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How to cite: Tamam, M. F., Suprayitno, I. J., & Purnomo, E. A. (2026). Development of the Silindar E-Module Based on Problem Based Learning with a STEM Approach on SPLDV to Enhance Students Problem Solving Skills. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, 6(1), 281–301. <https://doi.org/10.51574/kognitif.v6i1.4752>

To link to this article: <https://doi.org/10.51574/kognitif.v6i1.4752>



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Published Online on 26 February 2026



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Development of the Silindar E-Module Based on Problem Based Learning with a STEM Approach on SPLDV to Enhance Students Problem Solving Skills

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Article Info

Article history:

Received Jan 15, 2026

Accepted Feb 22, 2026

Published Online Feb 26, 2026

Keywords:

E-Module
Problem Solving Skills
Problem Based Learning
STEM Approach

ABSTRACT

Mathematics learning in schools should be able to optimally stimulate these higher-order thinking skills to meet the demands of 21st-century competencies. However, conditions in the field show that learning still tends to be teacher-centered and the availability of contextual teaching materials is limited. This condition triggers students' difficulties in formulating mathematical models, especially in the SPLDV material, so that students' problem-solving abilities are not optimally honed. This development research is specifically limited to the objective of developing and testing the level of validity and practicality of the Silindar E-Module on SPLDV material based on Problem Based Learning (PBL) and the STEM approach. The method used is development research with the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model. Data collection uses validation sheets from media experts and material experts, as well as questionnaire responses from teachers and students. The results of the study show that the Silindar E-module meets the criteria of being very valid in terms of design and material substance with an average overall validity score of 3.68 consisting of a media expert assessment of 3.76 and a material expert assessment of 3.60. The Silindar E-module was also declared very practical when applied in learning based on an average combined practicality of 3.56 with the results of the teacher response questionnaire with an average of 3.73 and a student response of 3.39. These findings confirm that the Silindar E-module is suitable for use as an interactive learning tool to facilitate the improvement of students' mathematical problem-solving abilities and support the implementation of the independent curriculum.



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Introduction

Problem-solving skills include the stages of understanding the problem, developing a solution strategy, implementing the plan, and evaluating the solution obtained (Rambe & Arfi, 2020). This ability is a crucial aspect for students because mathematical problems related to everyday life can be solved by students who have good problem-solving skills (Sulhaliza et al., 2023). The demands of 21st century education emphasize that learning is not only oriented towards delivering information, but must also be able to develop high-level thinking skills including critical, creative, collaborative thinking, and problem-solving skills (Syerlita & Siagian, 2024). Through learning mathematics, students are expected to not only master calculation procedures, but also be able to relate concepts to real problems (Wardani et al., 2024). Therefore, mathematics learning in schools needs to be designed to support 21st century skills, not just teaching formulas alone.

The reality in the field indicates that mathematics learning is still dominated by a teacher-centered approach, so that students tend to be passive in the learning process (Nurhami et al., 2024). This learning pattern makes students memorize formulas more often than applying them in everyday life (Sulistiowati, 2022). As a result, quite a few students experience obstacles when faced with contextual problems that require mathematical problem-solving skills (Agnesti & Amelia, 2020). This condition has an impact on students' low mathematical problem solving abilities (Arrasyid et al., 2022). Students' low ability to solve mathematical problems is a challenge in the world of Indonesian education, even though this ability is a crucial aspect in learning mathematics (Mardicko et al., 2025). PISA 2022 data shows that Indonesian students' mathematics scores are at 366, still behind the OECD average of 472 (Sausan & Wibowo, 2024). Research has found that students experience difficulties when solving story problems due to their inability to transform information into an appropriate mathematical model (Pradini et al., 2020).

Similar problems were found among ninth-grade students at Nawa Kartika Junior High School, Kedungbanteng, Tegal Regency. Observations revealed that only 40% of ninth-grade students met the minimum competency criteria (KKM) on daily tests for contextual story problems, with the school setting a minimum of 70. Interviews with students and teachers confirmed that students experienced difficulties in fully understanding contextual problems and identifying important information, which led to students' inaccuracies in mathematical modeling. Furthermore, students demonstrated difficulty in designing problem-solving strategies and tended to write down final answers without systematic steps. This demonstrates students' weak skills in systematically solving problem-solving steps. Observations of learning showed that textbooks were still the dominant learning resource. This led to students feeling bored when reading to understand the material. The use of textbooks as the main source of learning in schools generally presents information descriptively and contains questions and solutions using written formulas only without providing an interactive learning experience (Lestari et al., 2025). Even though in the 21st century, technology has become an important and influential part of life, including in the context of education (Sinaga, 2023).

E-modules are an alternative solution that meets the demands of 21st century learning (Rahmani & Hikmawan, 2025). E-modules as a digital teaching material have advantages in the form of flexibility, accessibility, and the ability to present material in various formats such as text, images, animation, and video (Nuranisa et al., 2023). E-modules allow students to learn independently and review material at their own pace. The development of e-modules is a crucial step in strengthening the learning process, shifting from teacher-centered to one that positions students more at the center of learning activities (Meliana, 2020). Through appropriate design,

e-modules can facilitate structured problem-solving stages. This indicates the need for e-modules designed to train students' problem-solving skills.

Problem Based Learning (PBL) emphasizes contextual problems as the starting point for learning so that students are encouraged to explore, analyze, and formulate solutions to the problems they face (Kusasih et al., 2024). The development of PBL-based E-modules facilitates students to follow the PBL syntax stages independently, starting from understanding the problem to evaluating the solutions obtained (Husna et al., 2025). Research shows that PBL-based E-modules have a positive effect on improving students' problem-solving abilities (Irmawati & Hadi, 2024). Similar research by Ramadhani et al., (2024) This study shows that junior high school students' mathematical problem-solving abilities can be improved through the implementation of PBL-based e-modules. Efforts to optimize problem-solving abilities through PBL-based e-modules will be more effective when supported by an approach that can bridge abstract concepts with real-world applications.

The Science, Technology, Engineering, and Mathematics (STEM) approach emphasizes integration between disciplines so that mathematics learning is not only abstract, but also contextual and applicable (Arifin et al., 2020). Through STEM, students are invited to connect mathematical concepts with science, technology, and engineering, so that the understanding gained becomes more meaningful (Rosilawati & Abidin, 2025). Research shows that the application of STEM in mathematics learning contributes to increasing students' learning motivation, creativity, and problem-solving abilities (Siregar & Jumaisyaroh, 2024). In line with the development of educational technology, STEM integration can be realized through E-modules that present material with simulations, virtual experiments, and technology-based project activities (Laksana et al., 2025). The STEM approach e-module provides opportunities for students to explore mathematics in real contexts, for example by solving project-based problems that connect mathematics with simple technology, making learning more interesting and relevant.

The integration of the STEM approach enriches the application of PBL in E-modules by presenting a real connection between mathematical concepts and their application in other disciplines. Several studies have developed E-modules, implementing PBL, and the STEM approach separately, but there are still very few that integrate these three elements completely in one digital learning medium, especially in SLPV material. Therefore, a learning approach that fully integrates teaching materials, models, and approaches is needed. The Silindar E-module is specifically designed to systematically combine PBL syntax and STEM context in SLPV material and facilitate students in developing problem-solving skills.

Based on this description, the researcher designed an innovative e-module called Silindar, which integrates the PBL model with the STEM approach in the SPLDV material. This e-module combines the PBL model with the STEM approach in an interactive format containing text, images, illustrative videos, and contextual problem-based exercises. PBL syntax is used to guide the problem-solving process, while STEM elements are integrated to present real-life connections with science, technology, and engineering phenomena. This e-module is expected to not only bridge abstract mathematical concepts with real-life situations but also be able to provide more contextual, interactive, and meaningful learning, and support the implementation of the Independent Curriculum. Therefore, the researcher conducted a study aimed at developing the Silindar e-module based on the PBL STEM approach in the SPLDV material and testing its validity based on expert assessment and practicality in learning based on teacher and student responses.

Method

Settings

This research is a Research and Development (RnD) study that applies the ADDIE development model. This model includes five stages: Analysis, Design, Development, Implementation, and Evaluation (Tika et al., 2024). The ADDIE model was chosen because its stages are structured, clear, and have an evaluation process at each step, making it very suitable for ensuring product development, as in Figure 1 below.

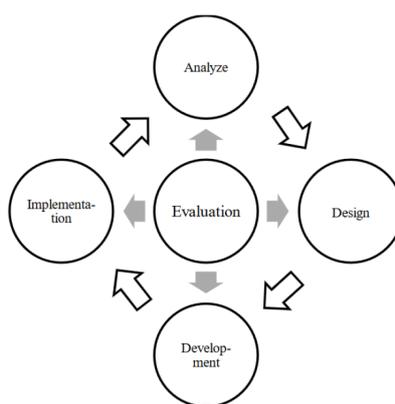


Figure 1. ADDIE Model Research

The objectives of this research focus on developing learning media and determining the product's validity based on expert assessments and its practicality based on teacher and student responses. Details regarding the research subjects, instruments, procedures, and data analysis techniques are outlined in the following research stages:

Analysis Stage

Analysis is the initial stage used to identify problems, conditions, and student needs in order to provide appropriate solutions. This stage involves analyzing the problem, curriculum, materials, and student characteristics. The analysis process is carried out through interviews with teachers and students, along with direct observation of classroom learning.

Design Stage

The design stage is focused on product design based on the results of the analysis stage including collecting study materials, determining the media used as well as compiling the material to be presented and designing the appearance of the product.

Development Stage

The development stage is the stage in realizing the design that has been made in the previous design stage, which consists of a validity test by experts, and improvements if there are deficiencies. The criteria for a media expert is someone who has competence in media development, while the criteria for a material expert is someone who has a specialization in mathematics, especially in the topic of spldv. The data collection instrument used is a validation

sheet. The use of the validation sheet to obtain assessments and input from experts regarding the feasibility of the E-Module product before implementation. To measure the level of product validity, the assessment is carried out using an instrument that covers the following aspects:

Table 1. Media Expert Validation Aspects

No.	Aspect	Number of Items
1	Display Aspect	3
2	Presentation Aspect	8
3	Usage Aspect	1

The media expert validation instrument includes 12 statement items containing 3 aspects, namely the appearance aspect, presentation systematics and usage aspect.

Table 2. Subject Matter Expert Validation Aspect

No.	Aspect	Number of Items
1	Curriculum Suitability	3
2	Content Suitability	4
3	Quality of Exercises and Evaluation	5
4	Implementation of the Problem-Based Learning Model	1
5	Integration of the STEM Approach	2
6	Integration of the STEM Approach	2

The six aspects of the material expert assessment include curriculum suitability, content feasibility, quality of training and evaluation, implementation of the Problem-Based Learning model, integration of the STEM approach, and problem-solving indicators, with a total of 17 items. The next stage, the data obtained will be analyzed and processed thoroughly. Data analysis is applied to measure the level of validity of the developed e-module product based on validity criteria. The assessment of the material and media expert validation questionnaire refers to the Likert scale as shown in Table 3.

Table 3. Likert Scale Scoring Criteria

Score	Description
4	Very Good
3	Good
2	Fairly Good
1	Poor

(Wijayandaru et al., 2025a)

The data from the validator's assessment results were then analyzed by calculating the average score of the material and media expert validation questionnaire using the following formula:

$$\bar{x} = \frac{\sum x}{n}$$

Description:

\bar{x} = Average score

$\sum x$ = Total scores

n = Number of items

The average value is then interpreted into qualitative categories based on the validation criteria in the following table:

Table 4. Expert Validation Criteria

Validity Value	Criteria	Description
$1 \leq x < 1,75$	Invalid	Not yet usable
$1,75 \leq x < 2,5$	Less Valid	Usable with many revisions
$2,5 \leq x < 3,25$	Valid	Usable with few revisions
$3,25 \leq x \leq 4$	Very Valid	Usable without revisions

(Wijayandaru et al., 2025a)

Based on the above criteria, learning media is suitable for implementation if it at least meets the valid criteria..

Implementation Stage

The Implementation stage is the stage of applying the e-module after it has been declared feasible by experts in classroom learning. The subjects in this stage are teachers and ninth-grade students. The purpose of this stage is to test the product's practicality. Data collection was conducted through the distribution of response questionnaires to teachers and students. The questionnaires were used to obtain users' opinions and direct experiences regarding the use of the e-module as a learning medium. Several instrument grids in this study include:

Table 5. Student Response Questionnaire Grid

Aspect	Indicator
Appearance Aspect	The attractiveness of the E-module display The title reflects the content of the material The e-module is easy to operate The user manual is easy to understand
Ease of Access Aspect	The text in the e-module is clearly legible Real-life examples The material presented is easy to understand
Material Quality Aspect	The illustrations and videos provided help in understanding the material The e-module is presented in a coherent and clear manner The questions presented are relevant to the material The terms used are common to students. Sentences and paragraphs are clear and easy to understand.
Language Clarity Aspect	The language used in the material and questions is easy to understand.

Table 6. Teacher Response Questionnaire Grid

Aspect	Indicator
Material Aspects	Alignment of the material with CP and ATP Completeness and consistency of the material Suitability of PBL in the E-module Suitability of STEM integration in the E-module Problem-solving ability indicator content in the E-module The material and questions tested measure problem-solving ability The language used is clear and easy to understand The design and visualization in the E-module are attractive.
Language Aspects	Font readability
Display Aspects	Ease of operation and navigation
Usage Aspects	

The data collected through the questionnaire was then processed using a Likert scale. This scale is commonly used to measure individual perceptions of a phenomenon (Dalimunthe et al., 2025). The practical data analysis technique was carried out by calculating the Likert scale questionnaire response scores and then calculating the average of those scores. The scoring provisions used in this study are as follows:

Table 7. Likert Scale Scoring Criteria

Answer	Score
Strongly Agree (SA)	4
Agree (A)	3
Disagree (D)	2
Strongly Disagree (SD)	1

(Wijayandaru et al., 2025b)

The next analysis step is to determine the average value of the data obtained using the formula:

$$\bar{x} = \frac{\sum x}{n}$$

Description:

\bar{x} = Average score

$\sum x$ = Total scores

n = Number of items

The average results obtained were then interpreted into category intervals to determine the level of practicality of the developed E-Module teaching materials. The categories are as follows:

Table 8. Practicality Category

Average	Category
$x > 3,25$	Very Practical
$2,5 < x \leq 3,25$	Practical
$1,75 < x \leq 2,5$	Less Practical

$$x \leq 1,75$$

Not Practical

(Angriani et al., 2020)

Evaluation Stage

The evaluation stage is conducted formatively at each stage to correct any deficiencies found, thus minimizing development errors. In accordance with the limitations of the scope of this study, the evaluation conducted is focused on formative evaluation to assess the quality of feasibility based on the validity and practicality data of the product. However, summative evaluation to test the level of effectiveness of the E-Module is not conducted within the scope of this study and is formulated as a recommendation for further research.

Research Findings

The results of this study produced a product in the form of a PBL-based e-module with a STEM approach to SPLVD material. The study also presents findings from the media and material validation process, and practicality results based on student and teacher questionnaire responses. The development of the following e-module uses the ADDIE model, which includes five stages: Analysis, Design, Development, Implementation, and Evaluation.

Analysis Stage

Based on observations and interviews with teachers and students at Nawa Kartika Junior High School in Kedungbanteng, it was identified that learning is still predominantly teacher-centered. Consequently, student engagement in class tends to be minimal. Learning tends to emphasize solely memorizing formulas, resulting in students experiencing difficulties when faced with contextual problems that require problem-solving skills because they are accustomed to receiving information directly without undergoing a deep thought process. This school has implemented the independent curriculum, which emphasizes the development of 21st-century skills and higher-order thinking skills. However, findings in the field indicate that the learning media used to support the implementation of the independent curriculum is still very limited and dominated by the use of textbooks as the sole learning resource. These textbooks tend to present material descriptively and use collections of problems and solutions based on written formulas without providing interactive learning experiences. This condition makes students feel bored when understanding the material, thus not supporting the development of problem-solving skills that are a competency requirement.

SPLDV is one of the mathematics materials considered difficult by students. This is evidenced by the results of daily SPLDV material tests where only 40% of the total grade IX students managed to achieve the minimum passing grade (KKM) of 70. The main difficulty for students lies in understanding contextual problems thoroughly and identifying important information needed, resulting in inaccuracies in constructing mathematical models. This weakness is evident in students' low ability to translate information into formulating mathematical models from given story problems. In addition, students also face obstacles in determining solution strategies and tend to only write final answers without accompanying systematic solution steps. This condition indicates that students' skills in carrying out problem-solving stages in a complete and structured manner have not yet developed optimally. The results of the analysis of the characteristics of grade IX students show that students tend to feel bored with printed teaching materials dominated by text. On the other hand, students have a

close relationship with technology in their daily lives, but this potential has not been fully utilized to support learning activities. Students' need for learning media that presents visualization and interactivity is the basis for the development of the Silindar E-module based on PBL with a STEM approach in an interactive digital format through the use of video and animation. The aim is to develop students' ability to solve problems and facilitate independent learning.

Design Stage

The design phase is a crucial phase where researchers transform the results of the needs analysis into a systematic framework for the Silindar E-module. This process begins with the development of a comprehensive E-module structure, starting with the introduction containing the cover, foreword, and clear instructions for use so that students can use the media independently. Researchers then develop concept maps and learning outcomes aligned with the independent curriculum, ensuring that the SPLDV material presented has a logical and structured flow. Researchers harmoniously integrate PBL syntax and the STEM approach. Each learning activity is designed to begin with a real-life problem, followed by challenges for students to design mathematical models as solutions. The use of technology is designed through the integration of interactive features, animated videos, graphic applications, and dynamic visual elements to overcome student boredom with conventional textbooks. All concepts are unified in the Silindar E-module identity, which specifically refers to the material on systems of linear equations in two variables with the aim of facilitating each stage of students' problem-solving abilities systematically. The following is a display of the Silindar E-module for the SPLDV material for grade IX:

Table 9. Silindar E-Module Display

Silindar E-Module Display	Description
	<p>The cover page of the E-Module contains the complete visual identity, including the Ministry of Education and Culture logo, the Merdeka Curriculum logo, the university logo, the name of the E-Module, the name of the material, and the class identity of the material. At the beginning, there is a page about the E-Module's compiler, which lists the name of the author and the institution from which the E-Module was written..</p>
	<p>The foreword page contains expressions of gratitude, the purpose of media development, and appreciation to the parties who contributed, as well as a table of contents page that makes it easier for users to navigate.</p>



The introduction outlines instructions for using the E-Module so students can learn independently. The problem-based learning syntax page presents the PBL stages implemented in the E-Module, which serve as a reference for students' learning flow.



The STEM elements page contains a description of the application of each STEM component in the e-module. In addition, there is a dedicated page explaining problem-solving indicators that serve as a reference in the learning process.



The learning outcomes and objectives pages contain the competencies students are expected to master. The concept map page provides a coherent overview of the structure of the material contained in the E-Module.



On the learning activities page, SPLDV material is presented through a series of activities designed to follow problem-based learning steps and problem-solving indicators supported by visualization of images and learning videos.



The practice page contains contextual challenges for students to test their problem-solving skills. There's also a STEM Project simulation to help students connect the material to real life.

Development Stage

The development stage is the concrete realization where the previously prepared design is transformed into a digital product ready for testing. Researchers developed the Silindar E-module using various supporting tools to produce material rich in multimedia features, such as illustrative videos to orient the problem and interactive practice questions. This e-module covers in-depth coverage of SPLDV material, from basic concepts to solution methods using graphs, substitution, elimination, and mixed methods. The main advantage of this developed product lies in the insertion of a STEM-based project at the end of the material that requires students to apply mathematical concepts in practical situations, so that learning becomes more meaningful and applicable. After the E-module was completed, the next step was to carry out a validation process to ensure the product's feasibility from the perspective of media experts and material experts. The assessment results obtained from media experts and material experts are then presented in the following Table 10.

Table 10. Media Expert Validation Results

Aspect	Media Expert			Average
	I	II	III	
Display Aspect	3,33	3,33	4	3,5
Presentation Aspect	3,75	3,5	4	3,75
Usage Aspect	4	4	4	4
Final Results				3,76
Category				Very Valid

Referring to the media validity data presented in Table 11, the usability aspect received the highest average score of 4, categorized as very valid. This finding demonstrates the user-friendliness of the Silindar e-module, demonstrating its ease of operation and use by students, consistent with the characteristics of good digital teaching materials. This confirms that a good e-module must prioritize user accessibility. Meanwhile, the display aspect received the lowest score of 3.5, but remains in the very valid category.

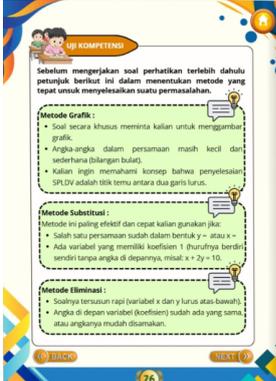
Table 11. Material Expert Validation Results

Aspect	Materials Expert			Average
	I	II	III	
Curriculum Suitability	4	3	4	3,6
Content Suitability	4	3,75	3,75	3,83
Quality of Exercises and Evaluation	3,8	3,2	3,8	3,6
PBL Model Implementation	4	3,5	4	3,83
STEM Approach Integration	2	3	4	3
Problem Solving Indicators	4	3.5	3.5	3,6
Final Results				3,6
Category				Very Valid

In terms of material validity, as presented in Table 11, the quality of the content ranked highest, with an average score of 3.83, categorized as very valid. This data confirms that the SPLDV material presented is very comprehensive, easy to understand, and strongly synchronized with the applicable CP and ATP. This aligns with the principle of teaching material development, where a quality e-module must be able to minimize student learning barriers. Meanwhile, the STEM approach integration aspect obtained an average score of 3, categorized as valid. Although ranked lowest compared to other aspects, this score indicates that the STEM content in the e-module is quite clear and able to facilitate students in

understanding the relationship between mathematics and other disciplines. The following is a revision of the e-module based on suggestions from the validator:

Table 12. E-Module Suggestions and Revisions

Improvement Suggestions	Before Revision	After Revision
Change the name of the E-module to suit the material		
Using contextual images		
Add instructions for working using the most efficient method on the competency test.		
Add STEM elements to every learning activity.		

Add more clear information in the steps of creating possibilities in the table.



The combined assessment from media and material experts showed an average validity score of 3.68, obtained from an average of 3.76 from media experts and 3.60 from material experts. Referring to the established validation criteria, this score is categorized as "Very Valid," indicating that both in terms of design and material, the Silindar E-Module has met high feasibility standards. Thus, the Silindar E-Module is declared feasible and ready to be implemented in learning.

Implementation Stage

After the E-Module underwent validity testing and revisions based on input from the validators, the implementation phase was carried out by applying the E-Module in learning for 30 ninth-grade students of Nawa Kartika Kedungbanteng Middle School. The implementation was carried out via smartphones owned by students with internet connection. The activity began with an introduction to how to operate the E-Module along with an explanation of the activities and elements contained in the E-Module, followed by the implementation of learning according to the guidelines in the E-Module. At the end of the learning activity, a response questionnaire was distributed to students and teachers to measure the level of practicality of the E-Module. The data obtained was then analyzed in the form of a combined average of each aspect as presented in the following figure:

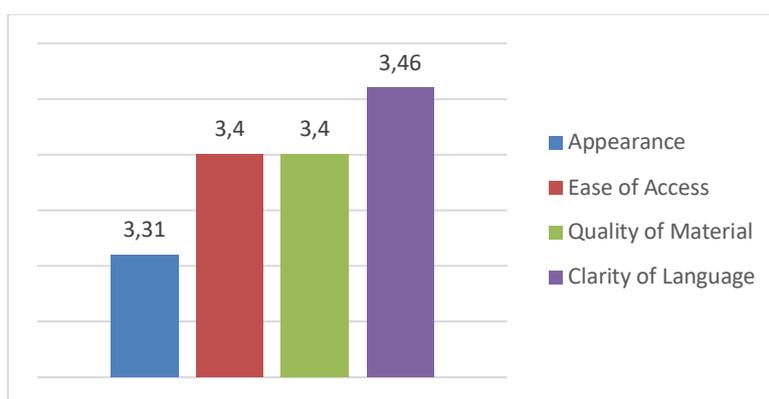


Figure 2. Student Response Results for Each Aspect

It is known that the average result of the student assessment of the Silindar E-Module Based on Problem Based Learning Approach STEM SPLDV Material obtained a score of 3.39 with the criteria of "very practical". Based on the responses given by students in the student response questionnaire and student interactions when using the E-Module, it is known that students are very happy and enthusiastic about using the E-Module. Students think that the

Silindar E-Module has very attractive colors and images, has buttons on each page, contains learning videos, and can be accessed via smartphone. The learning activities designed in the E-Module are considered to help students in understanding the material while supporting students in solving the problems presented. The suggestions given by students include adding a variety of games or interactive quizzes at the end of the learning activity to make the evaluation process more challenging.

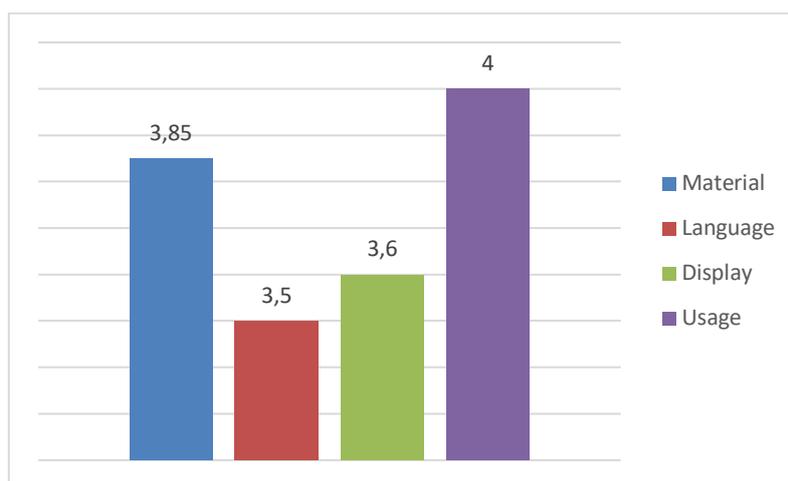


Figure 3. Teacher Response Results for Each Aspect

The teacher assessment results showed an average score of 3.73, with the criteria of very practical. Teachers assessed that the material presented was aligned with the Learning Outcomes (CP) and Learning Objective Flow (ATP), and the PBL syntax and STEM approach were appropriately integrated to facilitate students' problem-solving abilities. In addition, the use of language in the E-Module was considered communicative and easy to understand. Overall, the combined student and teacher responses resulted in an average score of 3.56. Referring to the practicality criteria used, this score indicates that the Silindar E-Module is in the Very Practical category. These findings indicate that the Silindar E-Module is easy to use and able to support teaching and learning activities in the classroom.

Evaluation Stage

The evaluation phase of this study was conducted to refine the developed E-Module by referring to the findings from the validity and practicality tests. Improvements to the E-Module were made based on expert input. From the media aspect, revisions included adjusting the E-Module name to better reflect the material and replacing animated images with contextual ones, as well as adding instructions for completing the competency test. In terms of material, revisions focused on strengthening STEM integration in learning activities and adding clearer information in the material discussion. Through a series of five stages in the ADDIE model that have been implemented, the final product obtained is the Silindar E-Module based on PBL with a STEM approach and SPLDV material that is categorized as very valid and very practical. This feasibility is supported by the characteristics of the Silindar E-Module which is interactive, interesting, and easy to use using devices owned by students. In accordance with the established limitations, the evaluation at this stage is formative to refine the E-Module, so it does not include a summative evaluation related to the effectiveness test.

Discussion

The Silindar e-module was developed as an interactive digital solution to address the limitations of printed learning resources for SPLDV materials. The Silindar e-module is systematically designed by integrating multimedia features such as learning videos, animations, and modern visual designs to create a more dynamic learning experience for ninth-grade students. As an independent learning material, the Silindar e-module facilitates flexible access through technological devices that are close to students' daily lives, so that the learning process is not bound by the limitations of place or time. This is in line with research findings that show that e-modules designed with good navigation make it easier for students to learn due to their attractive and easily accessible presentation (Fitriwanti et al., 2023; Sembiring et al., 2021). The e-module is structured in a logical flow, starting with an introduction to Learning Outcomes and continuing through evaluations in the form of practice questions and projects. Each component, such as concept maps, glossaries, and user manuals, is designed to support students in independent exploration. The use of communicative language and appropriate visualizations aims to reduce student boredom with the SPLDV material, which is often considered difficult (Iriani et al., 2025). Thus, the Silindar E-module is transformed into an effective learning tool in increasing students' active involvement through the use of relevant educational technology.

The integration of the PBL model in the Silindar e-module specifically hones students' mathematical problem-solving skills through five measurable stages of syntax. Learning begins with a contextual problem orientation that challenges students to identify important information and formulate mathematical models independently. Through the help of guiding questions in the e-module, students are guided to plan appropriate solution strategies, thus stimulating their thinking processes from the early stages of learning. This indicates that the learning flow in the e-module is able to guide students not only to focus on the final solution, but also to the process of verifying and evaluating the solutions obtained. The integration of PBL syntax in digital teaching materials effectively trains students to formulate problem-solving strategies systematically, rather than simply memorizing formulas (Ramadanti et al., 2021; Wulandari et al., 2025). By getting used to solving problems systematically through this E-module, students are expected to be able to overcome obstacles in working on story problems and be able to formulate appropriate problem-solving solutions (Ramadhani et al., 2024).

The STEM approach in the Silindar e-module provides a new dimension to solving mathematical problems by connecting them to the disciplines of Science, Technology, and Engineering. Through the Science and Technology elements, students are encouraged to see the connection between SPLDV and real-world phenomena and the use of digital tools like GeoGebra. The integration of technology like GeoGebra has been shown to contribute to improving students' mathematical problem-solving skills by helping them visualize abstract concepts (Fauzy et al., 2023; Shofa et al., 2026). Meanwhile, the Engineering aspect requires students to design procedural solutions in a project, which directly trains students' creativity and analytical skills in dealing with complex situations. The validation results of the material show that the STEM integration in this e-module meets the standards for supporting student understanding. The presence of a project at the end of the material provides a forum for students to apply Mathematics concepts in a simple engineering context. The synergy between these STEM elements ensures that the problem-solving skills developed by students are not only theoretical but also applicable, making learning more meaningful and aligned with the challenges of the 21st century (Fauziyah & Wijayanti, 2024). Research reinforces this by stating that STEM-based mathematics teaching materials are very effective in helping students connect mathematical concepts with real-world applications (Nurhidayat & Asikin, 2021; Utami & Amidi, 2022).

Problem-solving skills in this study are positioned as the main competency target facilitated through each activity in the Silindar E-Module. The Silindar E-Module consistently trains four main indicators: understanding the problem, developing a plan, implementing the plan, and reviewing the solution. The emphasis on these systematic steps aims to improve students' learning patterns, which tend to only write final answers without a clear mathematical modeling process, especially for SPLDV story problems. The practice questions and learning videos in the E-Module provide feedback that helps students correct strategic errors independently. Focusing on developing the ability to model real-world situations into mathematical models, the Silindar E-Module helps students overcome frequently encountered cognitive barriers. Ultimately, improving problem-solving skills through this E-Module is expected to equip students with higher-order thinking skills that are useful for supporting learning success at the next level of education (Islahiyah et al., 2021). Research confirms that the habituation of structured work steps in E-modules based on PBL with a STEM approach is the key to significantly improving students' problem-solving abilities compared to conventional learning (Tika et al., 2024).

The main characteristic of the Silindar e-module lies in its interactive, independent, and integrative nature across two learning frameworks: PBL and STEM. Its advantage over conventional teaching materials is its ability to present abstract SPLDV concepts in a more concrete way through animations and video illustrations. Furthermore, its user-friendly design ensures easy navigation for students, supported by media expert validation results with the highest usability score of 4.00, indicating that this media is very user-friendly. The Silindar e-module, which specifically synergizes PBL syntax and the STEM framework in SPLDV material for ninth-grade students, fills the innovation gap in mathematics learning, which rarely combines problem-based learning models in digital format. This integration makes the Silindar e-module a strategic contribution to the development of learning media that supports the implementation of the Independent Curriculum and the development of students' problem-solving abilities.

The feasibility of the Silindar E-Module as a learning tool was confirmed through expert validation and practicality testing in the field. Based on expert assessment, the Silindar E-Module was deemed highly valid. The E-Module's design was deemed very user-friendly, and its presentation aligned with CP and ATP in the Merdeka Curriculum. The integration of PBL and STEM by linking the material to everyday life stimulated students' problem-solving abilities. These qualities were also reflected in classroom implementation, where teachers assessed that the Silindar E-Module facilitated students' independent learning. The Silindar E-Module assisted teachers' tasks, especially because the material presented aligned with CP and ATP in the Merdeka Curriculum. Teachers no longer had difficulty finding teaching materials that integrated PBL and STEM models as a whole, as the Silindar E-Module presented them in easy-to-understand and communicative language. This was reinforced by students' enthusiasm in using the Silindar E-Module. This enthusiasm arose because the Silindar E-Module transformed students' learning styles from simply listening to teachers or reading textbooks to becoming more active using smartphones. Features such as clear navigation buttons and learning videos prevent students from getting bored. Students feel more supported in understanding the SPLDV material because they can learn independently at their own pace using their own devices. This confirms that the development of the Silindar E-module successfully bridges student learning needs with the demands of the curriculum, which expects interactive and in-depth learning. Therefore, the Silindar E-module can be declared a comprehensive, valid, and practical teaching material solution for use in learning.

Conclusion

Based on research and development conducted using the ADDIE model, the Silindar E-Module, a PBL-based SPLDV material and STEM approach, was successfully developed with excellent quality. Based on expert assessments, the Silindar E-Module was proven to be highly valid, meaning it was systematically designed with a user-friendly interface and navigation, and presented material that aligns with the demands of the independent curriculum. In addition to being tested as valid, the Silindar E-Module was also confirmed to be highly practical when implemented in learning. This level of practicality is reflected in the positive perceptions of teachers who felt helped in facilitating contextual learning, as well as the ease and enthusiasm of students in operating the E-Module. Thus, the Silindar E-Module was declared valid and practical to be applied in learning. Although the Silindar E-Module has met the criteria for validity and practicality, this study has limitations in the scope of implementation. The main weakness in this study is that the implementation stage has only been carried out to test the practicality of the E-Module. This study has not implemented the product to measure its level of effectiveness. This means that the direct impact of using the E-Module on improving problem-solving skills has not been quantitatively measured. Based on these limitations, the recommendation for further research is to conduct research to test the effectiveness of the Silindar E-Module with a broader scope to comprehensively validate its effectiveness.

Conflict of Interest

The author declares no conflict of interest.

Authors' Contributions

M.F.T. conceived the research idea presented and collected the data. The other two authors, I.J.S. and E.A.P., actively participated in the development of theory, methodology, organization and analysis of data, discussion of results, and approval of the final version of the work. All authors declare that the final version of this paper has been read and approved. The total percentage of contributions to the conceptualization, preparation, and correction of this paper are as follows: M.F.T.: 40%, I.J.S.: 30%, and E.A.P.: 30%.

Data Availability Statement

The author declares that the data supporting the results of this study will be made available by the corresponding author, M.F.T, upon reasonable request.

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