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Development of a PBL-based differentiated e-module to improve mathematical problem-solving skills of fifth grade elementry school

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Abstract: *This study aimed to develop a differentiated e-module based on the Problem-Based Learning (PBL) model to improve mathematical problem-solving skills among fifth-grade elementary students. The study employed a Research and Development (R&D) approach using the ADDIE model: Analysis, Design, Development, Implementation, and Evaluation. Participants included fifth-grade students and teachers in Blitar. The e-module was validated by material experts, media experts, and practitioners, and tested through small-group (6 students) and large-group (28 students) trials. Data were collected using validation sheets, questionnaires, and pretest–posttest instruments. Results showed high validity, with scores of 89% from material experts and 88% from media experts, while practicality reached 92%, indicating a very practical product. Effectiveness testing revealed improved student performance (mean pretest = 55.40; mean posttest = 80.20), supported by a significant paired t-test result ($p = 0.000 < 0.05$). The e-module effectively supports adaptive, student-centered mathematics learning.*

Keywords*: e-modul; differentiated learning; learning styles; PBL; problem-solving skill*

Introduction

Mathematics learning in elementary school plays an essential role in developing students' logical, critical, and systematic thinking. One of its core competencies is mathematical problem-solving, a higher-order ability that involves understanding information, selecting strategies, and evaluating solutions (Polya, 1973). However, classroom observations show that many students still struggle to solve contextual problems due to traditional, procedural, and teacher-centered learning approaches. This is consistent with findings by Cahyani and Setyawati (2016), who noted that weak problem-solving competence often originates from a lack of varied and adaptive instructional strategies.

In the context of the Merdeka Curriculum, teachers are expected to implement differentiated learning that accommodates differences in students' readiness, interests, and learning profiles, including visual, auditory, and kinesthetic (VAK) styles (Tomlinson, 2001; Marlina, 2019). In practice, many teachers rely on generic teaching materials from the Platform Merdeka Mengajar that do not adequately address variations in students' learning needs, resulting in suboptimal problem-solving development. Hadi et al. (2022) confirmed that differentiated PBL-oriented learning significantly improves students' critical thinking when instructional resources are designed to accommodate diverse learning profiles.

Digital teaching materials, particularly e-modules, have emerged as a promising solution to address these challenges. E-modules provide multimedia integration, interactive navigation, and flexible learning pathways that support independent and self-paced learning (Mahmudah et al., 2022; Kusumastuti et al., 2021). When designed with VAK-aligned elements, e-modules can address diverse learning needs and promote deeper conceptual understanding. When

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designed with VAK-aligned elements, e-modules can address diverse learning needs and promote deeper conceptual understanding. When combined with the Problem-Based Learning (PBL) model, e-modules can effectively guide students through authentic, real-world problem situations, strengthening reasoning, exploration, and metacognitive skills (Ramadanti et al., 2021).

Previous research consistently shows that PBL enhances student engagement, critical thinking, and problem-solving skills in mathematics (Setiawan, 2017; Cahyani & Setyawati, 2016). However, scholars emphasize that PBL becomes more impactful when learning resources accommodate differences in students' readiness, interests, and learning styles (Tomlinson, 2001; Hadi et al., 2022). Differentiated learning ensures that instructional content and tasks are accessible to all learners, enabling students to engage meaningfully according to their VAK profiles. Noorbaiti et al. (2018) demonstrated that VAK-based instruction positively influenced mathematics learning outcomes in middle school students, and Dalila et al. (2022) showed that integrating differentiated approaches within PBL significantly improved cognitive outcomes in high school students. Yet, research specifically integrating differentiated learning with PBL through an e-module for elementary mathematics—particularly fractions—remains limited.

The novelty of the present study lies in its integration of VAK-based differentiated learning with a structured PBL framework within a single digital e-module designed specifically for fifth-grade elementary school students on fraction material. Unlike prior studies that apply PBL or differentiated learning separately, or focus on secondary education contexts (Dalila et al., 2022; Hadi et al., 2022), this study produces an instructional product that simultaneously addresses content accessibility, learning style diversity, and problem-solving development at the elementary level. This contribution fills a critical gap in the existing literature and provides a contextually grounded model for Merdeka Curriculum implementation.

Based on this identified gap, this study aims to develop and examine the feasibility, practicality, and effectiveness of a PBL-based differentiated e-module for fifth grade mathematics (fractions material) to enhance students' mathematical problem-solving skills.

Method

This study employed a Research and Development (R&D) design using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The research subjects consisted of 34 fifth-grade students (6 in the small-group trial and 28 in the large-group trial) and two practitioner teachers at an elementary school in Blitar, East Java. Expert validators included two material experts in mathematics education and two media experts in educational technology. Data were collected using (1) expert validation sheets assessing content accuracy, design quality, and practicality; (2) student and teacher response questionnaires using a Likert-type scale; and (3) pre-test–post-test instruments comprising open-ended problem-solving tasks aligned with PBL stages. Quantitative data from expert validation and user responses were analyzed using descriptive percentages, while pre-test–post-test results were analyzed using the N-Gain formula (Hake, 1998) and confirmed by a paired-samples t-test at $\alpha = 0.05$.

Table 1. Stages of the ADDIE Development Model

Stage	Description
Analysis	Identification of curriculum demands, student needs, and learning style profiles.
Design	Drafting the module structure, flowcharts, storyboard, differentiated activities, and PBL-based learning sequence.
Development	Producing the e-module, integrating multimedia (text, images, videos), and aligning with VAK-based differentiated tasks.
Implementation	Conducting small-group (6 students) and large-group (28 students) trials.
Evaluation	Revising the module and analyzing its effectiveness using the N-Gain test.

Adaptation from: Sugiyono (2020)

The table explains that The ADDIE development process in this study consisted of five stages. The analysis stage focused on identifying curriculum demands, student learning needs, and their learning style profiles to ensure that the product aligned with instructional requirements. In the design stage, the structure of the e-module was outlined through the creation of flowcharts, storyboards, differentiated learning activities, and a sequence of Problem-Based Learning (PBL) steps. The development stage involved producing the e-module by integrating multimedia elements such as text, images, and videos, and ensuring alignment with VAK-based differentiated tasks. During the implementation stage, the module was tested through small-group and large-group trials to examine its practicality and usability (Dalila et al., 2022). Finally, the evaluation stage included revising the e-module based on input from trials and analyzing its effectiveness using the N-Gain test to determine improvements in students' problem-solving skills. Quantitative data from validation and user responses were analyzed using descriptive percentages, while pre-test–post-test results were analyzed using the N-Gain formula.

Results and Discussion

Product Feasibility Based on Expert Validation

Material experts, media experts, and practitioner teachers conducted a comprehensive evaluation of the developed e-module, examining content accuracy, conceptual clarity, alignment with learning objectives, presentation quality, visual design, and interactivity. Material experts confirmed that the module's content was theoretically accurate, well-structured, and appropriate for fifth-grade mathematics, with each activity arranged according to PBL stages to guide students from problem identification to solution formulation.

Table 2. Material Expert Validation Results

No	Assessment Aspects	Assessment Indicators	Score Obtained	Maximum Score
1	Clarity of Information	Suitability of content with CP, indicators, and learning objectives.	12	12
2	Content Eligibility	Material appropriate to students' ability level; covers skills, knowledge, and attitudes; complete and accurate.	12	12
3	Presentation Eligibility	Systematically presented, engaging, easy to understand, aligned with grade 5 characteristics, indicators, and learning objectives.	32	40

No	Assessment Aspects	Assessment Indicators	Score Obtained	Maximum Score
4	Linguistic Eligibility	Sentences easy to understand; writing clearly legible; colors contrast with background.	12	12
	Total Score		**68**	**76**
	Percentage	89%		100%
	Category	Very Valid		
	Overall Criteria	Can be used without revision		

Adaptation from: Putri et al. (2022)

The material validation reached 89%, classifying the e-module as "very valid." This finding reinforces prior studies which established that high-quality digital teaching materials must reflect curriculum demands, conceptual clarity, and structured learning pathways (Putri et al., 2022; Rahayu et al., 2022). The e-module effectively integrates PBL components known to enhance students' critical thinking when presented through step-by-step problem-solving activities (Arta et al., 2020).

Media experts evaluated the module's design and technical quality, assessing layout consistency, navigation flow, typography, and multimedia integration. Table 3 presents the media expert validation results.

Table 3. Media Expert Validation Results

No	Assessment Aspects	Assessment Indicators	Score Obtained	Maximum Score
1	Product Display	Display is attractive and age-appropriate; varied attractive colors.	20	24
2	E-Module Application	Images are relevant to the material; multimedia elements support learning.	50	52
3	Product Usage	Easy to use; easily accessible within the software; not large in size.	28	32
4	E-Module Presentation	Easy to use and access; navigation buttons facilitate use; accessible anywhere and anytime.	8	12
	Total Score		**106**	**120**
	Percentage	88%		
	Category	Very Valid		
	Overall Criteria	Can be used without revision		

The media validation percentage was 88%, also in the "very valid" category. This indicates that the e-module demonstrates strong usability and technical quality, with an engaging layout, accessible navigation, and appropriate multimedia integration elements shown to increase retention and accommodate varied learning preferences (Najuah et al., 2020; Avivah Rofizah et al., 2021). Practitioner teachers confirmed these findings by rating the module as highly practical in real classroom settings. Table 4 presents the practitioner teacher validation results.

Table 4. Practitioner Teacher Practical Validation Results

No	Assessment Aspects	Assessment Indicators	Score Obtained	Maximum Score
1	Suitability	Material aligns with learning outcomes.	8	12
2	Material	Material aligns with indicators.	12	12
3	Material Presentation	Material aligns with learning objectives.	12	12
4	Product Presentation	Material is presented systematically.	12	12
	Total Score		**44**	**48**
	Percentage	92%		
	Category	Very Practical		
	Overall Criteria	Can be used with minor revisions		

The practitioner validation reached 92%, classified as "very practical." Teachers emphasized that the e-module effectively supported differentiated learning by accommodating VAK learning styles, aligning with Tomlinson's (2001) theory of differentiated instruction and findings by Brodersen and Melluzzo (2017). The integrated PBL activities, multimedia explanations, and differentiated task options significantly reduced planning time and facilitated inquiry-based learning, consistent with prior studies showing that well-designed digital modules streamline teacher workload (Trinter et al., 2015; Ningsih et al., 2022). Across all validators, the overall validation placed the e-module in the "very valid" category, confirming its alignment with curriculum requirements, clarity of content, interactive features, and suitability for differentiated PBL instruction (Kristiawan et al., 2020).

Practicality Based on User Responses

Small-group and large-group trials were conducted with students representing diverse VAK learning style profiles. Students consistently reported that the tasks were clear, enjoyable, and supportive of their understanding. Visual learners benefited from diagrams and multimedia elements; auditory learners appreciated guided explanations and discussions; kinesthetic learners were engaged through hands-on and movement-based activities. Table 5 summarizes the student response results.

Table 5. Student Response Questionnaire Results

No	Trial Stage	Positive Response (Yes)	Negative Response (No)
1	Small-Group Trial (6 students)	80%	20%
2	Large-Group Trial (28 students)	91–92%	8–9%

These results with positive ratings ranging from 80% to 92%—confirm strong user acceptance and indicate that students found the module engaging and effective for solving mathematical problems (Sugiyono, 2020). Teachers also rated the e-module as "practical" and "interesting," noting that it significantly reduced lesson preparation time and improved classroom engagement (Perdana & Slameto, 2016). These findings reinforce Tomlinson's (2001)

principle that learning becomes more effective when aligned with students' readiness levels and learning profiles (Marlina, 2019).

Effectiveness in Improving Problem-Solving Skills

Effectiveness was assessed through pretest and posttest scores analyzed with the N-Gain formula and a paired-samples t-test. Table 6 presents the summary of effectiveness test results.

Table 6. Summary of Effectiveness Test Results (N-Gain)

Group	Mean Pretest	Mean Posttest	N-Gain Category
Fifth Grade	55.40	80.20	Moderate–High

The moderate-to-high N-Gain category indicates a significant improvement in students' mathematical problem-solving abilities after using the e-module. The paired t-test yielded a significance value of 0.000 ($p < 0.05$), confirming that the observed improvements were statistically significant and attributable to the e-module intervention (Creswell, 2014). This aligns with Noorbaiti et al. (2018) and Arta et al. (2020), who confirmed that PBL supports higher-order thinking, especially when supported by structured digital materials. The integration of differentiated learning with PBL thus effectively fosters student-centered learning, increases engagement, and enhances mathematical problem-solving competencies (Dalila et al., 2022; Rahmani & Widyasari, 2018).

The results of expert validation indicate that the developed PBL-based differentiated e-module possesses strong feasibility in terms of content accuracy, presentation quality, and technical design. Material experts emphasized that the content was aligned with curriculum standards, conceptually accurate, and supportive of students' problem-solving development. This finding reinforces previous studies stating that high-quality digital teaching materials must reflect curriculum demands, clarity of concepts, and structured learning pathways to be considered valid for instructional use (R.Roro Rastrani Rahada Putri et al., 2022; Rahayu et al., 2022). The e-module also effectively integrates the essential components of the PBL model, which is known to enhance students' critical thinking and reasoning skills when presented through clear, step-by-step problem-solving activities (Arta et al., 2020).

Media expert validation further showed that the e-module demonstrates strong usability and technical quality, supported by an engaging layout, accessible navigation, and appropriate multimedia integration. These elements are critical, as multimedia-rich digital materials have been shown to increase retention, deepen comprehension, and accommodate varied learning preferences (Najuah, N., Lukitoyo, Suhendro, P., & Wirianti, 2020). The validation results, which fell into the "very valid" category, suggest that the e-module is capable of supporting interactive and visually appealing learning experiences. This aligns with the findings of (Avivah Rofizah et al., 2021), who highlighted the importance of clarity, visual consistency, and intuitive navigation in the development of effective interactive learning applications.

Practicality testing conducted with teachers and students revealed that the e-module is not only feasible but also highly practical and engaging. Teachers noted reduced preparation time because the e-module provided complete instructions, multimedia materials, and differentiated activity sets in one integrated platform. This confirms earlier findings that digital modules can simplify instructional planning and support student-centered learning environments (Ningsih et al., 2022). Students also reported that the differentiated activities aligned well with their VAK learning styles, enabling them to engage with mathematical concepts according to their preferred modes of learning. This supports Tomlinson's (2001) assertion that differentiated instruction enhances participation and comprehension by addressing differences in students' readiness and learning profiles. Similar conclusions were also presented by Brodersen and Melluzzo (2017), who emphasized the need for responsive and adaptive instructional materials.

The results of the student response questionnaires, which reached up to 80–92% positive ratings, further validate the practicality and attractiveness of the e-module. These findings suggest strong user acceptance and confirm that students found the module enjoyable and effective in helping them solve mathematical problems. This is consistent with Sugiyono's (2020) interpretation framework for categorizing product practicality based on percentage responses. The high level of student engagement also supports the claim that interactive, differentiated, and technology-based learning environments lead to improved motivation and learning outcomes (Perdana & Slameto, 2016)

Effectiveness testing demonstrated substantial improvements in students' mathematical problem-solving skills, as reflected in N-Gain values within the moderate-to-high category. This indicates that the PBL-based differentiated e-module was successful in promoting higher-order thinking skills, supporting findings from previous studies showing that PBL enhances analytical and reasoning abilities when implemented through structured digital materials (Rahmani & Widyasari, 2018). Furthermore, the paired t-test results, which showed a significant difference with a p-value of $0.000 < 0.005$, confirm that the observed improvements were not coincidental but were indeed due to the implementation of the e-module. This aligns with Creswell's (2014) explanation that statistically significant results indicate meaningful intervention impacts in experimental or quasi-experimental research designs.

Overall, the discussion of these findings demonstrates that the developed e-module is valid, practical, and effective for improving elementary students' problem-solving abilities. The integration of differentiated learning and PBL within a digital format provides adaptive, student-centered learning pathways that are consistent with current pedagogical demands and 21st-century learning competencies. These findings strongly support the continued use and further refinement of the e-module as an innovative instructional resource in elementary mathematics education.

Conclusion

This study successfully developed a PBL-based differentiated e-module that is valid (89% material, 88% media), practical (92% practicality), and effective (moderate-to-high N-Gain; $p = 0.000 < 0.05$) for improving fifth-grade students' mathematical problem-solving skills. The integration of VAK-based differentiated learning within a structured PBL framework produces an adaptive, student-centered digital resource that supports diverse learners and aligns with Merdeka Curriculum demands. Future studies are recommended to conduct broader implementation across multiple schools and explore the long-term impact on problem-solving competence.

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References

Arta, I. M., Japa, I. G. N., & Sudarma, I. K. (2020). Problem Based Learning Berbantuan Icebreaker Berpengaruh Terhadap Kemampuan Pemecahan Masalah Matematika. *MIMBAR PGSD Undiksha*, *8*(2), 264–273. https://ejournal.undiksha.ac.id/index.php/JJPGSD/article/view/25435

Avivah Rofizah, Suesthi Rahayuningsih, & Ulil Nurul Imanah. (2021). Penerapan pembelajaran berdiferensiasi berbasis gaya belajar untuk mendukung kemampuan pemecahan masalah siswa pada materi sistem persamaan linier dua variabel kelas viii di mts negeri 4 mojokerto. *Prosiding seminar nasional pendidikan fakultas keguruan dan ilmu pendidikan unim*, 165–174.

Brodersen, R. M., & Melluzzo, D. (2017). Summary of research on online and blended learning programs that offer differentiated learning options. *Regional Educational Laboratory Central*, 1–22.

Cahyani, H., & Setyawati, R. W. (2016). Pentingnya Peningkatan Kemampuan Pemecahan Masalah Melalui PBL untuk Mempersiapkan Generasi Unggul Menghadapi MEA. *PRISMA, Prosiding Seminar Nasional Matematika*, 151–160.

Dalila, A. A., Rahmah, S., Liliawati, W., & Kaniawati, I. (2022). Effect of Differentiated Learning in Problem Based Learning on Cognitive Learning Outcomes of High School Students. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 2116–2122. https://doi.org/10.29303/jppipa.v8i4.1839

Feriyanti, N. (2019). Pengembangan e-modul matematika untuk siswa SD. *Teknologi Pendidikan Dan Pembelajaran*, *6*(1), 1–12.

Hadi, W., Prihasti Wuriyani, E., Yuhdi, A., & Agustina, R. (2022). Desain Pembelajaran Diferensiasi Bermuatan Problem Based Learning (Pbl) Mendukung Critical Thinking Skill Siswa Pada Era Kenormalan Baru Pascapandemi Covid-19. *Basastra*, *11*(1), 56. https://doi.org/10.24114/bss.v11i1.33852

Kristiawan, M., Kartini, D., Fitria, H., Negeri, S., & Sugihan, M. (2020). The Influence of Principal's Leadership, Academic Supervision, and Professional Competence toward Teachers' Performance Mapping Managerial Competence of Primary School Principals in South Sumatera View project The Influence of Principal's Leadership, Academic Supervision, and Professional Competence toward Teachers' Performance. *International Journal of Progressive Sciences and Technologies (IJPSAT)*, *20*(1), 156–164. http://ijpsat.ijsht-journals.org

Kusumastuti, F., Kurnia, N., Astuti, S. I., Birowo, M. A., Hartanti, L. E. P., Amanda, N. M. R., & Kurnia, N. (2021). Modul Etis Bermedia Digital. In *Modul Etis Bermedia Digital*. https://literasidigital.id/books/modul-etis-bermedia-digital/

Mahmudah, I., Prastowo, A., & Sunedi, S. (2022). Model Drill and Pratice Berbasis Media Audio-Visual Terhadap Hasil Belajar Pada Mata Pelajaran Matematika Sekolah Dasar. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *6*(3), 2652–2659. https://doi.org/10.31004/cendekia.v6i3.1202

Maniq, L. N. K., Karma, I. N., & Rosyidah, A. N. K. (2022). Pengembangan E-Modul Matematika Pada Materi Pecahan. *Journal of Classroom Action Research*, *4*(1), 83–88. https://doi.org/10.29303/jcar.v4i1.1405

Marlina. (2019). *Panduan Pelaksanaan Model Pembelajaran Berdiferensiasi di Sekolah Inklusif*. 1–58.

Najuah, N., Lukitoyo, Suhendro, P., & Wirianti, W. (2020). *Modul Elektronik: Prosedur Penyusunan dan Aplikasinya (Janner Simarmata (ed.)*. Yayasan Kita Menulis.

Ningsih, I. S., Destiniar, & Fuadiah, N. F. (2022). Pengembangan E-modul Berbasis Problem Based Learning (PBL) Pada Materi Persegi Panjang Untuk Siswa SMP. *JEMS: Jurnal Edukasi Matematika Dan Sains*, *10*(2), 285–294. https://doi.org/10.25273/jems.v10i2.11804

Noorbaiti, R., Fajriah, N., & Sukmawati, R. A. (2018). Implementasi Model Pembelajaran Visual-Auditori-Kinestetik (VAK) pada Mata Pelajaran Matematika di Kelas VII E MTsN Mulawarman Banjarmasin. *EDU-MAT: Jurnal Pendidikan Matematika*, *6*(1), 108–116. https://doi.org/10.20527/edumat.v6i1.5130

Perdana, S. A., & Slameto, S. (2016). Penggunaan Metode Problem Based Learning (Pbl) Berbantuan Media Audio Visual Untuk Meningkatkan Hasil Belajar Matematika Siswa Sekolah Dasar. *Jurnal Pendidikan Dasar Universitas Sebelas Maret*, *4*(2), 73–78.

R.Roro Rastrani Rahada Putri, Kaspul, K., & Arsyad, M. (2022). Pengembangan Media Pembelajaran Modul Elektronik (E-Modul) Berbasis Flip Pdf Professional Pada Materi Sistem Peredaran Darah Manusia Kelas XI SMA. *JUPEIS : Jurnal Pendidikan Dan Ilmu Sosial*, *1*(2), 93–104. https://doi.org/10.55784/jupeis.vol1.iss2.46

Rahayu, R., Iskandar, S., & Abidin, Y. (2022). Inovasi Pembelajaran Abad 21 dan Penerapannya di Indonesia. *Jurnal Basicedu*, *6*(2), 2099–2104. https://doi.org/10.31004/basicedu.v6i2.2082

Rahmani, W., & Widyasari, N. (2018). Meningkatkan Kemampuan Pemecahan Masalah Matematis Siswa Melalui Media Tangram. *FIBONACCI: Jurnal Pendidikan Matematika Dan Matematika*, *4*(1), 17. https://doi.org/10.24853/fbc.4.1.17-23

Ramadanti, F., Mutaqin, A., & Hendrayana, A. (2021). Pengembangan E-Modul Matematika Berbasis PBL (Problem Based Learning) pada Materi Penyajian Data untuk Siswa SMP. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *5*(3), 2733–2745. https://doi.org/10.31004/cendekia.v5i3.759

Setiawan, H. (2017). Pembelajaran Matematika Model PBL (Problem Based Learning) Pada Mata Pelajaran Matematika Materi Luas Bidang Pada Siswa Kelas III SD. *Inovasi*, *XIX*(1), 8–17.

Sugiyono. (2020). *Metode Penelitian Kuantitatif, Kualitatif dan R&D*. Alfabeta.

Tomlinson, C. A. (2001). How TO Differentiate instruction in mixed-ability classrooms. In *Association for Supervision and Curriculum Development*.

Trinter, C. P., Brighton, C. M., & Moon, T. R. (2015). Designing Differentiated Mathematics Games Discarding the One-Size-Fits-All Approach to Educational Game Play. *Gifted Child Today*, *38*(2), 88–94. https://doi.org/10.1177/1076217514568560