



Lumi Education-Assisted Problem-Based Mathematics Modules to Foster Students' Mathematical Problem-Solving and Scientific Reasoning

Erlan Juarsa^{1*}, Elita Zusti Jamaan¹

¹ Universitas Negeri Padang, Padang, Indonesia

Received: December 24, 2025

Revised: January 21, 2026

Accepted: February 25, 2026

Published: February 28, 2026

Corresponding Author:

Erlan Juarsa

erlanjuarsa313500@gmail.com

DOI: [10.29303/jppipa.v12i2.14386](https://doi.org/10.29303/jppipa.v12i2.14386)

 Open Access

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



Abstract: This research aimed to develop mathematics teaching modules based on Problem-Based Learning (PBL) with Lumi Education assistance to enhance students' mathematical problem-solving abilities. The development research employed the Plomp model, consisting of preliminary investigation, prototyping, and assessment phases. Data collection utilized interviews, questionnaires, checklists, and mathematical problem-solving ability tests. The resulting teaching module and student worksheets demonstrated excellent validity with validity scores of 3.64 and 3.62, respectively, across content feasibility, presentation, graphic, and language aspects. Practicality assessment revealed 91% student response during small group evaluation and 85.36% during field testing, both rated as highly practical. Additionally, educator responses reached 93% practicality rating. The module proved effective with an average percentage of 71.87% in enhancing students' mathematical problem-solving abilities. This research concludes that the PBL-based teaching module assisted by Lumi Education for matrix material is valid, practical, and effective for improving mathematical problem-solving skills among vocational high school students.

Keywords: Lumi Education Mathematical; Problem-Based Learning; Problem-Solving Teaching Modules; Scientific Reasoning

Introduction

Literacy numeracy problem-solving has long been recognized as a fundamental skill that enables students to develop ideas and strategies for constructing knowledge across various disciplines (Alashwal & Barham, 2025; Ceballos et al., 2025; Liu et al., 2025). As one of mathematics' most essential competencies, problem-solving ability empowers learners not only to address mathematical challenges but also to navigate complex real-world situations effectively (Atkins et al., 2025; Czocher et al., 2025; Rincón et al., 2025). Despite its critical importance, students' mathematical problem-solving abilities remain consistently low across Indonesian secondary education, as evidenced by recent PISA results where Indonesian students scored significantly below the international average (Alashwal & Barham, 2025; Amalina & Vidákovich, 2023;

Suherman & Vidákovich, 2025). This performance gap is particularly concerning given that mathematics problem-solving questions form a substantial portion of international assessments and are increasingly emphasized in national educational standards (Alashwal & Barham, 2025; Braeken et al., 2025; Natale et al., 2025).

The persistent challenges in developing students' problem-solving skills can be attributed to several factors (Ceballos et al., 2025; Luo et al., 2025; Oo et al., 2025). Traditional lecture-based instruction often fails to engage students actively in the learning process, while conventional learning resources typically present mathematics in decontextualized, abstract forms that students struggle to connect with real-life applications. Additionally, classroom environments frequently lack authentic problem scenarios that encourage students to develop and apply mathematical reasoning (Adler &

How to Cite:

Juarsa, E., & Jamaan, E. Z. (2026). Lumi Education-Assisted Problem-Based Mathematics Modules to Foster Students' Mathematical Problem-Solving and Scientific Reasoning. *Jurnal Penelitian Pendidikan IPA*, 12(2), 301-307. <https://doi.org/10.29303/jppipa.v12i2.14386>

Shani, 2025; Ahmed, 2025; Taye, 2025). These limitations are especially pronounced in vocational high schools, where students often require more concrete, contextualized approaches to mathematical concepts that directly relate to their future professions (Berger et al., 2025; Lotz et al., 2025; Weinhandl et al., 2024).

In response to these challenges, there is a compelling need for innovative, technology-enhanced instructional materials that can transform how mathematics is taught and learned (Avci et al., 2025; Candido et al., 2025; Wang & Wang, 2024). Problem-Based Learning (PBL) has emerged as a promising pedagogical approach, particularly for mathematics education, as it engages students with authentic problems that mirror real-world contexts while developing their reasoning abilities (Al-Gerafi et al., 2024; Fredy et al., 2025; Pimdee et al., 2024). When combined with digital technologies that provide interactive, multimedia-rich learning experiences, PBL can potentially overcome many limitations of traditional mathematics instruction. Lumi Education, with its capacity to create interactive, HTML5-based learning content, represents a particularly valuable tool for developing such resources, especially within the flexible framework of Indonesia's Merdeka Curriculum (Lockwood et al., 2022; Pérez-Muñoz et al., 2024; Whelan & Kelly, 2025).

This research aims to address these educational challenges by developing and validating mathematics teaching modules based on Problem-Based Learning principles, enhanced with Lumi Education technology. Specifically, the study focuses on creating modules for matrix material in vocational high schools with electrical engineering specialization, where mathematical applications to electrical systems can provide meaningful contextualization. The development process follows rigorous design research methodology to ensure the modules are valid, practical, and effective in fostering students' mathematical problem-solving abilities. By integrating authentic electrical engineering problems with interactive digital elements through Lumi Education, this research seeks to create learning materials that not only improve students' mathematical competencies but also enhance their scientific reasoning skills within professionally relevant contexts.

Method

Research Design and Procedure

This study employed a Research and Development (R&D) approach using the Plomp model (Plomp, 2013), which consists of three systematic phases: preliminary investigation, prototyping, and assessment. The development research was specifically designed to

create mathematics teaching modules based on Problem-Based Learning (PBL) with Lumi Education assistance.

Participants

The study involved multiple participant groups: one mathematics teacher from an electrical engineering vocational high school; three students for one-to-one evaluation (selected to represent high, medium, and low ability levels); six students for small group evaluation (heterogeneous grouping with two students of each ability level); and one intact class (32 students) for the field test in the electrical engineering program (TKL) at SMKN 7 Batam.

Data Collection Instruments

Multiple instruments were employed to gather comprehensive research data: interview guides for teachers and students during preliminary research and formative evaluations; questionnaires measuring student characteristics, module practicality, and teacher feedback; observation checklists to document implementation fidelity during classroom trials; mathematical problem-solving ability tests with four contextual problems related to electrical engineering applications; and validation instruments for expert assessment of module quality across four dimensions (content feasibility, presentation aspects, graphic aspects, and language aspects)

Data Analysis Techniques

Both qualitative and quantitative analysis methods were employed in this research. Descriptive analysis of interview transcripts, observation notes, and open-ended questionnaire responses was conducted. Thematic coding identified recurring patterns related to implementation challenges and student engagement.

Several specific analytical procedures were applied. Alidity analysis calculated using a Likert scale-based formula where validator scores were averaged, with established criteria.

Table 1. Category validity score by Likert scale

Score	Categories
$1 \leq V < 1.6$	Not Valid
$1.6 \leq V < 2.2$	Less Valid
$2.2 \leq V < 2.8$	Quite Valid
$2.8 \leq V < 3.4$	Valid
$3.4 \leq V \leq 4$	Very Valid

Practicality analysis: Measured using frequency technique with percentage calculations: $P = (R/SM) \times 100\%$ Where P = Practicality value, R = Obtained score, SM = Maximum score Practicality criteria:

Table 2. Category practicality score by Likert scale

Score	Categories
85 ≤ P ≤ 100	Very Practical
75 ≤ P < 85	Practical
60 ≤ P < 75	Quite Practical
55 ≤ P < 60	Less Practical
25 ≤ P < 55	Not Practical

Effectiveness analysis: Determined through: $N = (S/I) \times 100\%$ Where N = Student score, S = Student score, I = Ideal score Percentage of students achieving mastery learning criteria (KKM) The module was considered effective if at least 65% of students achieved mastery learning standards in mathematical problem-solving abilities.

This comprehensive methodological approach ensured rigorous development and validation of the Lumi Education-assisted PBL mathematics modules, providing robust evidence for their quality and impact

on students' mathematical problem-solving abilities and scientific reasoning.

Result and Discussion

The development and validation of the Lumi Education-assisted Problem-Based Learning mathematics modules yielded significant outcomes across validity, practicality, and effectiveness dimensions. The results demonstrate the module's quality and its potential impact on students' mathematical problem-solving abilities.

Validity Assessment Results

The validity evaluation by four expert validators revealed high quality across all assessed dimensions. Table 3 presents the detailed validity scores for both the teaching module and student worksheets.

Table 3. Validity Assessment Results of Learning Module and Worksheets

Assessment Aspect	Teaching Module Score	Student Worksheets Score	Validity Category
Content Feasibility	3.75	3.68	Very Valid
Presentation Aspects	3.58	3.63	Very Valid
Graphic Aspects	3.70	3.59	Very Valid
Language Aspects	3.50	3.58	Very Valid
---	---	---	---
Overall Average	3.64	3.62	Very Valid

The overall validity scores of 3.64 for the teaching module and 3.62 for student worksheets both exceeded the threshold of 3.4, categorizing them as "Very Valid". This indicates that the developed materials met high-quality standards across all evaluated dimensions, with content feasibility receiving the highest ratings due to the authentic electrical engineering contexts integrated throughout the modules.

Practicality Assessment Results

The practicality assessment was conducted during both small group evaluation and field testing phases. Table 4 summarizes the practicality percentages from different stakeholder perspectives.

Table 4. Practicality Assessment Results Across Evaluation Phases

Evaluation Phase	Student Response (%)	Teacher Response (%)	Practicality Category
Small Group Evaluation	91.00	93.00	Very Practical
Field Testing	85.36	93.00	Very Practical

Both evaluation phases demonstrated excellent practicality ratings. The small group evaluation achieved 91% student response and 93% teacher response, while field testing maintained high practicality with 85.36% student response and consistent 93% teacher response. These results indicate that the module was not only theoretically sound but also practically implementable in real classroom settings. The slight decrease in student practicality during field testing (from 91% to 85.36%) can be attributed to the

larger sample size and diverse student characteristics in the actual classroom environment.

Effectiveness Assessment Results

The effectiveness of the module was measured through students' mathematical problem-solving ability tests. Table 5 presents the effectiveness results based on mastery learning criteria.

Table 5. Effectiveness Assessment Results for Mathematical Problem-Solving Abilities

Assessment Criteria	Percentage (%)	Category
Students achieving KKM (≥ 75)	71.87	Effective
Average post-test score	78.42	High
Improvement from pre-test to post-test	35.60	Significant

The module proved effective with 71.87% of students achieving the minimum completeness criteria (KKM) of 75 for mathematical problem-solving abilities. The average post-test score of 78.42 indicated high achievement levels, while the 35.6% improvement from pre-test to post-test demonstrated significant learning gains.

The discussion of these results reveals several important implications. The exceptionally high validity scores (3.64 and 3.62) suggest that the integration of Lumi Education technology with Problem-Based Learning created materials that were both theoretically sound and contextually relevant. This aligns with previous research indicating that technology-enhanced PBL approaches can significantly improve instructional material quality when properly designed. The validity scores exceeded typical thresholds reported in similar studies, suggesting that the systematic development process using the Plomp model contributed to superior material quality.

The practicality results demonstrate that the module was well-received by both teachers and students in real classroom settings. The consistently high teacher practicality rating (93%) across both evaluation phases indicates strong educator acceptance, which is crucial for successful implementation. Teachers particularly valued the time efficiency of the module and its alignment with the Merdeka Curriculum's flexibility requirements. The student practicality ratings, while slightly lower during field testing, remained in the "Very Practical" category, suggesting that the interactive elements created with Lumi Education successfully engaged students despite initial concerns about technology adaptation in vocational settings.

The effectiveness results (71.87% mastery) are particularly significant given the historically low mathematical problem-solving performance in Indonesian vocational schools. This improvement surpasses the minimum effectiveness criterion of 65% and demonstrates that contextualized, technology-enhanced PBL can substantially improve student outcomes. The 35.6% improvement from pre-test to post-test suggests that the authentic electrical engineering problems provided meaningful contexts that helped students develop transferable problem-solving strategies (Alashwal & Barham, 2025).

Several factors contributed to these positive outcomes. First, the authentic electrical engineering

contexts made abstract matrix concepts tangible and relevant for vocational students. Second, the interactive elements created with Lumi Education provided multiple representations of mathematical concepts, catering to diverse learning styles. Third, the PBL structure encouraged collaborative problem-solving and scientific reasoning, developing both mathematical and professional competencies simultaneously (Menz & Huff, 2025; Sayed & Pesambili, 2026).

The findings have important implications for mathematics education in vocational schools (Habibi et al., 2019). They demonstrate that well-designed technology-enhanced materials can overcome traditional barriers to mathematical engagement in non-academic student populations. However, the slight decrease in practicality during field testing suggests that technology integration requires careful scaffolding, particularly in resource-constrained educational settings. Future implementations should include more comprehensive teacher training and gradual technology introduction to maintain high engagement levels.

These results also contribute to the broader discourse on digital transformation in education. The successful integration of Lumi Education demonstrates that interactive HTML5-based tools can enhance traditional PBL approaches without overwhelming teachers or students. This balanced approach to technology integration—where digital tools support rather than replace pedagogical strategies—offers a sustainable model for educational innovation in diverse contexts.

The study's limitations include the single-field test location and relatively small sample size, which may affect generalizability. Future research should expand to multiple schools and different vocational specializations to validate these findings across diverse contexts. Additionally, longitudinal studies are needed to assess the retention of problem-solving skills and their transfer to professional settings.

Conclusion

This research successfully developed and validated mathematics teaching modules based on Problem-Based Learning with Lumi Education assistance, specifically designed for vocational high school students in electrical engineering programs. The findings demonstrate that the developed modules achieved excellent validity

scores of 3.64 for the teaching module and 3.62 for student worksheets, confirming their high quality across content feasibility, presentation, graphic, and language aspects. The practicality assessment revealed consistently high ratings, with 91% student response during small group evaluation, 85.36% during field testing, and 93% educator acceptance, indicating strong usability in real classroom contexts. Most significantly, the module proved effective in enhancing students' mathematical problem-solving abilities, with 71.87% of students achieving mastery learning criteria and demonstrating a 35.6% improvement from pre-test to post-test scores. These results confirm that the integration of Lumi Education technology with Problem-Based Learning principles creates valid, practical, and effective instructional materials for developing mathematical problem-solving skills among vocational students. The authentic electrical engineering contexts combined with interactive digital elements successfully bridged the gap between abstract mathematical concepts and real-world applications, fostering both mathematical competence and scientific reasoning abilities. This research contributes to educational innovation by demonstrating how carefully designed technology-enhanced learning modules can address persistent challenges in mathematics education, particularly in vocational settings where contextual relevance is crucial. The successful implementation provides a replicable model for developing similar modules across different mathematical topics and vocational specializations, supporting the broader transformation of mathematics education toward more engaging and effective learning experiences.

Acknowledgments

Thank you to all parties who have helped in this research so that this article can be published

Author Contributions

All authors contributed to writing this article

Funding

No external funding.

Conflicts of Interest

No conflict interest

References

- Adler, I., & Shani, Y. (2025). Hybrid Human-GenAI cognitive apprenticeship: Encouraging pre-service teachers to implement instructional practices to support students' self-regulated learning. *Teaching and Teacher Education*, *169*, 105268. <https://doi.org/10.1016/j.tate.2025.105268>
- Ahmed, M. K. (2025). Investigating coping strategies for anxiety and speech disorders in classroom presentations: A case study on Bangladeshi tertiary students. *Acta Psychologica*, *261*, 105832. <https://doi.org/10.1016/j.actpsy.2025.105832>
- Al-Gerafi, M. A., Goswami, S. S., Khan, M. A., Naveed, Q. N., Lasisi, A., AlMohimeed, A., & Elaraby, A. (2024). Designing of an effective e-learning website using inter-valued fuzzy hybrid MCDM concept: A pedagogical approach. *Alexandria Engineering Journal*, *97*, 61-87. <https://doi.org/10.1016/j.aej.2024.04.012>
- Alashwal, H. A., & Barham, A. I. (2025). Sustaining problem-based learning: A mixed-methods exploration of its long-term effects on primary students' mathematical problem solving. *Social Sciences & Humanities Open*, *12*, 101717. <https://doi.org/10.1016/j.ssaho.2025.101717>
- Amalina, I. K., & Vidákovich, T. (2023). Development and differences in mathematical problem-solving skills: A cross-sectional study of differences in demographic backgrounds. *Heliyon*, *9*(5), 16366. <https://doi.org/10.1016/j.heliyon.2023.e16366>
- Atkins, R., Brown, K. M., Mudd, S. S., Ghobadi, K., Baker, D. J., & Szanton, S. (2025). Reimagining nursing education: Leveraging competency-based education, artificial intelligence, and simulation for a diverse and practice-ready workforce. *Nursing Outlook*, *73*(6), 102582. <https://doi.org/10.1016/j.outlook.2025.102582>
- Avci, H., Lunn, S. J., & Hazari, Z. (2025). Exploring STEM educators' perspectives on the integration of AI-enabled technologies in teaching and learning. *Computers and Education Open*, *9*, 100304. <https://doi.org/10.1016/j.caeo.2025.100304>
- Berger, C., Angonin, S., & Lafay, A. (2025). Mathematical vocabulary in preschool children: Effects of linguistic and socio-economic factors on the production and comprehension of quantitative and spatial words and concepts. *Journal of Experimental Child Psychology*, *263*, 106416. <https://doi.org/10.1016/j.jecp.2025.106416>
- Braeken, J., Lehre, A.-C., & Marcq, K. (2025). Pearls and perils when interpreting item-specific results from international large-scale educational assessments: The case of the "Nordic" fractions. *Studies in Educational Evaluation*, *88*, 101552. <https://doi.org/10.1016/j.stueduc.2025.101552>
- Candido, V., Cattaneo, A., & Petko, D. (2025). Exploring multimedia principles and learning from errors in augmented reality and video. *Learning and Instruction*, *101*, 102244. <https://doi.org/10.1016/j.learninstruc.2025.102244>
- Ceballos, H., Bogaart, T. va. den, Ginkel, S., Spandaw, J.,

- & Drijvers, P. (2025). How collaborative problem solving promotes higher-order thinking skills: A systematic review of design features and processes. *Thinking Skills and Creativity*, 59, 102001. <https://doi.org/10.1016/j.tsc.2025.102001>
- Czocher, J. A., White, A., Kularajan, S. S., Roan, E., & Baas, A. (2025). Quantizing and visualizing the influence of scaffolding moves on mathematical modeling competencies. *Methods in Psychology*, 13, 100210. <https://doi.org/10.1016/j.metip.2025.100210>
- Fredy, L.-D., Oscar, B., & Ana, V.-S. (2025). Pedagogical mediation with ICT for the development of critical thinking in primary education: A systematic review. *Thinking Skills and Creativity*, 60, 102085. <https://doi.org/10.1016/j.tsc.2025.102085>
- Habibi, M., Chandra, C., & Azima, N. F. (2019). Pengembangan bahan ajar menulis puisi sebagai upaya mewujudkan literasi sastra di sekolah dasar. *Elementary School Journal Pgsd Fip Unimed*, 9(1). <https://doi.org/10.24114/esjpgsd.v9i1.14297>
- Liu, J., Sun, D., Sun, J., Wang, J., & Yu, P. L. H. (2025). Designing a generative AI enabled learning environment for mathematics word problem solving in primary schools: Learning performance, attitudes and interaction. *Computers and Education: Artificial Intelligence*, 9, 100438. <https://doi.org/10.1016/j.caeai.2025.100438>
- Lockwood, B. J., Gustin, J., Verbeck, N., Rossfeld, K., Norton, K., Barrett, T., Potts, R., Towner-Larsen, R., Waterman, B., Radwany, S., & others. (2022). Training to promote empathic communication in graduate medical education: a shared learning intervention in internal medicine and general surgery. *Palliative Medicine Reports*, 3(1), pmr--2021. <https://doi.org/10.1089/pmr.2021.0036>
- Lotz, C., Hawlitschek, P., & Deiglmayr, A. (2025). From aspiration to passion - Investigating the role of career choice motivation and self-concept for teacher enthusiasm in early stages of teacher education. *Teaching and Teacher Education*, 165, 105102. <https://doi.org/10.1016/j.tate.2025.105102>
- Luo, Q., Zhang, S., & Gu, Z. (2025). Development and validation of a game-based assessment tool for abstraction skills in lower primary students. *Thinking Skills and Creativity*, 59, 101955. <https://doi.org/10.1016/j.tsc.2025.101955>
- Menz, M., & Huff, M. (2025). Perception of Human-Robot Relationships: Professional, Communicative, Impersonal and Emotionless. *Computers in Human Behavior: Artificial Humans*, 100226. <https://doi.org/10.1016/j.chbah.2025.100226>
- Natale, L., Fargetta, G., Scrimali, L. R. M., & Battiato, S. (2025). Multi-agent reinforcement learning and variational inequality models for international trade networks under crisis. *Simulation Modelling Practice and Theory*, 146, 103219. <https://doi.org/10.1016/j.simpat.2025.103219>
- Oo, T. Z., Kadyirov, T., Kadyirova, L., & Józsa, K. (2025). Design-based learning in higher education: Its effects on students' motivation, creativity and design skills. *Thinking Skills and Creativity*, 53, 101621. <https://doi.org/10.1016/j.tsc.2024.101621>
- Pérez-Muñoz, S., Castaño Calle, R., Morales Campo, P. T., & Rodríguez-Cayetano, A. (2024). A systematic review of the use and effect of virtual reality, augmented reality and mixed reality in physical education. *Information*, 15(9), 582. <https://doi.org/10.3390/info15090582>
- Pimdee, P., Sukkamart, A., Nantha, C., Kantathanawat, T., & Leekitchwatana, P. (2024). Enhancing Thai student-teacher problem-solving skills and academic achievement through a blended problem-based learning approach in online flipped classrooms. *Heliyon*, 10(7), 29172. <https://doi.org/10.1016/j.heliyon.2024.e29172>
- Plomp, T. (2013). Educational design research: An introduction. *Educational Design Research*, 11-50. Retrieved from <http://www.fi.uu.nl/publicaties/literatuur/educational-design-research-part-a.pdf#page=12>
- Rincón, Y. R., Munárriz, A., & Magreñán Ruiz, A. (2025). Flipped Classroom or flip to foster self-regulation competencies in Mathematics in Economics and Business students. *International Journal of Educational Research*, 130, 102556. <https://doi.org/10.1016/j.ijer.2025.102556>
- Sayed, Y., & Pesambili, J. C. (2026). The world bank's Coach model of teacher professional development: The politics of recognition, regulation, and reframing. *International Journal of Educational Development*, 120, 103481. <https://doi.org/10.1016/j.ijedudev.2025.103481>
- Suherman, S., & Vidákovich, T. (2025). Ethnomathematical test for mathematical creative thinking. *Journal of Creativity*, 35(2), 100099. <https://doi.org/10.1016/j.yjoc.2025.100099>
- Taye, T. (2025). The benefits and challenges of integrating literary texts in English language textbooks in ethiopian grade 12 English language classrooms. *Social Sciences & Humanities Open*, 11, 101545. <https://doi.org/10.1016/j.ssaho.2025.101545>
- Wang, H.-H., & Wang, C.-H. A. (2024). Teaching design students machine learning to enhance motivation for learning computational thinking skills. *Acta*

- Psychologica*, 251, 104619.
<https://doi.org/10.1016/j.actpsy.2024.104619>
- Weinhandl, R., Mayerhofer, M., Houghton, T., Lavicza, Z., Kleinfurber, L. M., Anđić, B., Eichmair, M., & Hohenwarter, M. (2024). Enhancing user-centred educational design: Developing personas of mathematics school students. *Heliyon*, 10(2), 24173.
<https://doi.org/10.1016/j.heliyon.2024.e24173>
- Whelan, J., & Kelly, O. (2025). Towards flourishing: the understanding and experience of the staff in one Irish primary school of Forest School. *Journal of Adventure Education and Outdoor Learning*, 25(4), 1012–1030.
<https://doi.org/10.1080/14729679.2024.2404653>