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Physics history e-module based on project-based learning integrated with Google Sites: Validity and practicality analysis

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ABSTRACT

Innovation in learning material presentation is crucial for enhancing student engagement. This research aims to develop a physics history e-module based on the Project-based Learning (PjBL) model integrated with Google Sites and to analyze its validity and practicality as a learning resource. The research followed the ADDIE model. Validation was conducted through expert review, while a limited trial involving students assessed its practicality. Revisions were made based on evaluation results to refine the module. The findings indicated that the developed e-module was highly feasible, with a validity score of 92% and a positive student response rate of 85%. The study concludes that the e-module effectively enhances students' understanding of physics history and can be integrated into modern learning to foster engagement. This research implies the development of Google Sites-based PjBL e-modules to improve student engagement and understanding.

E-modul sejarah fisika berbasis model project based learning terintegrasi Google Sites: Analisis validitas dan kepraktisan

Kata Kunci:

e-modul, Google Site, pembelajaran interaktif, sejarah fisika, PjBL

ABSTRAK

Inovasi dalam penyajian materi pembelajaran sangat penting untuk meningkatkan keterlibatan siswa. Penelitian ini bertujuan untuk mengembangkan e-modul sejarah fisika berbasis Project-Based Learning (PjBL) yang terintegrasi Google Sites serta menganalisis validitas dan kepraktisannya sebagai sumber pembelajaran. Penelitian ini menggunakan model ADDIE. Validasi dilakukan melalui uji ahli, sedangkan uji coba terbatas pada mahasiswa digunakan untuk menilai kepraktisannya. Evaluasi hasil uji coba dilakukan untuk menyempurnakan modul. Hasil penelitian menunjukkan bahwa e-modul yang dikembangkan memiliki tingkat kelayakan tinggi dengan skor validitas 92% dan respons positif mahasiswa sebesar 85%. Studi ini menyimpulkan bahwa e-modul efektif dalam meningkatkan pemahaman mahasiswa terhadap sejarah fisika serta dapat diintegrasikan dalam pembelajaran modern untuk meningkatkan keterlibatan siswa. Penelitian ini berimplikasi dalam pengembangan e-module PjBL berbasis Google Sites untuk meningkatkan keterlibatan dan pemahaman siswa.

Contribution to the literature

This research contributes to:

- Advancing physics history education by integrating PjBL-based e-modules, transforming traditional teaching into interactive digital learning.
- Illustrating how Google Sites can effectively create engaging and accessible learning resources.
- Highlighting how combining PjBL and digital tools can enhance student engagement and understanding in learning physics history.

1. INTRODUCTION

As technology advances, the digital era shifts from traditional methods to digital-based learning [1]. The development of technology also results in a person's ability to innovate to produce something new [2]. This phenomenon also happens in the learning process, where teachers or lecturers must adjust their learning process to technological developments to be more interesting. Innovations in the learning process include developing learning media and teaching materials. A combination of teaching materials and digital-based media is necessary for today's learning so students can use their smartphones wisely.

Smartphones, which students almost universally own, can be effective learning tools, facilitating access to information and enhancing learning experiences. While typically used for social media and online games, smartphones can be leveraged as crucial educational tools through digital learning materials such as e-modules. Yulkifli *et al.* [3] support 21st Century learning. Smartphone-based teaching materials, such as e-modules, are needed so students can easily understand the material. Fawareh and Jusoh [4] explain that the development of technology and its applications allows a person to use his smartphone for various purposes, such as sending and receiving emails, reading the news, and looking for information for various needs. Yulkifli *et al.* [3] explained that the development of web-based learning media and teaching materials provides an effective solution as a learning resource for students to improve their critical thinking skills. Integrating PjBL with Google Sites creates an interactive and engaging learning environment [5]–[7]. PjBL has been shown to improve students' critical thinking and problem-solving skills. When combined with the accessibility of Google Sites, it offers an innovative and user-friendly platform for developing interactive learning materials. Research in subjects like science, engineering, and even social studies has shown that PjBL enhances students' understanding by involving them in hands-on, real-world projects that require them to apply their knowledge in practical situations [8]. In subjects like biology and chemistry, students have demonstrated better retention of concepts and an improved ability to think critically when they engage in projects that require them to research, analyze, and solve problems based on real-world challenges.

In line with the shift toward digital tools, PjBL emerges as a highly effective model for engaging students and deepening their understanding [9]. PjBL is especially suited to teaching physics history as it allows students to explore the historical development of physics more interactively and engagingly. Rather than just memorizing facts or dates, students can take on projects that involve researching important physicists, understanding the context of their discoveries, and applying these historical concepts to modern scientific issues. This approach deepens students' understanding of the subject matter. It encourages them to develop teamwork [10], research, and presentation skills vital in academic and professional settings. By using PjBL in physics history, students are not just passive recipients of information; they become active participants in their learning, exploring the relationships between scientific discoveries and the historical context in which they occurred [11]. This approach also helps students see the relevance of physics in everyday life and society [12], making the learning process more meaningful and engaging. One alternative to developing web-based learning media and teaching materials is Google Site, which is easy to use and does not require complicated IT skills [13].

Almost all students, especially in the Physics Education Study Program at Universitas Khairun, have smartphones. However, their use is limited to social media and online games, and they are sometimes used as a medium to find information when completing coursework. Parmar *et al.* [14] explained that current students have in-depth internet experience, so web-based learning is an important medium to complement the traditional learning process. Web-based learning through Google Sites can touch deeper aspects of learning by serving as a form of improvement of traditional learning to IT-based learning [15].

Physics history is traditionally taught through lectures and assignments, focusing more on memorizing facts than developing critical thinking skills [16]. This approach does not fully engage students in understanding the context and relevance of scientific discoveries [17]. Innovative approaches, such as PjBL-based e-modules, are needed to make physics history learning more interactive and connected to real-world experiences [18]. The development of digital teaching materials (e-modules) in this research involved students by providing the opportunity to convey ideas and give feedback on the concepts presented, especially examples related to real life. It also encouraged students' creativity in choosing content and utilizing digital media to improve the quality of learning materials [5]. The development of the physics history e-module was carried out because, so far, the learning of physics history has been carried out through discussion, question-and-answer methods, and assignments [19]. The history of physics was emphasized more on students' simultaneous understanding and did not think about critical thinking skills [20]. The development of learning in higher education using various learning models, one of which is the PjBL model [21], motivated the researchers to develop a physics history e-module based on the PjBl model with the help of Google Sites.

The results of previous research on the development of Google Site-based e-modules have been widely studied. For example, Rahman *et al.* [22] highlighted that the development of Google Sites-assisted teaching materials is used as a learning resource and a learning medium, incorporating model syntax that motivates student engagement with materials tailored to 21st-century learning. Additionally, Parmar *et al.* [14] emphasized that web-based learning modules significantly enhance student learning experiences. Furthermore, Mutanga [8] concluded that Google Site-based teaching materials improve critical thinking skills. Similarly, Jusriati *et al.* [23] affirmed that implementing Google Sites in e-learning boosts students' abilities. On the other hand, PjBL is an approach that centers students in the learning process, allowing them to apply acquired knowledge in real-world contexts [24]. PjBL aims to create meaningful learning experiences that help students develop skills and knowledge through project planning, execution, and evaluation, ultimately enhancing their critical thinking abilities [25].

However, this research differentiates itself by integrating PjBL with Google Sites to develop an e-module specifically for teaching physics history. Unlike previous research, which has primarily focused on general or subject-neutral e-modules, this approach tailors both the learning model and digital platform to suit the unique needs of history in physics education. By combining PjBL with Google Sites, this research offers a more interactive and engaging learning experience that enhances content delivery and fosters deeper student involvement and creativity. This integration allows for a more hands-on and contextual understanding of physics history, setting it apart from other e-learning models that do not integrate project-based methodologies or Google Sites' interactive capabilities. While many studies focus on web-based modules or PjBL, this research uniquely combines PjBL with Google Sites to develop an e-module specifically for teaching physics history. This combination provides a more interactive and contextual learning experience, separating it from previous research focusing on general e-modules or digital learning platforms. [26] Physics history is traditionally taught through methods like lectures and assignments, which focus more on memorizing facts than developing critical thinking skills

Recent studies have demonstrated significant advances in web-based learning and e-module development. Google Sites-assisted teaching materials serve dual purposes as learning resources and media, particularly when incorporating model syntax that enhances student motivation [12]. The effectiveness of web-based learning modules in improving student learning experiences [14]. In a related study, Google Sites-based teaching materials effectively enhance students' critical thinking abilities [14]. Supporting these findings, Jusriati confirmed that Google Sites implementation in e-learning improves student capabilities. In the context of PjBL, Zhang *et al.* [24] emphasized that PjBL centers learning on students and facilitates knowledge transfer into practical learning applications. Sevtia *et al.* [16] highlighted PjBL's role in creating meaningful learning experiences, enabling students to develop skills through project planning, scheduling, executing, and evaluating processes. This existing research landscape provides a strong foundation for integrating PjBL with Google Sites-based e-modules, particularly in physics history education, where traditional teaching methods have predominated. The current study builds upon these findings by uniquely combining PjBL methodology with digital platform capabilities, addressing the need for more engaging and interactive learning experiences in physics history education.

2. METHOD

This research adopted the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) as a development research method consisting of five stages. In the Analysis stage, the needs and specifications for the e-module were identified, including audience analysis and the learning objectives to be achieved. This process ensured that the developed e-module aligned with the learning needs and students' context. The Design stage focused on creating a detailed plan for the e-module, which included developing a prototype, selecting learning materials, and designing a user-friendly interface that was easily accessible to students. During the Development stage, the e-module prototype was created based on the design. This included the development of digital content, interactivity features, and supporting elements necessary to facilitate PjBL. In the Implementation stage, the e-module was tested with a small group of students to assess its effectiveness in supporting physics learning. This phase aimed to identify the strengths and weaknesses of the e-module based on student feedback. The Evaluation stage involved assessing the effectiveness and feasibility of the e-module after the trial. The evaluation covered various aspects, such as usability, content relevance, and the impact on students' understanding of physics concepts. After receiving ethics approval, the research was conducted. A flowchart illustrating the stages of the ADDIE model is provided below to offer a clear overview of the research process. This structured approach ensured that each phase contributed meaningfully to the development of a high-quality educational product.

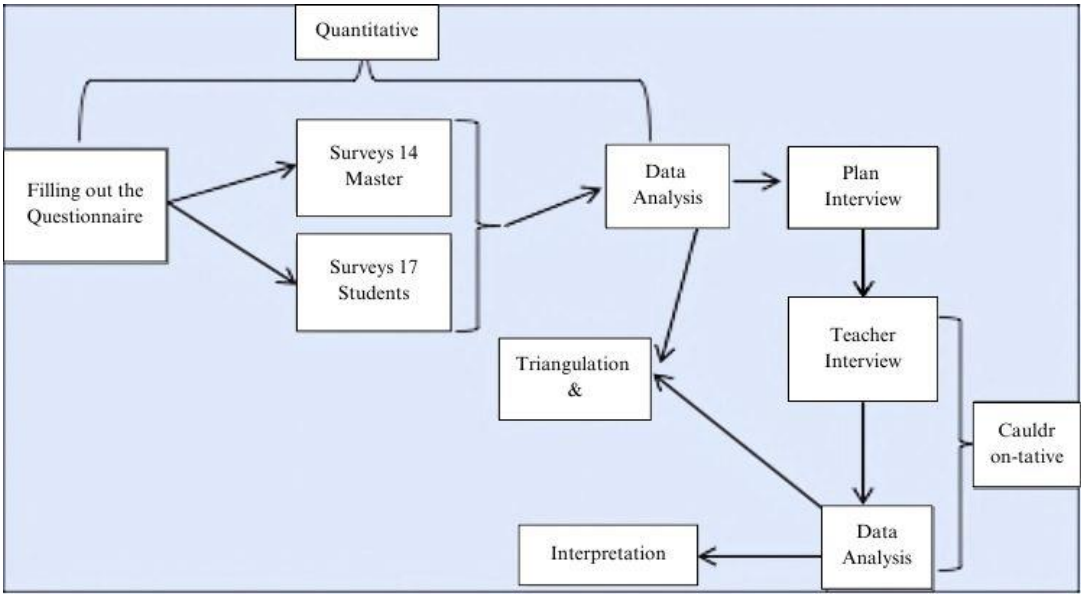

Figure 1. A Flowchart Illustrating the Stages in the ADDIE Model

Three expert validators with educational technology and physics education backgrounds assessed the module to validate the product. Their qualifications ensured the validity of the research process. After receiving feedback from the experts, the product was revised accordingly. The module was then tested with a sample of 10 second-semester students.

The sample in this research consisted of 10 second-semester students from the Physics Education Program at Universitas Khairun, selected through purposive sampling. This method was used to select students with relevant experience in basic physics courses, allowing them to provide constructive feedback on the developed e-module. After obtaining consent from the students, the research was conducted.

In addition to validation sheets from expert validators, several other instruments were used in this research. Observations were conducted to assess the level of student engagement while using the e-module. Interviews were carried out with students to gather in-depth insights into their experiences with the e-module. Students also completed questionnaires to evaluate the ease of use and quality of the e-module content. The validation results were analyzed using a percentage formula:

$$\overline{X} = \frac{\sum X}{n}\ x\ 100\ \% \qquad (1)$$

The validation results from the experts were analyzed using a percentage formula to determine the feasibility of the e-module. If the average validation score reached 80% or higher, the e-module was considered feasible. If the score was below 80%, revisions were made, and it was retested. The validation results were categorized into feasibility levels: highly feasible (≥90%), feasible (80%-89%), and requiring improvement (<80%). Revisions were conducted iteratively based on the feedback received after each round of validation. The feedback from validators was used to improve the e-module, and after all feedback was gathered, a final evaluation was conducted to ensure the module's feasibility and effectiveness.

This research employed a development research design based on the ADDIE model, focusing on creating and evaluating a Google Sites-based e-module integrating the PjBL model. The study involved students as participants, who served as the subjects for the e-module trials. The population in this research consisted of students from the Physics Education Program at Universitas Khairun. The sample was selected using purposive sampling to choose students with relevant experience in basic physics courses. The instruments used included validation sheets, questionnaires, interviews, and observations.

The study was conducted in four main stages: analysis and design (first month), e-module prototype development (second month), trial implementation (third month), and evaluation and revision of the e-module (fourth month). The data from the validation results and trials were analyzed using descriptive methods with percentages to measure the e-module's feasibility. Statistical tests were also performed to compare students' understanding before and after using the e-module.

3. RESULTS AND DISCUSSION

The initial stage in developing the physics history e-module, based on the PjBL model and supported by Google Sites, began with analyzing the second-semester lecture plan. This analysis focused on the history of physics courses to identify aspects that could be transformed into project-based assignments for students. It was found that the previously used model combined PjBL and the case method. However, student projects were limited to assignments in which they analyzed videos on the development of optics and electricity and presented their findings in written papers. This approach resulted in a passive learning experience, as students were not actively searching for learning resources or undertaking challenging tasks.

This research aimed to develop a physics history e-module based on the PjBL model, incorporating Google Sites, and to assess its feasibility through validation and practicality tests [27]. During the planning stage, various references were collected to design the e-module. These included PDF texts, quizzes created with Quizizz, videos related to optics and electricity concepts, and virtual labs to support experiments. The design addressed previously identified needs, particularly enhancing student engagement and supporting more meaningful project-based assignments.

The development of the e-module integrated relevant concepts interactively, fulfilling the goal of encouraging students to engage more actively in project work [28]. This aligned with findings from previous research by Resmanti *et al.* [29] and Andanawarih *et al.* [30], highlighting that PjBL-based e-modules support independent learning inside and outside the classroom. The e-module encouraged students to explore concepts and apply them in project-based assignments by enabling flexible access to materials.

During the development phase, validation results indicated that the e-module was highly feasible, receiving an average rating of 85.13%. The material/concept validator assessed the e-module as suitable for implementation, awarding a rating of 80.4%. These findings were consistent with research by Yulkifli *et al.* [3], which suggested that well-designed e-modules enhance student knowledge and stimulate creativity, particularly in understanding the role of physics in technological advancements. Integrating technology with learning models was shown to develop students' skills and promote active learning. Similarly, Rahman *et al.* [22] concluded that Google Site-assisted teaching materials significantly enhance students' critical thinking skills. This was attributed to the engaging nature of Google Site-based e-modules, which reduce boredom, make learning more interesting, improve material comprehension, and help lecturers deliver concepts more effectively. These findings underscore the importance of using innovative digital platforms to create meaningful and effective learning experiences.

From a media perspective, validators also rated the Google Sites-based e-module as highly feasible, assigning a score of 85%. Several recommendations for improvement were provided, including simplifying Google Site links and ensuring that all images and videos included proper source attribution. These findings reinforced the idea that Google Sites offer an accessible and flexible learning platform, allowing students to study anytime and anywhere, thereby promoting independent learning. Beyond serving as a learning resource, Google Sites also functioned as an instructional medium, guiding students through structured project completion aligned with the learning model's syntax. Regarding grammar and readability, the language validator rated the e-module as highly feasible, with a score of 90%. However, a few revisions were suggested, such as increasing font sizes for better readability on mobile devices and ensuring proper capitalization in headings (e.g., "Figures and Discoveries" instead of "figures and inventions").

These findings aligned with research by Yanti and Novaliyosi [21], which demonstrated the effectiveness of Google Site-based learning media in enhancing learning quality and critical thinking skills. Similarly, research by Jusriati *et al.* [23] supported the idea that Google Sites improves students' interest in and comprehension of physics concepts. Moreover, Bukhori *et al.* [31] highlighted the negative impact of smartphone addiction on textbook reading habits, emphasizing the importance of using smartphones wisely for academic purposes, such as accessing course materials. Further studies by Amamou and Cheniti-Belcadhi [32] concluded that PjBL-based e-modules can enhance students' critical thinking and learning flexibility. Ilmi *et al.* [33] also emphasized that well-developed e-modules improve student understanding and engagement.

Overall, the findings indicated that the developed e-module enhanced student comprehension and fostered creativity and motivation—key elements in developing higher-order thinking skills, self-inquiry activities, and collaborative problem-solving. This aligned with Andanawarih *et al.* [30], who stated that PjBL-based e-modules effectively promote critical thinking and learning motivation. A summary of the feasibility test results for the developed physics teaching materials is presented in Table 1.

Table 1. Data on the Results of Assessments by Experts

Assessment Aspects	Average Rating	Category
Substance	93%	Highly Feasible
Construction	91,33 %	Highly Feasible
Practicability	98,33 %	Highly Feasible
Linguistics	87 %	Highly Feasible

The assessment results were then used as a basis for revising the e-module. This revision aimed to produce a quality product that meets the needs of both lecturers and students. Table 2 contains some suggestions from the validator team regarding the developed e-module.

Table 2. Suggestions from the Validator Team

Assessment Aspects	Suggestions
Graphics Aspects	The size of the Google Site-assisted e-module *needs* to be enlarged. The design of the e-module cover needs to be made more attractive by displaying images according to the concept. The color design of the module content must be made that is not monotonous.

Eligibility Aspects of content and presentation	Google Site links need to be made simpler. The material/concept needs to be adjusted to the development of physical theories related to the concept. The accuracy of the material needs to be considered, especially related to the examples presented. The presentation technique in the e-module must use simple and easy-to-understand language.
Language aspects	Pay attention to the writing, and it needs to be considered. Images and videos need to be sourced. The characters of the letters need to be enlarged so that students can easily read them on mobile phones. Capital letters need to be considered for their use.

The product, which had undergone the development and validation process by the validator team, was then revised based on the feedback received. This revision aimed to produce a high-quality final product. Additionally, the revision of the e-module was intended to enhance product quality, meet user needs by supporting students in the learning process, and improve learning effectiveness. The goal was for the revised e-module to optimize the PjBL model, provide a better learning experience, and facilitate active engagement and learning.

The next stage in the development process was implementation, which involved a limited trial with 10 students. The results of the student response test to the e-module, on average, are presented in Figure 2.

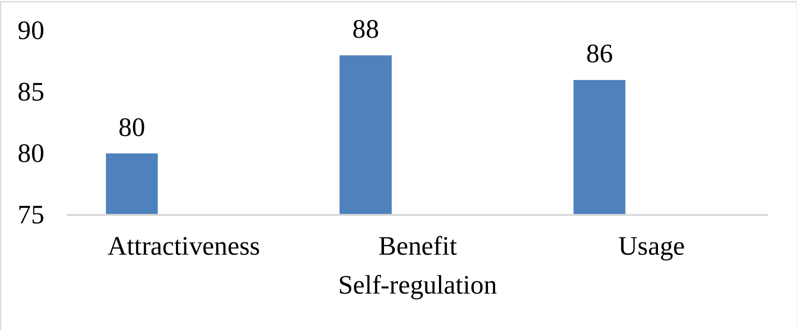

Figure 2. Student Response to the History of Physics E-Module

Based on data analysis, it was concluded that the average student response to the developed e-module fell into the "highly feasible" category. This indicates that the e-module, which integrates the PjBL model with Google Sites, is easy to understand, engaging for individual and group use, and effectively motivates students during the learning process. These findings align with the views of Fadhilah and Thahir [28], who stated that digital e-modules offer advantages in terms of interactivity, flexibility, and visual appeal. Similarly, Maryanti *et al.* [34] and Nursamsu *et al.* [35] emphasized that e-modules designed with the PjBL model can significantly enhance students' creative thinking by guiding them through problem-solving steps—from addressing fundamental questions and designing projects to evaluating completed tasks.

Integrating virtual laboratories within PjBL-based e-modules has proven highly beneficial in developing students' process skills. Research findings also support that PjBL-based e-modules are particularly effective in improving creative thinking skills and learning motivation [36]. Beyond fostering conceptual understanding, the development of these e-modules plays a crucial role in creating engaging learning experiences that enhance students' creativity, motivation, and higher-order thinking skills while promoting self-inquiry and collaborative problem-solving [37].

Technology integration into education is becoming increasingly prevalent, with e-modules emerging as a valuable tool for enhancing learning. Implementing e-modules plays a crucial role in creating an engaging learning experience that not only deepens students' understanding of concepts but also fosters creativity and motivation—both essential for developing higher-order thinking skills [38], [39]. When combined with PjBL, interactive e-modules significantly enhance learning motivation and stimulate creative thinking by promoting self-inquiry and collaborative problem-solving. Through PjBL, students develop teamwork and communication skills, vital for academic and professional success [40], [41]. Zhang and Ma [42] found that integrating PjBL into e-modules fosters a sense of ownership in students over their learning process while encouraging an innovation-driven and problem-solving mindset. Additionally, the emphasis on active participation and integrating guiding questions within the PjBL framework create a dynamic learning environment where students can explore and express creative ideas.

Despite these promising outcomes, several limitations must be acknowledged. The study’s limited sample size and the short-term implementation of the e-module may affect the generalizability of the findings. Future research should explore the long-term impact of PjBL-based e-modules on students' conceptual understanding and critical thinking skills. Moreover, the findings highlight important implications for physics education, emphasizing the need for educators to incorporate project-based digital learning resources to enhance student engagement and learning outcomes. Future studies could also focus on expanding the application of e-modules across diverse educational settings and integrating advanced interactive features to further optimize the learning experience.

4. CONCLUSION

Based on the research findings and discussion, it can be concluded that the development of a physics history e-module incorporating the PjBL learning model supported by Google Sites was validated as highly feasible for use in physics history lectures, receiving an average expert rating of 90.42%. Student response analysis from the trial class also indicated highly positive feedback, with 92% of students finding the e-module engaging, 94% stating it was beneficial for their learning, and 91% reporting ease of use.

These results demonstrate that the developed e-module is effective and practical for students in physics history courses. Additionally, this research underscores the importance of integrating digital learning tools into PjBL to enhance student engagement, critical thinking, and independent learning. Future studies could explore broader implementation and further refinements to maximize its impact on physics education. This research also has significant implications for developing Google Sites-based PjBL e-modules to improve student engagement and comprehension in physics history courses.

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AUTHOR CONTRIBUTION STATEMENT

MHR contributed to the article's writing, research methods analysis, data collection and processing, data analysis implementation, and results preparation and discussion sections. FH contributed to the article's writing, research methods analysis, data collection and processing, data analysis implementation, and results preparation and discussion sections. VV contributed by providing direction and guidance in topic development, assisting in writing and editing, and providing input on relevant references and literature. HHI contributed by providing direction and guidance in topic development and assisting in writing and editing. AI contributed to providing direction and guidance in topic development and assisting in writing and editing. MP contributed to providing direction and guidance in topic development and assisting in writing and editing.

REFERENCES

[1] W. M. B. B. Sinaga and A. Firmansyah, "Changes in educational paradigms in the digital era," *J. Teknol. Pendidik.*, vol. 1, no. 4, pp. 1-10, 2024, doi: 10.47134/jtp.v1i4.492.

[2] N. Purba, M. Yahya, and N. Nurbaiti, "Industrial revolution 4.0: the role of technology in the existence of business mastery and its implementation," *J. perilaku dan Strateg. bisnis*, vol. 9, no. 2, pp. 91–98, 2021, doi: 10.26486/jpsb.v9i2.2103.

[3] Y. Yulkifli, Y. Yohandri, and H. Azis, "Development of physics e-module based on integrated project-based learning model with ethno-STEM approach on smartphones for senior high school students," *Momentum Phys. Educ. J.*, vol. 6, no. 1, pp. 93–103, 2022, doi: 10.21067/mpej.v6i1.6316.

[4] H. Ma'azer Al Fawareh and S. Jusoh, "The use and effects of smartphones in higher education," *Ijim*, vol. 11, no. 6, pp. 103–111, 2017, doi: 10.3991/ijim.v11i6.7453.

[5] A. Aziza and K. Baroroh, "Development of Google Sites-based social science learning media to increase students' critical thinking ability," *Int. J. Multidiscip. Res. Anal.*, vol. 7, no. 05, pp. 1919-1923, 2024, doi: 10.47191/ijmra/v7-i05-12.

[6] T. K. F. Chiu, "Digital support for student engagement in blended learning based on self-determination theory," *Comput. Human Behav.*, vol. 124, no. 1, pp. 1–10, 2021, doi: 0.1016/j.chb.2021.106909.

[7] B. M. S. Efendi and N. Insani, "Implementation of e-modules assisted by Google Sites with the pbl model in social sciences learning to increase student interest and learning outcomes,," *J. Ris. dan Inov. Pembelajaran*, vol. 4, no. 1, pp. 402–416, 2024, doi: doi.org/10.51574/jrip.v4i1.1406.

[8] M. B. Mutanga, "Students' perspectives and experiences in project-based learning: a qualitative study," *Trends High. Educ.*, vol. 3, no. 4, pp. 903–911, 2024, doi: 10.3390/higheredu3040052.

[9] F. Musa'ad, R. E. Ahmad, S. Sundari, and H. Hidayani, "Project based learning to improve students' critical thinking abilities," *J. Cendekia J. Pendidik. Mat.*, vol. 8, no. 2, pp. 1481–1487, 2024, doi: 10.31004/cendekia.v8i2.3361.

[10] A. Hartoyo and R. I. Budiana, "Increasing students' collaboration ability in mathematics subjects using the class v project based learning model at sd negeri 19 southeast pontianak," *Didakt. J. Ilm. PGSD STKIP Subang*, vol. 9, no. 4, pp. 2384–2396, 2023, doi: 10.36989/didaktik.v9i04.1822.

[11] R. Amaliya and K. Kubro, "Active learning strategies (PjBL) to increase student engagement in elementary schools," *J. Ilm. Res. Student*, vol. 2, no. 1, pp. 223–235, 2025, doi: 10.61722/jirs.v2i1.3639.

[12] A. Zaida Ilma, E. Utami, and D. A. Kusumaningtyas, "STEM-project based learning in physics concept of measurement to enhance high school students' scientific literacy," *J. Penelit. Pengemb. Pendidik. Fis.*, vol. 10, no. 2, pp. 273–

284, 2024, doi: 10.21009/1.10206.

[13] I. E. Pertiwi and P. Purnawarman, "Google Sites as an e-learning module for online learning: a mode of choice during the covid-19 pandemic," *Proj. (Professional J. English Educ.*, vol. 6, no. 1, pp. 187–200, 2023, doi: 10.22460/project.v6i1.p187-200.

[14] P. Parmar, S. Patond, G. Rathod, and S. Ninave, "Google Site as a tool for teaching undergraduate students in forensic medicine," *Indian J. Forensic Med. Toxicol.*, vol. 14, no. 4, pp. 427–431, 2020, doi: 10.37506/ijfmt.v14i4.11512.

[15] C. Meldiana and D. Nurhamidah, "The effectiveness of Google Sites media in learning indonesian for class VII middle school," *Deiksis J. Pendidik. Bhs. Dan Sastra Indones.*, vol. 10, no. 1, pp. 1–15, 2023, doi: 10.33603/8h069526.

[16] A. F. Sevtia, M. Taufik, and A. Doyan, "Development of physics learning media based on Google Sites to improve high school students' concept mastery and critical thinking abilities," *J. Ilm. Profesi Pendidik.*, vol. 7, no. 3, pp. 1167–1173, 2022, doi: 10.29303/jipp.v7i3.743.

[17] M. Pedaste *et al.*, "Phases of inquiry-based learning: definitions and the inquiry cycle," *Educ. Res. Rev.*, 2015, pp. 47–61, doi: 10.1016/j.edurev.2015.02.003.

[18] F. Novelia and R. Raihanati, "Development of physics e-modules using a science, technology, engineering, mathematical (STEM) approach based on project based learning," *Proc. 2022 SNF Natl. Phys. Semin. (E-Journal)*, vol. 1, no, 1, 2022, pp. 51–56, doi: 10.21009/03.SNF2022.02.PF.08.

[19] M. H. Rahman *et al.*, "Implementation of the physics history learning e-module using Google Site with a project based learning model for physics students," *Educ. J.*, vol. 22, no. 2, pp. 849–858, 2024.

[20] Satriani, Khaeruddin, and P. Palloan, "Hubungan pemahaman konsep dengan keterampilan berpikir kritis pada pembelajaran fisika," *J. Sains dan Pendidik. Fis.*, vol. 20, no. 3, pp. 249–259, 2024, doi: 10.35580/jspf.v20i3.5296.

[21] R. A. Yanti and N. Novaliyosi, "Systematic literature review: model pembelajaran project based learning (PjBL) terhadap skill yang dikembangkan dalam tingkatan satuan pendidikan," *J. Cendekia J. Pendidik. Mat.*, vol. 7, no. 3, pp. 2191–2207, 2023, doi: 10.31004/cendekia.v7i3.2463.

[22] M. H. Rahman, S. Saprudin, N. Nana, and N. Adam, "Development of physics teaching materials based on the prediction, observation, explanation, elaboration, writing, and evaluation (POE2WE) learning model assisted by Google Site," in *KnE Soc. Sci.*, 2024, pp. 459–471, doi: 10.18502/kss.v9i19.16534.

[23] J. Jusriati, N. Nasriandi, W. Kurniadi, and R. Ratna, "The implementation of Google Site as e-learning platform for teaching EFL during covid-19 pandemic," *English Rev. J. English Educ.*, vol. 10, no. 1, pp. 129–138, 2021, doi: 10.25134/erjee.v10i1.5363.

[24] Z. Zhang, C. T. Hansen, and M. A. E. Andersen, "Teaching power electronics with a design-oriented, project-based learning method at the technical university of denmark," *IEEE Trans. Educ.*, vol. 59, no. 1, pp. 32–38, 2015, doi: 10.1109/TE.2015.2426674.

[25] A. C. Kean and N. M. Kwe, "Meaningful learning in the teaching of culture: the project based learning approach.," *J. Educ. Train. Stud.*, vol. 2, no. 2, pp. 189–197, 2014, doi: 10.11114/jets.v2i2.270.

[26] H. Firmansyah, "Analysis of the application of the inquiry learning approach in improving critical thinking skills in history subjects," *Innov. J. Soc. Sci. Res.*, vol. 4, no. 3, pp. 7832–7842, 2024, doi: 10.31004/innovative.v4i3.11189.

[27] M. A. Setiawan, S. Sriadhi, and S. Silaban, "Development E-LKPD based guided inquiry using Google Sites for elementary school students," *in Proc. 9th Annu. Int. Semin. Transform. Educ. Educ. Leadership, AISTEEL 2024*, Medan, North Sumatera Prov., Indonesia., 2024, pp. 1-8.
[28] N. Fadhilah and R. Thahir, "Development of an electronic module with project based learning," *Bioeduscience*, vol. 7, no. 3, pp. 350–357, 2023, doi: 10.22236/jbes/11817.
[29] P. Resmanti, A. Faridah, Y. Yusmerita, and Y. Hendriyani, "Development of the e-module with project-based learning for the flat pattern design course," *J. Innov. Educ. Cult. Res.*, vol. 5, no. 3, pp. 408–416, 2024, doi: 10.46843/jiecr.v5i3.1505.
[30] M. Andanawarih, S. Diana, and A. Amprasto, "The implementation of authentic assessment through project-based learning to improve student's problem solving ability and concept mastery of environmental pollution topic," in *Journal of Physics: Conference Series*. *IOP Publishing*, 2019, pp. 1-6, doi: 10.1088/1742-6596/1157/2/022116.
[31] B. Bukhori, H. Said, T. Wijaya, and F. M. Nor, "The effect of smartphone addiction, achievement motivation, and textbook reading intensity on students' academic achievement," *Int. J. Interact. Mob. Technol.*, vol. 13, no. 9, pp. 66–80, 2019, doi: 10.3991/ijim.v13i09.9566.
[32] S. Amamou and L. Cheniti-Belcadhi, "Tutoring in project-based learning," *Procedia Comput. Sci.*, 2018, pp. 176–185, doi: 10.1016/j.procs.2018.07.221.
[33] R. Ilmi, I. M. Arnawa, and N. N. Bakar, "Development of an android-based for math e-module by using adobe flash professional CS6 for grade x students of senior high school," in *Journal of Physics: Conference Series*, vol. 1742, no. 1, pp. 1-7, 2021, doi: 10.1088/1742-6596/1742/1/012026.
[34] E. Maryanti, T. Suminar, and Ellianawati, "Development of ethno-STEM e-module with project based learning model based on yogyakarta local wisdom to improve student's creative thinking abilities," *Int. J. Res. Rev.*, vol. 10, no. 10, pp. 105–114, 2023, doi: 10.52403/ijrr.20231014.
[35] N. Nursamsu, S. R. Mahyuny, R. Nafaida, and S. Rezeqi, "Development of e-book based instructional design PjBL model integrated science literacy to improve critical thinking abilit," *J. Penelit. Pendidik. IPA*, vol. 9, no. 9, pp. 6896–6903, 2023, doi: 10.29303/jppipa.v9i9.4948.
[36] N. R. Millen and S. Supahar, "The effectivity study: implementation of the physics e-module with pjbl-stem model to describe students' creative thinking skills and learning motivation profile," *J. Sci. Educ. Res.*, vol. 7, no. 2, pp. 106–113, 2023, 10.21831/jser.v7i2.62131.
[37] Y. D. A. Sagala, M. P. Simanjuntak, N. Bukit, and M. Motlan, "Application of project based learning based of worksheet to student™ s critical thinking skills," *J. Pendidik. Fis.*, vol. 8, no. 2, pp. 85–90, 2019, doi: 10.23887/tscj.v6i2.66763.
[38] T. Mutia, Y. Suharto, A. Sahrina, A. Wahyudi, M. A. R. Atmaja, and R. Aprilia, "Efektivitas e-modul interaktif berbasis project based learning terhadap kemampuan berfikir kreatif siswa," *Geodika J. Kaji. Ilmu dan Pendidik. Geogr.*, vol. 9, no. 1, pp. 42–51, 2025, doi: 10.29408/geodika.v9i1.28193.
[39] S. A. Rahman, "The development of mathematics e-modules by using flip pdf professional software on algebraic forms of material," *Annu. Int. Conf. Islam. Educ. Students*, vol. 1, no. 1, pp. 460–469, 2022, doi: 10.18326/aicoies.v1i1.264.
[40] C. Ismaniati and B. Iskhamdhanah, "Development of interactive e-modules to increase learning motivation and science literacy in elementary school students,"

J. Iqra' Kaji. Ilmu Pendidik., vol. 8, no. 1, pp. 156–173, 2023, doi: 10.25217/ji.v8i1.2699.

[41] L. Zhang and Y. Ma, "A study of the impact of project-based learning on student learning effects: a meta-analysis study," *Front. Psychol.*, 2023, pp. 1–14, doi: 10.3389/fpsyg.2023.1202728.

[42] S.-J. Lou, C.-C. Chung, W.-Y. Dzan, and R.-C. Shih, "Construction of a creative instructional design model using blended, project-based learning for college students," *Creat. Educ.*, vol. 3, no. 07, pp. 1281–1290, 2012, doi: 10.4236/ce.2012.37187.