-Based Learning (PBL) for Informatics using the 4D development model (Define, Design, Develop, Disseminate). The validation process confirmed that the product met very high standards of content and media quality, while practicality testing showed that the E-LKPD is easy to use, engaging, and supportive of students' learning independence. These findings indicate that the developed E-LKPD is both valid and practical, making it a feasible tool to enhance Informatics learning in secondary schools.

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Author Contributions

This research article was written by four authors with their respective contributions: Conceptualization, methodology, F.A. and A.H.; formal analysis, data curation, writing – original draft preparation, F.A.; writing – review and editing, Y.H. and F.; supervision, A. H. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

No conflicts of interest are disclosed by the writers.

References

- Akbar, M. F., & Zahrotun, L. (2024). TK-Means Centroid Optimization with Genetic Algorithm for Clustering Micro, Small, Medium Enterprises in Yogyakarta. *JUITA: Jurnal Informatika*, 13(2), 87-97. <https://doi.org/10.30595/juita.v13i2.25480>
- Amron, A., Azizi, H., Arofi, M., Paramita, C., & Naufal, M. (2025). Perbandingan Performa SIFT dan ORB dalam Pengolahan Dataset Wajah nist_2. *Jutisi: Jurnal Ilmiah Teknik Informatika dan Sistem Informasi*, 14(2). <http://dx.doi.org/10.35889/jutisi.v14i2.2738>
- Angeli, C., & Giannakos, M. N. (2020). Computational

- Thinking Education: Issues and Challenges. *Computers in Human Behavior*, 105(106185), 1–10. <https://doi.org/10.1016/j.chb.2019.106185>
- Dewitasari, A. P., & Rusmini, R. (2023). Feasibility of Interactive E-LKPD Based on Nature of Science (NoS) to Train Students' Critical Thinking Skills on Chemical Bonding Material. *Jurnal Penelitian Pendidikan IPA*, 9(9), 7122–71317. <https://doi.org/10.29303/jppipa.v9i9.4436>
- Fahrizy, R. M., & Fathurrahman, M. (2024). Development of Interactive E-LKPD Liveworksheets Based on Differentiated Instruction in IPAS for Grade V Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, 10(8), 5867–5876. <https://doi.org/10.29303/jppipa.v10i8.7366>
- Fitrah, M., Sofroniou, A., Setiawan, C., Widiastuti, W., armanetti, N., Jaya, M. P. S., Panuntun, J. G., Arfaton, A., Beteno, S., & Susianti, I. (2025). The Impact of Integrated Project-Based Learning and Flipped Classroom on Students' Computational Thinking Skills: Embedded Mixed Methods. *Education Sciences*, 15(4), 448. <https://doi.org/10.3390/educsci15040448>
- Fitriyah, I. M. N., & Ghofur, M. A. (2018). Development of Android-Based E-LKPD with Problem Based Learning (PBL) to Improve Students' Critical Thinking. *Edukatif: Jurnal Ilmu Pendidikan*, 3(5), 1957–1970. <https://doi.org/10.31004/edukatif.v3i5.718>
- Ghaisani, N. R. T., & Setyasto, N. (2023). The Development of Liveworksheets-Based Electronic Student Worksheets (E-LKPD) to Improve Science Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, 9(8), 6147–6156. <https://doi.org/10.29303/jppipa.v9i8.4571>
- Gitakarma, M. S., & Tjahyanti, L. P. A. S. (2020). Modifikasi Claroline dengan Metode Pembelajaran Computer-Supported Collaborative Learning (CSCL) Berbasis Konstruktivisme. *JANAPATI*, 1(1), 37–46. <https://doi.org/10.23887/janapati.v1i1.9764>
- Grover, S., & Pea, R. (2020). Computational Thinking in K–12: A Review of the State of the Field. *Educational Researcher*, 42(1), 38–43. <https://doi.org/10.3102/0013189X12463051>
- Hidar, R. N., & Indana, S. (2025). Pengembangan E-LKPD Berbasis PBL Materi Pertumbuhan dan Perkembangan untuk Melatihkan Keterampilan Berpikir Kritis Peserta Didik SMA. *BioEdu: Berkala Ilmiah Pendidikan Biologi*, 14(2), 404–413. <https://doi.org/10.26740/bioedu.v14n2.p404-413>
- Hidayah, F. N., Rahmawati, Y., Findawati, Y., & Azizah, N. L. (2025). Pengenalan Bahasa Isyarat Indonesia dengan Algoritma YOLOv8 Berbasis Mobile. *Infotek: Jurnal Informatika dan Teknologi*, 8(2), 323–333. <https://doi.org/10.29408/jit.v8i2.30189>
- Ismawati, E. Y., Khoiri, N., Saefan, J., Ristanto, S., Prakosa, H. A., & Ristianti, S. (2023). Development of E-LKPD Based on Problem-Based Learning to Improve Students' Decision-Making Ability. *Jurnal Inovasi Pembelajaran di Sekolah (JIPS)*, 4(2), 712–720. <https://doi.org/10.51874/jips.v4i2.174>
- Khoerunnisa, N., Nedin, B., & Gani, R. A. (2023). Pengembangan Lembar Kerja Peserta Didik Elektronik (E-LKPD) Berbasis Liveworksheets pada Subtema Lingkungan Tempat Tinggalku. *DWIJA CENDEKIA: Jurnal Riset Pedagogik*, 7(1), 391–397. <https://doi.org/10.20961/jdc.v7i1.71718>
- Liu, Z., Gearty, Z., Richard, E., Orrill, C. H., Kayumova, S., & Balasubramanian, R. (2024). Bringing Computational Thinking into Classrooms: A Systematic Review on Supporting Teachers in Integrating Computational Thinking into K-12 Classrooms. *International Journal of STEM Education*, 11(51), 1–18. <https://doi.org/10.1186/s40594-024-00510-6>
- Montuori, C., Gambarota, F., Altoè, G., & Arfé, B. (2024). The Cognitive Effects of Computational Thinking: A Systematic Review and Meta-Analytic Study. *Computers & Education*, 210(104961), 1–23. <https://doi.org/10.1016/j.compedu.2023.104961>
- Moreno-Palma, N., Hinojo-Lucena, F.-J., Romero-Rodríguez, J.-M., & Cáceres-Reche, M.-P. (2024). Effectiveness of Problem-Based Learning in the Unplugged Computational Thinking of University Students. *Education Sciences*, 14(7), 693. <https://doi.org/10.3390/educsci14070693>
- Natalia, N., & Muhtarom, T. (2024). Peran Teknologi Pendidikan dalam Meningkatkan Kualitas Pendidikan di Era Disrupsi. *Jurnal Nakula: Pusat Ilmu Pendidikan, Bahasa dan Ilmu Sosial*, 2(5), 79–87. <https://doi.org/10.61132/nakula.v2i5.1008>
- Nengsih, W. (2020). Analisa Recall dan Precision Menggunakan VSM pada Kasus Text Mining. *InfoTekJar: Jurnal Nasional Informatika dan Teknologi Jaringan*, 5(1), 71–82. <https://doi.org/10.30743/infotekjar.v5i1.2663>
- Pambudi, R., Berlilana, B., & Karyono, G. (2024). Analysis of LMS Implementation Success Based on Information System Success and End-User Computing Satisfaction Models. *JUITA: Jurnal Informatika*, 13(2), 177–186. <https://doi.org/10.30595/juita.v13i2.25963>
- Putu, R., & Jan, P. (2024). Pengembangan E-LKPD Berbasis Problem Based Learning untuk Meningkatkan Kemampuan Pemecahan Masalah Peserta Didik. *Jurnal Pendidikan Fisika Undiksha*, 14(1), 443–453. <https://doi.org/10.23887/jjpf.v14i1.75941>

- Rianda, P., Edidas, I., Irfan, D., & Wulansari, R. E. (2025). Development of Android-Based Learning E-Modules in Informatics Subjects. *Jurnal Penelitian Pendidikan IPA*, 11(1), 1117-1122. <https://doi.org/10.29303/jppipa.v11i1.9652>
- Rich, K. M., Yadav, A., & Larimore, R. A. (2020). Teacher Implementation Profiles for Integrating Computational Thinking into Elementary Mathematics and Science Instruction. *Education and Information Technologies*, 25(4), 3161-3188. <https://doi.org/10.1007/s10639-020-10115-5>
- Rich, P. J., Mason, S. L., & O'Leary, J. (2021). Measuring the Effect of Continuous Professional Development on Elementary Teachers' Self-Efficacy to Teach Coding and Computational Thinking. *Computers & Education*, 168(104196), 1-13. <https://doi.org/10.1016/j.compedu.2021.104196>
- Risamasu, P., & Pieter, J. (2023). Development of E-LKPD Based on Problem Based Learning to Improve Students' Problem Solving Ability. *Jurnal JJP/Local Development Journal*, 14(1), 443-453. <https://doi.org/10.23887/jjpf.v14i1.75941>
- Rizkika, M., Putra, P. D. A., & Ahmad, N. (2022). Development of STEM-Based E-LKPD on Pressure of Substances to Improve Critical Thinking Skills of Junior High School Students. *Pancasakti Science Education Journal (PSEJ)*, 7(1), 41-48. <https://doi.org/10.24905/psej.v7i1.142>
- Sajidi, I., & Parmin, P. (2025). Development of E-LKPD Based on Group Investigation Integrated with Citizen Science Projects to Improve Analytical Thinking and Collaboration Abilities of Junior High School Students. *Jurnal Penelitian Pendidikan IPA*, 11(7), 633-644. <https://doi.org/10.29303/jppipa.v11i7.11707>
- Saputra, A. B., Hamidah, A., & Mataniari, R. (2024). Development of E-LKPD Based on Problem Based Learning on Excretory System Material for High Schools. *Jurnal Penelitian Pendidikan IPA*, 10(5), 2423-2430. <https://doi.org/10.29303/jppipa.v10i5.6935>
- Sari, A. A., & Purwaningsih, D. (2023). Development of e-LKPD Based on Problem Based Learning (PBL) with Liveworksheets on Acid-Base Material. *WUNY: Jurnal Ilmiah WUNY*, 5(2), 23-31. <https://doi.org/10.21831/jwuny.v5i2.66387>
- Silfiani, A., Suyatna, A., & Abdurrahman, A. (2024). Development of Differentiated E-LKPD Integrated with PjBL-STEM to Improve Students' Science Literacy. *Jurnal Penelitian Pendidikan IPA*, 10(7), 4404-4411. <https://doi.org/10.29303/jppipa.v10i7.8347>
- Sugiyono, S. (2017). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabet.
- Syaddad, H. N. (2020). Rancang Bangun Sistem Keamanan Sepeda Motor Menggunakan GPS Tracker Berbasis Mikrokontroler pada Kendaraan Bermotor. *Jurnal Media Informatika*, 11(2), 26-35. <https://doi.org/10.35194/mji.v11i2.1035>
- Syahputra, S. N. P. H., & Abil, M. (2023). Development of Electronic Worksheets (E-LKPD) Oriented to Problem Solving to Improve Mathematical Problem Solving and Learning Independence. *Cendekia*, 7(2), 1890-1901. <https://doi.org/10.31004/cendekia.v7i2.2341>
- Wahyuni, D. S., Koehler, T., Saari, E. M., & Sindu, I. G. P. (2024). Examining the Role of Augmented Reality Interactivity on Student Performance: Mediating Effects of Visuospatial and Auditory Knowledge. *Jurnal Nasional Pendidikan Teknik Informatika: JANAPATI*, 14(2), 200-212. <https://doi.org/10.23887/janapati.v14i2.93234>
- Wardhani, S., Yusnita, D., & Astriani, M. (2025). Effectiveness of Electronic LKPD for PBL-Based Practical Work to Improve Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, 11(1), 374-381. <https://doi.org/10.29303/jppipa.v11i1.9810>
- Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2019). Defining Computational Thinking for Mathematics and Science Classrooms. *Journal of Computer Assisted Learning, (Meta-Analysis Article)*, 25(1), 127-147. <https://doi.org/10.1007/s10956-015-9581-5>
- Yulanda, V., Hamidah, A., & Anggereini, E. (2023). Development of Electronic Student Worksheets (E-LKPD) Based on Problem Based Learning as an Effort to Improve Critical Thinking of Grade VIII Middle School Students on Respiratory System Material. *Jurnal Penelitian Pendidikan IPA*, 9(9), 7326-7332. <https://doi.org/10.29303/jppipa.v9i9.4144>
- Zhalila, Z., Rusdi, R., Aniswita, A., & Medika, G. H. (2024). Development of Electronic Student Worksheets (E-LKPD) Assisted by Liveworksheets to Facilitate Mathematics Learning Interest. *Cendekia: Jurnal Pendidikan dan Pengembangan*, 8(3), 133-142. <https://doi.org/10.31004/cendekia.v8i3.3624>
- Zhang, W., Guan, Y., & Hu, Z. (2024). The Efficacy of Project-Based Learning in Enhancing Computational Thinking Among Students: A Meta-Analysis of 31 Experiments and Quasi-Experiments. *Education and Information Technologies*, 29(1), 14513-14545. <https://doi.org/10.1007/s10639-023-12392-2>
- Zikri, T. A., & Handayani, S. (2024). Development of Electronic Student Worksheets Based on Multiple Representations for High School Students on Buffer Solution Material. *Jurnal Penelitian Pendidikan IPA*, 10(5), 2521-2529.

<https://doi.org/10.29303/jppipa.v10i5.5247>