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Development of Website Based Learning Media for Mathematical Modeling in The LPG Context to Support Mathematical Literacy Skills of Junior High School Students

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Abstract:
This study aims to develop website-based media for mathematical modeling with the Liquefied Petroleum Gas (LPG) context to support mathematical literacy skills. The method used is design research type development studies through Tessmer's formative evaluation flow, including self-evaluation, expert review, one-to-one, and small group. The product was evaluated in terms of validity and practicality. The expert validation results showed the media was very valid with a score of 4.38 in the media aspect and 4.25 in the material aspect. The practicality test at the small group stage obtained a score of 75.79 (practical category). The characteristics of the resulting media include: (1) valid media reviewed from the aspects of material, modeling, literacy, and display; (2) media that is practical to use in learning; (3) relevant and contextual media through the use of LPG as a real-world connection; (4) media that supports mathematical literacy skills through mathematical modeling structures; and (5) ease of navigation, automatic feedback, and communicative visual displays. Thus, the developed website-based media is proven to be valid, practical, and relevant to support students' mathematical literacy skills in small groups. In the pre-test stage, one student (16.7%) was classified in the medium category, while five students (83.3%) were in the low category. After the application of web-based mathematical modeling media, all six students (100%) achieved scores in the medium category.

Abstrak:
Penelitian ini bertujuan untuk mengembangkan media berbasis web untuk pemodelan matematika dengan konteks Gas Minyak Bumi Cair (LPG) untuk mendukung keterampilan literasi matematika. Metode yang digunakan adalah penelitian desain tipe pengembangan melalui alur evaluasi formatif Tessmer, termasuk evaluasi diri, tinjauan ahli, satu lawan satu, dan kelompok kecil. Produk dievaluasi dari segi validitas dan kepraktisan. Hasil validasi ahli menunjukkan media tersebut sangat valid dengan skor 4,38 pada aspek media dan 4,25 pada aspek materi. Uji kepraktisan pada tahap kelompok kecil memperoleh skor 75,79 (kategori praktis). Karakteristik media yang dihasilkan mencakup: (1) media yang valid ditinjau dari aspek materi, pemodelan, literasi, dan tampilan; (2) media yang praktis digunakan dalam pembelajaran; (3) media yang relevan dan kontekstual melalui penggunaan LPG sebagai keterkaitan dunia nyata; (4) media yang mendukung kemampuan literasi matematika melalui

struktur pemodelan matematika; dan (5) kemudahan navigasi, umpan balik otomatis, serta tampilan visual yang komunikatif. Dengan demikian, media berbasis website yang dikembangkan terbukti valid, praktis, dan relevan untuk mendukung kemampuan literasi matematika siswa pada kelompok kecil yaitu Pada tahap pra-uji, satu siswa (16,7%) diklasifikasikan dalam kategori sedang, sedangkan lima siswa (83,3%) berada dalam kategori rendah. Setelah penerapan media pemodelan matematika berbasis web, keenam siswa (100%) mencapai skor dalam kategori sedang.

Keywords:
Media Development, Website Based, Mathematical Modeling, LPG Context, Mathematical Literacy Skills

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INTRODUCTION

Students must have advanced critical thinking, creativity, teamwork, and problem solving abilities in a variety of real world situations in order to succeed in 21st-century education. Strengthening mathematical literacy that is, the capacity to comprehend, apply, and interpret mathematics meaningfully in practical contexts is how these goals are met in mathematics education (OECD, 2023a). Mathematical literacy is not only an indicator of readiness to face global challenges, but is also considered a key competency in data-based decision-making processes and logical reasoning (Secgin, Baskurt, & Guner, 2024). In line with this, mathematical literacy is a key skill for the 21st century because students are required to be able to interpret and apply mathematical concepts critically and reflectively in everyday life (Habibi & Suparman, 2020).

At the material level, one topic that significantly contributes to strengthening mathematical literacy is the System of Linear Equations in Two Variables (SLETV). This material plays a crucial role because the concept of linear relationships is often used to model real world problems such as price comparisons, profit analysis, distribution of goods, and the relationships between quantities (Kemendikbudristek, 2022). From a linear algebra perspective, SLETV is the most basic form of a system of equations that models two linear relationships and is the foundation for developing relational thinking

skills (Howard & Rorres, 2014). Thus, SLETV is not just procedural material, but an important means of building mathematical modeling and literacy skills.

However, learning conditions in the field indicate that students' mathematical literacy is still low. Pretest results on 41 ninth grade students at SMP LTI IGM Palembang showed that only 7% of students achieved mastery, while the other 93% experienced difficulties in almost all indicators of mathematical literacy. Most students were unable to identify important information, incorrectly determined variables, and were unable to transform context into the SLETV model. These findings are consistent with research by Jamil, Cahyono, and Ayu (2021) which revealed that students' main difficulties arise when applying mathematical concepts to real world situations because previous learning emphasized procedures and symbols rather than interpreting context.

The results of Kurniati, Inuhan, and Bonara (2025) research show that conceptual errors, inaccurate reading of context, and failure to connect information with mathematical models are common patterns of low mathematical literacy in students. Manullang, Elfani, and Fauzi (2025) research also found that students often have difficulty transforming story problems into SLETV equations and have not demonstrated adequate mathematical reasoning. This condition indicates that mathematics instruction should not rely solely on procedural exercises, but must be supported by an approach that guides students to understand the structure of the problem in depth.

As a key skill of the 21st century, mathematical literacy demands learning experiences that provide students with opportunities to analyze, formulate, and evaluate solutions in authentic contexts (Anwar, 2018). Mathematical modeling is a relevant approach for this purpose because it requires students to understand situations, identify variables, build relationships, solve models, and interpret results in real contexts (Niss & Blum, 2020). Secgin, Baskurt, and Guner (2024) emphasize that modeling plays a direct role in the development of mathematical literacy because it involves representation, mathematical analysis, and interpretation of results.

The effectiveness of mathematical modeling is further strengthened by the finding that modeling-based learning is able to increase mathematical literacy achievement to exceed the level of conventional learning (Demir & Guzel, 2024). Modeling-based assessments also allow for more authentic measurement of mathematical literacy because they incorporate real-world situations into the mathematical process (Hiltrimartin, Aisyah, Hartono,

Mulyono, Sukmaningthias, & Simarmata, 2022). In addition, the development of mathematical literacy needs to be supported by integrated assessment instruments so that formulate-employ-interpret abilities can be analyzed appropriately (Suciati, Munadi, Sugiman, & Febriyanti, 2020).

In efforts to improve mathematical literacy through real world context-based learning, the use of authentic contexts is a crucial element to make learning more meaningful and relevant for students. Research shows that real-world contexts increase student engagement in solving mathematical problems (Paradesa, Ilma, & Putri, 2025). And facilitate the process of modeling and interpreting the results of the solution when the context is close to students' daily lives (Jamil, Cahyono, & Ayu, 2021). One authentic context that is highly relevant for Indonesian students is the LPG (Liquefied Petroleum Gas), which is a gas fuel consisting of liquefied propane (C3H8) and butane (C4H10) gases (Ningrum, Sanwidi, Akbarita, Qomaruddin, & Blitar, 2023). As a basic household need that is related to socio-economic aspects and often becomes a national issue such as scarcity, price fluctuations, and distribution inequality the context of LPG is increasingly relevant, especially after the policy of limiting the distribution of 3 kg LPG which only allows purchases at official bases (Meilani, 2025), thus providing real data and situations that can be raised as contextual problems in learning mathematical modeling.

In mathematical modeling, contextual problems are used as a starting point for constructing mathematical models, solving them, and interpreting the results back to the original context. The LPG context has a strong quantitative structure because it involves variables such as distribution distance, route, transport capacity, demand, and distribution costs, making it suitable for representation through linear and transportation models (Armanda, Sari, & Garba, 2023). This includes an analysis of the distribution of 3 kg LPG cylinders with clear route, capacity, and cost constraints. The familiar activities of managing LPG inventory and sales help students understand the relationships between quantities in the System of Linear Equations in Two Variables in the SLETV model (Lesmana, Hertini, & Daradeyana, 2021), while empirical evidence shows a linear relationship between daily needs, buying and selling prices, and delivery capacity (Vikaliana, 2024). Thus, the use of the LPG context in mathematical modeling learning supports students' abilities in formulating, using, and interpreting mathematics according to the PISA mathematical literacy framework (OECD, 2023a).

To address students' low mathematical literacy, learning media are needed that can guide the modeling process in a structured, interactive, and contextual manner. Website based media is a relevant alternative due to its advantages in interactivity, accessibility, and the ability to present rich, contextual visualizations using an ethnomathematical approach to research tours that previously also developed website media, but in terms of real context problems and learning materials, it is also different from researchers on mathematical modeling learning (Hasanah, Purnomo, & Mawarsari, 2024). Then there is also other research that is in line with this, namely about developing website media to improve mathematical literacy skills; however, it does not use mathematical modeling learning (Nugroho, Hilalunnaja, Wuryastuti, & Ardiansyah, 2024). Therefore, the website developed by the researcher has a special characteristic in presenting mathematical modeling of SLETV material to improve mathematical literacy skills. The development of digital media has also been shown to enhance understanding of SLETV by providing visual representations that help students connect new information with prior knowledge (Noto, Karimah, Pramuditya, & Anggraeni, 2020). In addition, website media is superior to print media because it is able to provide a step-by-step flow, automatic feedback, and flexibility of access that supports independent learning.

Urgency was found when researchers conducted a direct survey at SMP LTI Indo Global Mandiri Grade 9 Students. Based on the results of the survey and pretest questions from the trial of 2 questions answered by the students, the results were 7% of 41 students answered correctly with an average of 70, while the remaining 93% of students still misunderstood the problem of the problem, mathematical modeling, students did not literate the questions well and correctly, the algorithm in operating the questions still had many errors, interpretations of the questions they had not mastered well. The questions given were related to the LPG context of the 2 questions. It can be stated that students at the school, as the subject of the research, still had many errors and difficulties in their mathematical literacy abilities. According to the research Nugroho, Hilalunnaja, Wuryastuti, and Ardiansyah (2024) Having developed website-based learning, it can be an interesting learning media innovation and become one of the best solutions in order to improve the quality of education for students with the support of good mathematical literacy skills.

Thus, the researcher provides a solution to the problem at SMP LTI Indo Global Mandiri by developing a mathematical modeling website to support the

mathematical literacy of ninth-grade students. Based on this problem, this study focuses on the characteristics of website based media in mathematical modeling learning with the LPG context to support the mathematical literacy skills of ninth-grade students. The purpose of the study is to produce website based media that is valid, practical, and able to support the mathematical literacy skills of ninth-grade students as seen from small group literacy ability trials.

METHODS

This study uses a design research approach, a development studies type, which focuses on the process of developing and testing website based learning media for mathematical modeling learning in the context of LPG. This approach was chosen because it allows for continuous improvement through a formative evaluation process, resulting in a valid, practical, and high quality product (Akker, Gravemeijer, Mckenney, & Nieveen, 2006). The research follows the Formative Evaluation flow (Tessmer, 1993a) in the following figure 1:

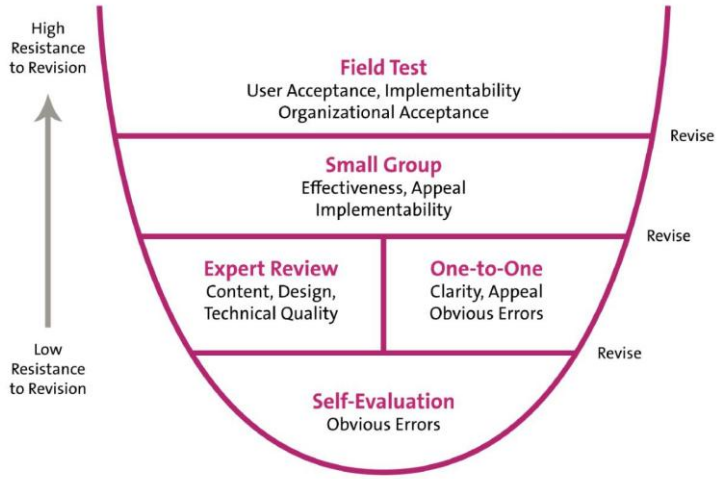


Figure 1. Formative Evaluation Flow (Tessmer, 1993a)

The self-evaluation phase began with a needs analysis, student characteristics analysis, a study of the LPG context, and a review of SLETV material from curriculum books (Kemendikbudristek, 2022) and relevant literature. At this stage, prototype I was developed, a preliminary design for a website based media containing the mathematical literacy structure (formulate employ interpret), SLETV material, examples of LPG contextual modeling, and problem designs. The initial draft was analyzed to identify content gaps and apparent errors, as characterized by this phase according to Tessmer.

After the prototype was completed, the research proceeded to two parallel evaluations: expert review by nine validators (five material experts, including modeling, literacy, and SLETV, and four media experts) and one on one trials with three ninth grade students at SMP LTI IGM Palembang to assess content, modeling flow, design, pedagogy, technical quality, readability, and navigation. In line with Tessmer's principles, feedback from both stages was combined to revise content, appearance, and navigation into prototype II, then further refined through a small group trial with 6 ninth grade students using observations and practicality questionnaires, producing a more mature prototype III focused on validity and practicality. The study used expert validation sheets, one on one and small group observation sheets, a Likert-scale practicality questionnaire, and a mini mathematical literacy test to ensure the media met early stage content validity and practicality standards, while validity analysis employed a combined validity formula to evaluate pedagogical quality, SLETV substance, correctness of the modeling flow, and display quality based on validator assessments (Febrianto & Puspitaningsih, 2020):

$$V_{tot} = \frac{\sum(V_1 + V_2 + V_3 + V_4 \ldots + V_n)}{n}$$

Information:

V_{tot} = Total combined validation percentage
$\sum V$ = Total Value
n = Number of response groups
Vn = Validation results from the nth validator

This formula yields a validity assessment score, which is then averaged to obtain a validity value that indicates the media's validity category. The following table shows the media validity categories.

Table 1. Media Validity Assessment

No.	Score	Assessment Categories
1.	4,2 < V ≤ 5	Very Valid
2.	3,4 < V ≤ 4,2	Valid
3.	2,6 < V ≤ 3,4	Quite Valid
4.	1,8 < V ≤ 2,6	No Valid
5.	0 ≤ V ≤ 1,8	Totally Invalid

Source: Modification Widoyoko (2009)

Information:

V = Average score

Practicality analysis was carried out at the small group stage using a 1–5 Likert-scale questionnaire to assess the clarity, attractiveness, and effectiveness of the media for students. The resulting practicality scores were used to determine the media's practicality category and, together with validity analysis, to provide an overall picture of media quality before the next implementation stage, using a specific calculation formula (Matondang, 2022).

$$Value = \frac{Raw\ Score}{Ideal\ Maximum\ Score} \times 100$$

Information:
Raw Score = Score of correct answer processing results
Skor Maksimum Ideal = The maximum score from all correct answers

Learning media is categorized as practical if it achieves a practicality score above 70. Table 2 presents the practicality categories and criteria used for classifying the media.

Table 2. Media Practicality Criteria

No.	Score	Practicality Category
1.	85 < P ≤ 100	Very Practical
2.	70 < P ≤ 85	Practical
3.	55 < P ≤ 70	Quite Practical
4.	40 < P ≤ 55	Less practical
5.	0 ≤ P ≤ 40	Impractical

Source: Modification Widoyoko (2009)

Information:
P = Practical

Table 2 provides the practicality categories used to determine whether the developed website media is sufficiently practical. Mathematical literacy skills are measured from small group students' answers, analyzed, and compared between the pretest and posttest stages, with the criteria presented in table 3.

Table 3. Interpretation of Mathematical Literacy Ability Values

No.	Score	Practicality Category
1.	78-100	Tinggi
2.	37-77	Currently
3.	0-36	Rendah

Source: Modification Widoyoko (2009)

RESULTS AND DISCUSSION

The development of the website-based media began with an analysis of the Merdeka Curriculum, which showed that systems of linear equations in two variables were among the most difficult topics, especially for solving contextual problems. Based on the results of the initial analysis survey, which distributed two pretest questions, the first two in the 60 minute pretest, only a few students were able to answer two of the four questions. The rest did not answer at all, and the questions were answered to the best of their ability. Therefore, the researchers reduced the number of questions to two in both the pretest and posttest stages.

Based on the research results, from the trial of 2 questions answered by the students, the results were 7% of 41 students answered correctly, above the average of 70; the remaining 93% of students only identified some important information, and were still confused about determining variables. The mathematical model was incomplete; some contextual information was not represented correctly at the formulation stage. Not able to apply the model. The answer did not show the use of the mathematical model. There was no attempt to calculate the employing stage. Not interpreting. Not evaluating the Interpreting stage. The questions given related to the LPG context from the 2 questions can be stated that students at school, as the subject of the research, still had many errors and difficulties in students' mathematical literacy abilities., following Tessmer (1993) development flow starting with a self-evaluation stage in which the mathematical modeling website design was reviewed with a supervisor to identify initial shortcomings.

During the self-evaluation stage, nine comments and suggestions from two supervisors served as the basis for revising the initial design of the website-based learning media. The revisions included refinement of the main page, improvement of item wording, modification of items from open ended to closed-ended questions, relocation of the calculator from the mathematical modeling menu to the SLETV tools, and the addition of evaluation items. These revisions produced prototype I, which was subsequently tested through the expert review and one to one stages in accordance with Tessmer's formative evaluation sequence. Based on feedback from these stages, prototype II was developed and piloted with a small group of students representing high, medium, and low levels of mathematical ability. At this stage, the researcher explained the learning objectives, outcomes, and procedures for using the website smatdu.sireatifly.com, asked students to complete a Likert scale (1–5)

practicality questionnaire assessing ease of use, clarity of instructions, and smoothness of the modeling process, and to complete evaluation items individually through their respective accounts, as illustrated in figure 2.

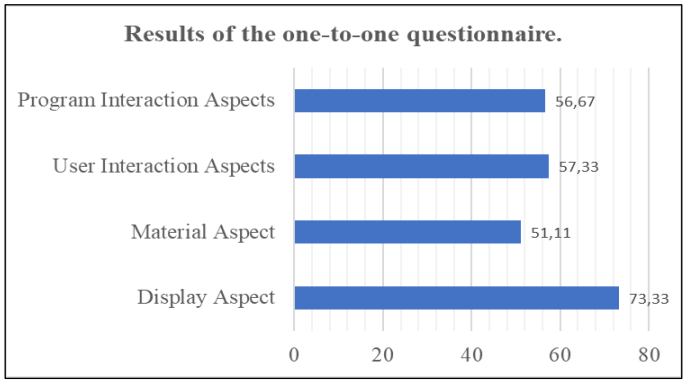
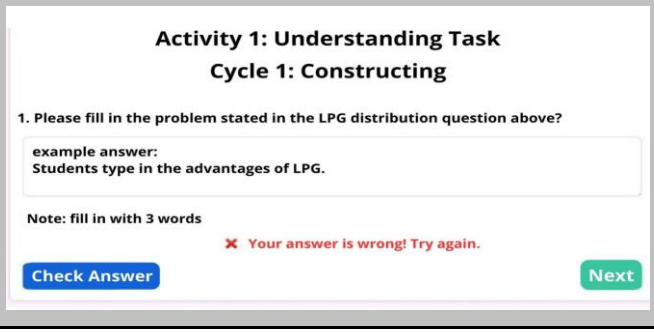
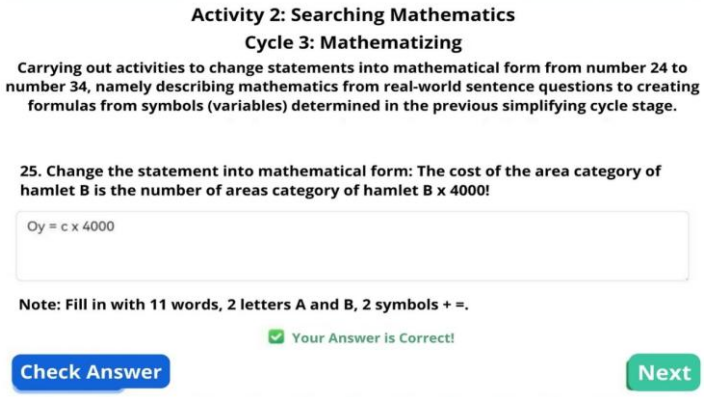
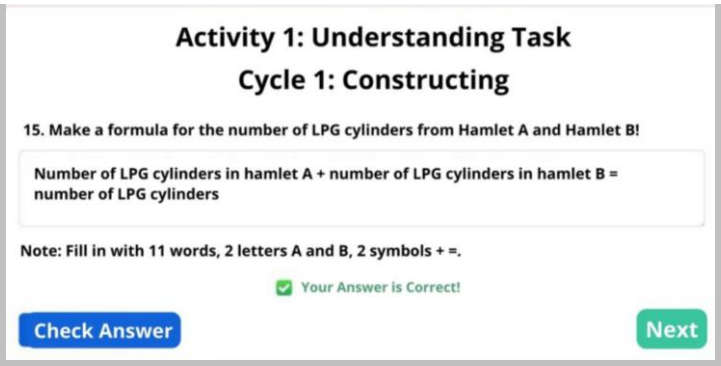


Figure 2. One-to-One Questionnaire Results Graph

The results of the one-to-one questionnaire shown in figure 2 indicate that the display aspect obtained a score of 73.33 and fell into the "practical" category, meaning the media's visual appearance was considered fairly attractive. In contrast, the material aspect score of 51.11, the user interaction aspect score of 57.33, and the program interaction aspect score of 56.67 were categorized as "not practical," indicating that while the material, user interaction, and program structure were functioning, several improvements were still needed to optimize their use in learning. In addition to these questionnaire results, the researcher also collected students' comments and suggestions, both orally and in writing, after they used the prototype 1 website-based media; these are presented in table 4, which summarizes student feedback at the one to one stage.

Table 4. Comments and Suggestions for the One to One Stage

Comments and Suggestions


Comments and Suggestions
Subject VL (High Ability) It's easy to understand, with clear visuals/images/infographics. The questions are easy, the material is simple, but very complex. I'd like to make inputting the answers easier. Only one answer key forces me to guess the  **Activity 2: Searching Mathematics** **Cycle 3: Mathematizing** **Carrying out activities to change statements into mathematical form from number 24 to number 34, namely describing mathematics from real-world sentence questions to creating formulas from symbols (variables) determined in the previous simplifying cycle stage.** **25. Change the statement into mathematical form: The cost of the area category of hamlet B is the number of areas category of hamlet B x 4000!** Oy = c x 4000 **Note: Fill in with 11 words, 2 letters A and B, 2 symbols + =.** Your Answer is Correct! Check Answer Next Subject BA (Medium Proficiency) It can train you to better understand the instructions/guidance before answering. I was enthusiastic about answering the questions because I received feedback on how correct they were, but I only managed to answer 25 questions. If I may suggest, make the questions multiple-choice so that inputting the answers is easier.  **Activity 1: Understanding Task** **Cycle 1: Constructing** **15. Make a formula for the number of LPG cylinders from Hamlet A and Hamlet B!** **Number of LPG cylinders in hamlet A + number of LPG cylinders in hamlet B = number of LPG cylinders** **Note: Fill in with 11 words, 2 letters A and B, 2 symbols + =.** Your Answer is Correct! Check Answer Next Subject AK (Low Ability) It's hard to understand because there are 50 essay questions, and I can only answer 15. Changing the questions is easier.

The revision decision, based on the suggestion from Table 4, was accepted because the essay questions were too complex and time-consuming. Therefore, based on VL's input, the researcher changed the 50 essay questions into a multiple-choice format to simplify answer input. Comments and suggestions in table 5 on the one-to-one stage with students of heterogeneous abilities. In the one to one stage, high-ability students can follow the modeling flow well, as modeling requires systematic steps that strong students can

understand (Riduan, Hartono, & Hiltrimartin, 2024). However, they still require simpler answer formats because input complexity can hinder mathematization. Medium-ability students benefit from step by step instruction and feedback. However, long problem sets can make them prone to losing consistency, just as complex modeling tasks can reduce students' accuracy (Riyanto, 2024). Low-ability students experience obstacles from formulation to interpretation because the questions are too long, in line with the finding that weak students have difficulty extracting information and building mathematical models (Wulandari, Rizki, & Hidayat, 2024). This condition shows the need for simplification of the context and stages in modeling (Aminah & Amidi, 2024).

Comments and suggestions from the one to one stage, combined with expert review input, became the basis for the researcher to revise prototype 1. However, the revisions were made after all validators had responded. This study involved 10 validators, consisting of 6 subject matter experts (teachers and lecturers in mathematics, mathematical literacy, and mathematical modeling) and 4 website media experts. The expert review process lasted for three weeks, with 6 validators conducting validation in person and 4 validators via WhatsApp. The results of the analysis of the validation sheet as a whole validate the website media expert construct in table 5.

Table 5. Construct Validation Sheet Results

No.	Rated aspect	V1	V2	V3	V4	Total	Assessment Categories
1	Usability Aspects	5	4,5	4	5	4,62	Very Valid
2	Functionality Aspect	5	5	4	5	4,75	Very Valid
3	Visual Communication Aspects	4,3	4	3,6	4,16	4,04	Valid
4	Display Aspect	4,6	4,4	3,8	4,4	4,3	Very Valid
5	Programming Aspects	5	4,6	4	4	4,4	Very Valid
6	Website Media Completeness Aspects	4,5	4,75	4	4,25	4,375	Very Valid
7	Website Usability Aspects	5	4,2	4	3,6	4,2	Very Valid

The graph in table 5 shows a score of 4.04 – 4.75, placing the website in the good very good category, consistent with findings that stable and easy to navigate web based media are considered highly suitable for mathematics

learning. High ratings for Usability, Programming, Appearance, and Completeness are also consistent with research that suggests accessibility, clear visuals, and comprehensive features support the effectiveness of digital media (Muhammad, Purba, & Sari, 2023).

While the need for minor improvements in the visual communication aspect is in line with findings that emphasize the importance of clarity of language and visual aesthetics (Fasa & Purwanti, 2023), and an average score of 4.38 confirms that this media is suitable for use as a validated digital media that is proven to support technology-based mathematics learning (Azmi, Sripatmi, Junaidi, & Wahidaturrahmi, 2024). With an average score of 4.38, the website based media was deemed suitable for use with minor revisions, as all aspects of usability, functionality, appearance, visuals, programming, completeness, and usefulness functioned well and supported students' mathematical modeling and mathematical literacy learning. In addition to the media expert validation sheet, the researchers also provided a material expert validation sheet to six material validators. The results of the analysis of the overall validation sheet of content and language validation of mathematical modeling experts and mathematical literacy ability experts are in table 6.

Table 6. Results of the Content and Language Validation Sheet

No.	Rated aspect	V5	V6	V7	V8	V9	V10	Total	Assessment Categories
1	Material Suitability	4,7	4,4	4,6	4,3	3,6	4,5	4,39	Very Valid
2	Mathematical Modeling Material Content	4,5	3,75	5	4,5	3,75	4	4,25	Very Valid
3	Language and communication	4	4,25	4,5	4,5	3,5	4,5	4,23	Valid
4	LPG Context and Literacy Skills	5	4,2	4	3,6	16,8	4,2	4,17	Very Valid

The validation results in table 6 show high scores (4.17 – 4.39), indicating that the website material is good and suitable for use, in line with the view that structured material increases the validity of mathematics learning. The highest score for the material suitability aspect confirms that the SLETV content and

modeling are appropriate for learning outcomes and authentic contexts, in line with the importance of contextual connectivity to mathematical literacy (Riyanto, 2022). The content aspect of the modeling is considered strong because it follows the modeling stages sequentially as recommended in the modeling literature (Niss & Blum, 2020).

Clear language and communication support the effectiveness of digital materials, while realistic LPG contexts support the Formulate, Employ, and Interpret processes as confirmed in real-world context-based research (Aminah & Amidi, 2024). With an average score of 4.25, the material was declared valid and suitable for use with minor revisions, consistent with the finding that highly validated learning devices are ready to be applied in mathematical modeling and literacy learning (Fajri, Hartono, & Hiltrimartin, 2022). In addition to reviewing the qualitative analysis results, the researchers also considered comments and suggestions from 10 validators to improve the website based mathematical modeling media and ensure it has the characteristics to be useful for school learning. The comments and suggestions from the expert review stage are shown in table 7 below.

Table 7. Comments and Suggestions for the Expert Review Stage

No.	Validator	Comments and Suggestions
Construct Validation		
1.	V1	The question language, navigation, "continue" system, and scoring were improved; questions were changed to multiple-choice, which more flexibly assesses students' thinking patterns.
2.	V2	Typos, punctuation, and question format were improved; all questions were made multiple-choice.
3.	V3	Admin and evaluation features were added, the website was made more dynamic and interactive (time, feedback, and modeling scores), and the login interface and location were improved. Evaluation scores were still assessed directly by researchers.
4.	V4	Focus was placed on improving the homepage, adding CP, learning objectives, video guides, and factual context; key suggestions were accepted.

No.	Validator	Comments and Suggestions
Content and Language Validation		
5.	V5	Emphasized improvements to the modeling cycle, separating the interpretation phase, simplifying the rules and question format, adding navigation and a time limit; all key points were addressed.
6.	V7	Requested sharpening of the assumptions section and minor revisions to the context and cycle, which were then adjusted for multiple-choice questions.
7.	V8	Limited modeling questions to a maximum of 20 items, suggested multiple-choice questions with distractors that support literacy, and added a paper answer sheet for calculations; all key points were addressed.
8.	V9	Emphasized the condensation of questions and objectives, and a shift to a simpler, less rigid multiple-choice format.
9.	V6	Highlighted the need for information on LPG distribution flows, simplified and reduced the number of questions, changed to multiple-choice, adjusted the time, and refined the contextual questions on LPG benefits; all key suggestions were implemented.
10.	V10	Ensured that evaluation questions align with mathematical literacy indicators.

After considering the comments and suggestions from table 7, the one to one trial results, and the expert validation results presented, the researchers conducted a series of revisions to adapt the media to student needs and the validators' recommendations. Student input during the one to one phase regarding difficulty understanding questions, complexity of answer input, and excessive number of questions was combined with expert suggestions regarding improvements to the display, navigation, quality of modeling materials, language use, and appropriateness of the LPG context and mathematical literacy. Based on these overall findings, the researchers made improvements to the media, some of the most frequent revisions requested by the validators and students based on suggestions and comments summarized in table 8 below.

Table 8. Revised View of Expert Review and One to one Stages

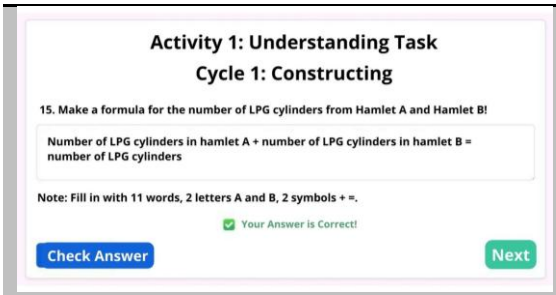
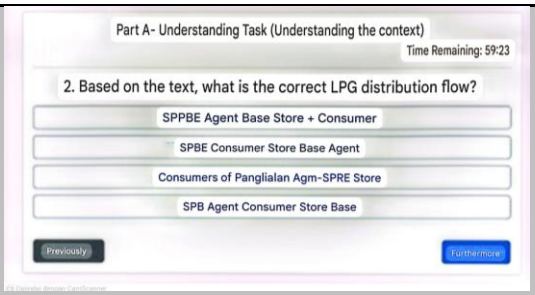
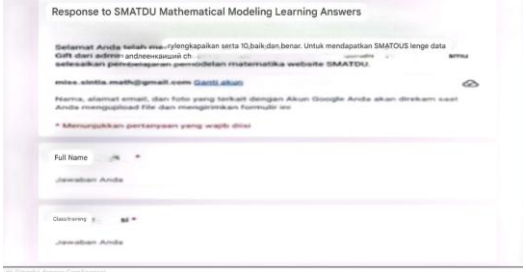
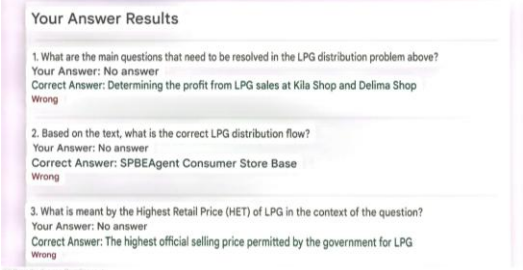
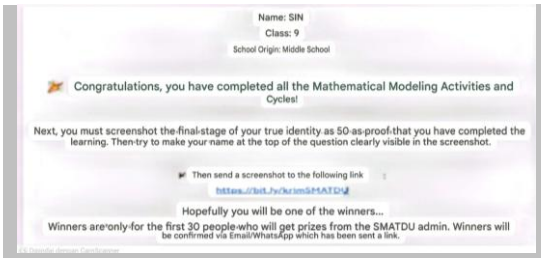
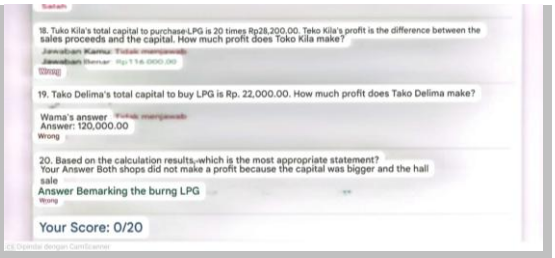
Before Revision	After Revision
	
Navigation flexibility, multiple-choice conversion, simplified rules/grading, typo fixes, and easier input.	Revisions: Navigation buttons added, questions converted to 20 multiple-choice with simplified rules, errors corrected, and student suggestions for easier input implemented.
	
Modeling questions should ideally be open-ended or have multiple correct answers.	Revisions: The questions have been replaced with multiple choice and have a series of questions that are interconnected according to the modeling cycle.
	
Admin scoring, interactive features, and flexible answer keys implemented.	Revisions: Admin scoring, interactive features, and multiple-choice answer keys implemented.

Table 8 presents the revised comments and suggestions from the expert review and one-to-one phases, which served as the basis for improvements in developing the mathematical modeling learning website. The expert validation

confirmed that the modeling content integrates understanding tasks, searching mathematics, and using mathematics activities, including model construction, mathematization, problem solving, and result interpretation. This indicates that the media not only provides SLETV exercises but also systematically guides students through a coherent mathematical modeling process aligned with the frameworks of Niss and Blum (2020) and PISA.

Based on the revisions summarized in the Improvement Table, the researchers developed prototype 2, which incorporated feedback from the one to one and expert validation stages. Prototype 2 was then tested in a small group to evaluate its practicality, usability, and students' understanding of mathematical modeling learning. This stage aimed to ensure that the revisions effectively improved media quality and resolved issues identified in the previous phase before proceeding to the field test.

The small group phase involved six students with heterogeneous abilities, consisting of two high, two medium, and two low ability students. The trial was conducted over three lesson hours, during which students used prototype 2 and completed a series of website-based mathematical modeling activities following the established procedures. The results of the small group questionnaire are presented in figure 3.

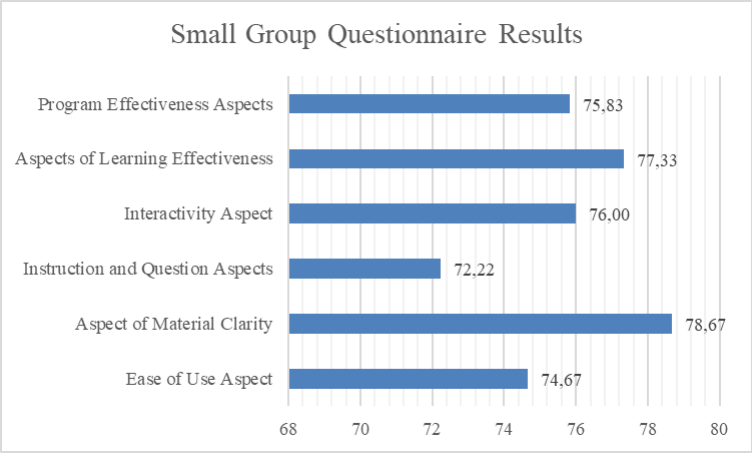


Figure 3. Small Group Questionnaire Results

In figure 3 small group subject 6 rated the overall website practicality at 75.79 (practical). Individual aspects: ease of use 74.67, material clarity 78.67, instructions 72.22, interactivity 76, learning effectiveness 77.33, program effectiveness 75.83. Eight comments informed prototype 2→3 revision.

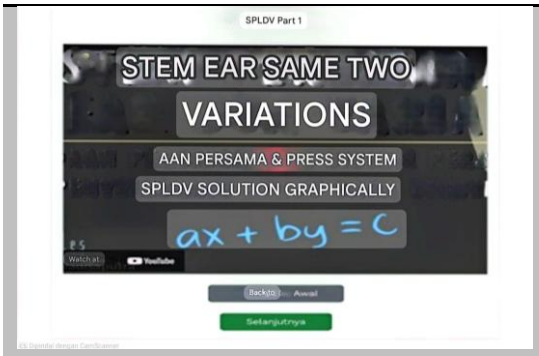
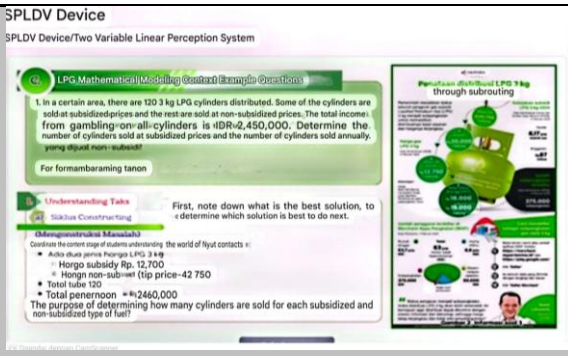
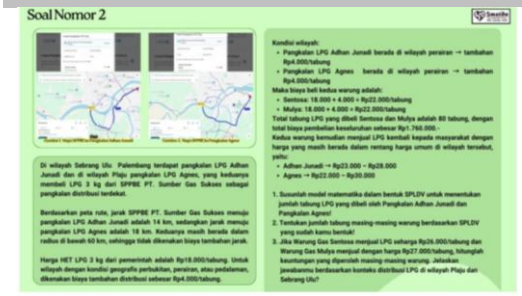
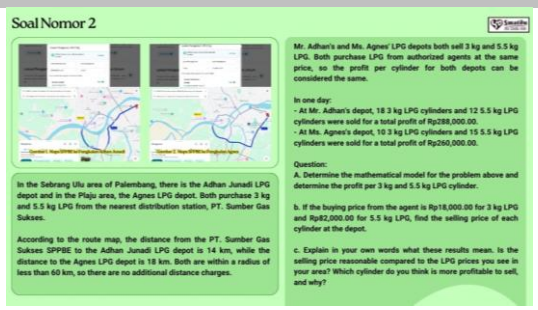
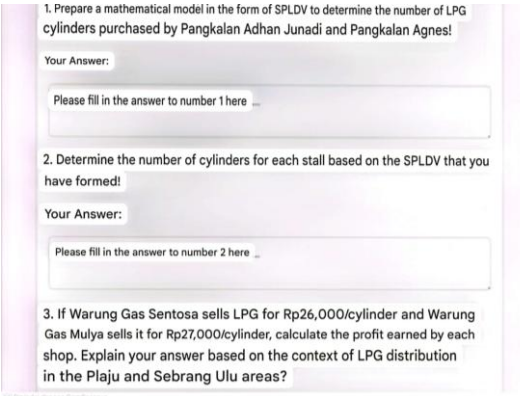
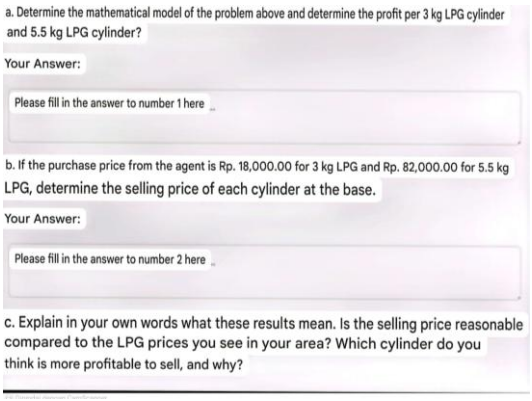
Researchers considered comments and suggestions on the prototype 2 website product to become prototype 3 when revised. The following table shows 8 comments and suggestions at the small group stage in table 9.

Table 9. Comments and Suggestions for the Small Group Stage

Small Group	Initial name	Comments and Suggestions
Group 1	MAR (High Ability)	The questions are complicated to solve. It's recommended to include examples and instructional videos on SLETV and mathematical modeling to help reinforce the concepts learned.
	HA (Moderate Ability)	because don't make it difficult.
	MFH (Low Ability)	The problem is long and difficult
Group 2	IRD (High Ability)	It was fun, but a bit confusing
	TJ (Medium Ability)	Awesome, cool, can learn a lot
	AYC (Low Ability)	Fun, Good, Exciting, but a bit difficult

Researchers collected comments and suggestions through direct feedback and questionnaires. Results from the small group stage indicated that high ability students found the media enjoyable but considered some questions too complex and suggested adding more examples and learning videos. Medium ability students perceived the media as engaging and helpful, although some felt the questions were still challenging. Low ability students found the display and activities interesting but experienced difficulties due to lengthy and complex questions. Overall, student feedback highlighted the need to simplify question difficulty, add examples, and strengthen conceptual explanations to support learners at all ability levels. These inputs were used to revise the website from prototype 2 to prototype 3, as summarized in table 10.

Table 10. Results of the Small Group Stage Revision

Before Revision	After Revision
	
Pre-revision: LPG videos lacked modeling; questions were difficult/long; needed SLETV examples. Mixed reactions (fun but confusing).	Learning videos have been added to address student difficulty with SLETV and modeling concepts.
	
	
Questions were simplified (especially number 2): not too difficult/long, matching real-world context.	Question 2 revised: real-world context, simplified language.

Based on table 10 Small group feedback prompted adding SLETV modeling videos (previously only covered LPG), simplifying complex questions, and revising visuals, resulting in a more stable prototype ready for further testing. The results of the study indicate that the developed media have three main characteristics: (1) valid, (2) practical, and (3) contextual, supporting mathematical modeling and mathematical literacy. In table 11, Supporting Small Group Mathematical Literacy.

Table 11. Supporting Small Group Mathematical Literacy.

No	Initials of name	Total Score of Pretest Questions on a 100-point Scale		Total of All Pretests	Total Score of Posttest Questions on a 100-point Scale		Total of All Posttests
		Question 1	Question 2		Question 1	Question 2	
1	MAR	29	27	56	44	33	77
2	HA	19	0	19	42	27	69
3	MFH	10	0	10	38	25	63
4	IRD	19	0	19	29	27	56
5	TJC	10	0	10	27	19	46
6	AYC	8	0	8	25	17	42

Based on the table 11 pretest and posttest results of the small group mathematical literacy test, the average score of the six students shifted from the low category (score < 37) to the moderate category (score 37–77). At the pretest stage, one student (16.7%) was classified in the moderate category, while five students (83.3%) were in the low category. After the implementation of the website-based mathematical modeling media, all six students (100%) achieved scores in the moderate category. This indicates an 83.3% increase in the proportion of students reaching at least a moderate level of mathematical literacy. These findings demonstrate that the website-based mathematical modeling media have a positive potential effect in supporting the improvement of ninth-grade students' mathematical literacy abilities. An example of a student's response is presented in table 12.

Table 12. Student Response Analysis

Student Answers in Indonesian	Student Answers in English
Laporan Evaluasi Peserta Didik : **Jawaban Soal Nomor 1 :** Jumlah tabung yang harus dibeli = 30 tabung Ht 3 kg = Rp 25.000 Hgt 12 kg = Rp 150.000 UPA = Rp 2.250.000 Total = 30 tabung Tb =18×25.000=450.000 18×25.000=450.000 12×150.000=1.800.000 Tt = Rp 2.250.000 X=30 Y=10	Number of cylinders to be purchased = 30 cylinders Ht 3 kg = Rp 25,000 Hgt 12 kg = Rp 150,000 UPA = Rp 2,250,000 Total = 30 cylinders Tb = 18 x 25,000 = 450,000 18 x 25,000 = 450,000 12 x 150,000 = 1,800,000 Tt = Rp 2,250,000 X = 30 Y = 10

Based on table 12, the analysis of student AYC's answer to question number 1 shows that only a few mathematical literacy indicators were achieved. For indicator (1), identifying mathematical aspects of the problem, the student identified only part of the important information and was still confused in determining variables and the relationships among information, resulting in a low score. For indicator (2), translating the problem into appropriate mathematical language, the student did not construct a mathematical model, and the answer was not relevant. At the employing stage, indicators (3) applying a mathematical model to find a solution and (4) applying facts, rules, and algorithms during the problem solving process were not achieved, as the student was unable to use a mathematical model. The response did not demonstrate the application of a model, rules, or correct mathematical operations, making the answer illogical. At the interpreting stage, the student's answer appeared contextually correct but was not supported by appropriate mathematical calculations using formulas. To strengthen these findings, the researcher conducted follow up interviews with the student after completing the evaluation test in the field test stage and after using the website-based learning media. The following section presents the interview transcript conducted by the researcher with the student.

The researcher asked about the difficulties encountered in question number 1, and AYC stated that they had difficulty constructing a mathematical model even though they understood the information provided in the problem. When asked about their understanding of mathematical modeling instruction,

AYC explained that they understood the concept but did not explicitly write the model in the website response for this particular problem.

Further clarification revealed that AYC used logical reasoning by estimating the cost per gas cylinder and adjusting it to match the required number of cylinders and the available budget. AYC also stated that the SPLDV modeling had been attempted separately on paper, but only the conclusion was written on the website answer. Based on the analysis of the data, results, and discussion, the researcher concluded that AYC was able to apply mathematical modeling through the learning process in a way that supported mathematical literacy, although the improvement was not significant. Furthermore, the researcher categorized the characteristics of the developed learning media as follows.

a. Characteristic 1: Valid Media in Terms of Material, Modeling, Literacy, and Appearance

The media expert validity score (4.38) and material expert score (4.25) indicate that the media fulfills content and construct validity. This is reflected in the appropriate modeling flow, clarity of the SLETV material, accurate use of the LPG context, and the quality of the website's visual design, consistent with the principle that valid media aligns with learning theory and curriculum objectives.

Furthermore, the media systematically integrates the mathematical modeling cycle proposed by Niss and Blum (2020), including constructing, simplifying, mathematizing, working mathematically, and interpreting, which supports the development of students' representational and analytical understanding.

b. Characteristic 2: Practical Media Used in Learning

The average practicality score of 75.79 indicates that the media is easy to use independently, with clear navigation, fast loading, and a stable display. This finding aligns with the usability criteria proposed by Tessmer (1993) as well as Andita (2023), which state that practical media can be operated efficiently without confusion. Student responses from the one-to-one and small group stages further confirmed that the media supported a coherent modeling flow and helped them understand the connections between context, mathematical models, and solutions.

c. Characteristic 3: Relevant and Contextual through the Use of LPG as an Authentic Context

The use of the LPG context was deemed relevant, authentic, and close to students' lives. The material validator stated that the LPG context was selected from real data on distribution, price, and distance, thus encouraging students to engage in literacy activities before building the SLETV model. This aligns with the perspective of (Arifin, Zulkardi, & Darmawijoyo, 2010) that local contexts strengthen meaningful learning and social reality-based modeling. Authentic contexts also strengthen mathematical literacy because students carry out the formulate–employ–interpret process according to the PISA framework (OECD, 2023a). Study Secgin, Baskurt, and Guner (2024) and Fajri, Marini, and Suyono (2025) also emphasized that modeling-based learning improves mathematical literacy skills because it encourages representation and reflection during problem solving.

d. Characteristic 4: Supporting Mathematical Literacy through Modeling Structures

This medium guides students through modeling structures:

1. Formulate – understand the LPG context, determine variables, and construct equations.
2. Employ – solve the SLETV.
3. Interpret – interpret the results according to the real-world context.

This structure is in line with the PISA framework OECD (2023b) and Niss and Blum (2020) modeling theory and is reinforced by research on modeling-based learning, which has been proven to improve mathematical literacy. The increase in mathematical literacy in this study is in line with the view that modeling helps students understand context, formulate models, and interpret solutions systematically (Kaur & Dindyal, 2010). The effectiveness of website media is also in accordance with the finding that authentic context clarifies the formulate employ interpret process in mathematical literacy (Nurhayati & Darmawijoyo, 2023). These results are supported by research that shows that modeling based learning tools can improve students' mathematical and interpretation skills. The use of real world contexts has been shown to improve mathematical literacy in developing PISA-oriented questions (Saputri & Turidho, 2020). Modeling-based teaching materials are also said to be effective in strengthening the ability to understand problems, build models, and reinterpret results in a realistic context (Darmawijoyo & Hartono, 2023).

e. Characteristic 5: Structured and Interactive Presentation of SLETV Material

The material is arranged sequentially according to the curriculum, equipped with modeling examples, videos, LPG distribution images, and exercises with automatic feedback. According to Noto, Karimah, Pramuditya, and Anggraeni (2020), Digital visualization helps reduce SLETV misconceptions and strengthens conceptual understanding.

f. Characteristic 6: Media Addresses the Problem of Low Mathematical Literacy

Initial findings indicated that students experienced difficulties in identifying information, determining variables, and interpreting results. After using the media, students showed improved understanding of problem structures, supporting Jamil, Cahyono, and Ayu (2021), who found that Indonesian students often struggle to connect real contexts with mathematical models and therefore require structured learning media.

Overall, media with these characteristics are suitable for mathematics learning, particularly for developing SLETV-based modeling skills in real contexts. The high level of validity in material content, modeling flow, and display and programming quality confirms that the media is appropriate for use as a website-based mathematical modeling learning tool in the LPG context for junior high school students.

CONCLUSION

The results of this study indicate that the website-based mathematical modeling learning media using the LPG real world context possesses valid, practical, and relevant characteristics to support the strengthening of ninth grade students' mathematical literacy. The validity of the media is evidenced by the average scores from media experts, 4.38, and material experts, 4.25, confirming that the SLETV structure and the stages of mathematical modeling constructing, simplifying, mathematizing, working mathematically, and interpreting are appropriately designed and aligned with mathematical modeling and mathematical literacy theories. Furthermore, the LPG context is presented as a real world context that supports meaningful and contextual learning. Practicality results from the one to one and small group stages, which demonstrate that the media is easy to use, features clear navigation, and effectively assists students in understanding contextual problems, constructing mathematical models, and interpreting solutions. Quantitative findings from

the small group trial reveal an improvement in students' mathematical literacy levels, where at the pretest stage, one student (16.7%) was categorized as moderate, and five students (83.3%) were in the low category, while after the implementation of the website-based mathematical modeling media, all six students (100%) reached the moderate category. These results indicate a positive potential effect of the developed media in facilitating students' mathematical literacy.

Based on these findings, the developed media successfully addresses the research objective of producing website-based learning media with high validity, good practicality, real world contextuality, and the capacity to support mathematical literacy. For future research, it is recommended to conduct field test trials with larger and more diverse samples to examine the direct impact of the media on improving students' mathematical literacy skills. In addition, future studies may enhance the media by integrating automatic assessment features, expanding variations of real world contexts, and incorporating adaptive learning elements to better accommodate diverse student learning needs.

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DECLARATIONS

Author Contribution	:	SA: Conceptualization, Writing–Review, Instrument development, Writing–Original Draft, Methodology, and Supervision. D: Conceptualization, Methodology refinement, Formal analysis, and Writing–Review & Editing. S: Data collection, Data analysis support, and Writing–Review & Editing.
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