

DEVELOPMENT OF LEARNING MEDIA BASED ON USING THE PREDICT-OBSERVE-EXPLAIN MODEL TO ENHANCE STUDENTS' MATHEMATICAL UNDERSTANDING SKILLS

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ABSTRACT

Learning in the subject of Three Variable Linear Equation Systems (SPLTV) still tends to focus on solution procedures, so that students' conceptual understanding has not developed optimally. This study developed a Google Sites-based learning medium integrated with the Predict-Observe-Explain (POE) model and examined its validity, practicality, and indications of effectiveness. The research used a Research and Development approach with ADDIE stages involving 40 tenth-grade high school students. Data were obtained through mathematical comprehension tests, expert validation sheets, and student response questionnaires, and analyzed descriptively using achievement percentages and N-Gain calculations. The validation results showed that the media was in the high validity category with a material expert assessment percentage of 90.3% and a media expert percentage of 84.7%, while student responses were in the practical category with a percentage of 75.23%. The improvement in mathematical comprehension ability was indicated by an average N-Gain score of 0.55, which is in the moderate category. These findings show that web-based media combined with the POE stages helped students compare their initial assumptions with their observations and systematically construct explanations of concepts, thereby supporting the formation of more meaningful mathematical comprehension.

Keywords: Learning Media, Google Sites, Predict-Observe-Explain, Mathematical Understanding, SPLTV

How to Cite: Suryati, N., Luritawaty, I. P., & Sumartini, T. S. (2026). Development of Learning Media Based on Using The Predict-Observe-Explain Model to Enhance Students' Mathematical Understanding Skills. *Mathline: Jurnal Matematika dan Pendidikan Matematika*, 11(2), 349-364. <http://doi.org/10.31943/mathline.v11i2.1119>

PRELIMINARY

Rapid technological developments and social changes have placed students in increasingly dynamic learning situations. Learning in the digital era no longer focuses only on the delivery of information but also on developing students' higher-order thinking skills and meaningful understanding through the integration of technology and contextual learning experiences (Ellianawati et al., 2025; Kemendikbudristek, 2022; Zubaidah, 2017).

Mathematics learning should not only emphasize procedural skills but also support students' conceptual understanding. Mathematics learning requires students to reason,

solve problems, and relate concepts to contextual situations (Masitah, 2024; Widad & Hadi, 2025). Mathematical understanding enables students to connect mathematical ideas, interpret concepts logically, and apply them in problem-solving situations (Huang & DosAlmas, 2024; Meliyana et al., 2020; Sari et al., 2022). In this study, mathematical understanding refers to students' ability to restate concepts, relate mathematical ideas, and apply concepts in problem-solving situations (Kilpatrick et al., 2001).

Facts in the field show that students' conceptual understanding in mathematics learning has not developed optimally. Based on observations conducted at a public high school in Garut Regency, students experienced difficulties in understanding the Three Variable Linear Equation System (SPLTV) material, especially when solving contextual problems and explaining the reasoning underlying solution procedures. Interviews with the mathematics teacher also indicated that students often made mistakes in translating contextual problems into algebraic models. In addition, the results of the initial test showed that most students were only able to perform procedural steps without understanding the underlying concepts. These findings indicate a gap between students' procedural abilities and conceptual understanding in mathematics learning (Istiqomah & Nurulhaq, 2021; Komariah et al., 2018).

The Predict-Observe-Explain (POE) model encourages students to actively construct understanding through prediction, observation, and explanation activities. In the prediction stage, students activate their prior knowledge, while the observation and explanation stages encourage students to compare their initial ideas with the obtained results and reorganize their understanding through reflection (Furqani et al., 2018; Gustina et al., 2023). Through this process, students are encouraged to develop conceptual understanding and strengthen mathematical representations (Yuan et al., 2018; Aprilla et al., 2024).

The prediction, observation, and explanation stages in the POE model require media that can present problems, visualizations, and reflection activities in a structured manner. Google Sites provides an accessible web-based platform that supports interactive and independent learning through the integration of learning materials, videos, worksheets, and reflection activities (Arnisyah et al., 2025; Widyawati et al., 2025). The integration of Google Sites with the POE model enables students to engage in prediction, observation, and explanation activities systematically, thereby supporting conceptual understanding and increasing student engagement (Maryanti, 2018; Wardana & Ardani, 2021).

The topic of the Three Variable Linear Equation System (SPLTV) is an important topic in algebra learning because it requires students to connect algebraic representations, mathematical modeling, and problem-solving processes simultaneously. Students are expected not only to determine the values of variables but also to understand how relationships between variables represent real-life situations. Therefore, learning SPLTV requires conceptual understanding so that students can interpret mathematical models meaningfully and apply them in solving contextual problems.

Several studies have discussed the application of active learning and the use of web-based media in mathematics education. Some studies focus more on the use of learning models, while others highlight the role of digital media in supporting the learning process. Previous studies have shown that the POE model can improve conceptual understanding through prediction and reflection activities (Furqani et al., 2018), while web-based media such as Google Sites can support interactive and accessible learning environments (Laili et al., 2025). However, most studies still examine these two aspects separately. Research that integrates Google Sites-based learning media with the pedagogical stages of the Predict-Observe-Explain model specifically to support students' mathematical understanding of SPLTV material is still limited. This indicates a research gap in the integration of pedagogical learning models and web-based digital media to support conceptual understanding in algebra learning.

Based on this description, this study aims to develop and evaluate the feasibility of Google Sites-based learning media integrated with the Predict-Observe-Explain (POE) model to support students' mathematical understanding of the Three Variable Linear Equation System (SPLTV). The developed media was expected to be feasible in terms of content and appearance and to be able to help students build conceptual understanding through the stages of prediction, observation, and explanation in a structured manner, while also increasing students' active involvement and independence in learning.

METHODS

This research is a development study that focuses on the design and testing of the feasibility of Google Sites-based mathematics learning media integrated with the Predict-Observe-Explain (POE) model in Three Variable Linear Equation System (SPLTV) material. The media was developed to support the formation of students' mathematical understanding. The development process followed the ADDIE framework, which includes the stages of analysis, design, development, implementation, and evaluation (Branch,

2009). In this study, each stage of the ADDIE model was carried out systematically to ensure that the developed learning media was aligned with students' learning needs and classroom learning conditions.

The analysis stage was conducted to identify students' learning needs, classroom learning conditions, and the potential use of digital learning media in SPLTV learning. Data were collected through classroom observations and student interviews to identify students' difficulties in understanding SPLTV concepts and to review the learning resources used in class. The results of this analysis were used as the basis for designing learning media that aligned with students' characteristics and classroom learning practices.

Based on the results of the needs analysis, the study proceeded to the design stage, which involved designing Google Sites-based learning media integrated with the POE stages. At this stage, learning objectives, SPLTV materials, and POE-based learning activities were prepared and organized systematically. In addition, worksheets, instructional videos, exercises, and evaluation activities were designed to support students' mathematical understanding.

The next stage was the development stage, in which the design that had been prepared was realized into Google Sites-based learning media. At this stage, learning materials, instructional videos, worksheets, and evaluation questions were integrated into the Google Sites platform. In addition, research instruments such as validation sheets, mathematical understanding tests, and student response questionnaires were prepared to evaluate the feasibility and practicality of the developed media.

The developed media and research instruments were then validated by experts before being implemented in learning. Media validation was conducted by three media experts, while material validation was carried out by three mathematics teachers. The validation process aimed to assess the appropriateness of the content, design, and instructional aspects of the developed media. The validators provided both quantitative scores and qualitative suggestions for improvement. Based on the validators' feedback, several revisions were made, including improving the clarity of learning instructions, refining the visual layout of the Google Sites interface, and adjusting several practice questions to better align with the SPLTV learning objectives.

The developed product was then tested on a limited basis to observe the feasibility of using the media in learning. This stage represents the implementation stage of the ADDIE model, in which the developed Google Sites-based learning media was used during mathematics learning activities in the classroom. The implementation was

conducted in two classroom meetings during the SPLTV learning sessions. The learning activities were facilitated by the mathematics teacher, while the researcher observed the implementation process and collected research data. All students in the selected class were involved in the learning activities using the developed media. During this stage, students accessed the learning media through the provided link and carried out learning activities according to the POE stages under the guidance of the teacher. The evaluation stage consisted of formative and summative evaluation. Formative evaluation was conducted during the development process to identify aspects of the media that required improvement, while summative evaluation was conducted after implementation to assess the feasibility, practicality, and effectiveness of the developed learning media.

The trial was conducted in the odd semester of the 2025/2026 academic year with 40 10th-grade students at a public high school. The subjects were selected purposively by considering the suitability of SPLTV material in the 10th-grade curriculum and the readiness to use web-based media at school. The selection of this class was based on the recommendation of the mathematics teacher and the consideration that the class had already studied prerequisite algebra material needed to understand SPLTV concepts. The functionality of the media in relation to students' mathematical understanding was reviewed using a one-group pretest-posttest design through tests administered before and after learning. Initial analysis was conducted descriptively to see changes in student scores, then the increase in ability was calculated using N-Gain.

The test instrument consisted of five essay questions compiled based on mathematical comprehension indicators, including the ability to state concepts, relate concepts, and use concepts in problem solving. The test instrument was validated by three subject matter experts to assess the suitability of the content and structure of the questions. The validation results were used as the basis for revising several questions that were considered unclear or less aligned with the intended indicators. After the revision process, the instrument was declared suitable for use in the research. The reliability of the instrument was calculated using a reliability coefficient and was found to be adequate.

Research data were collected through tests and questionnaires. The tests were used to measure changes in students' mathematical understanding, while questionnaires were used to assess the validity and practicality of the developed media. The validation process involved expert judgments to evaluate the quality of the media and learning materials. The media assessment aspects included learning, appearance, and design, while the material validation aspects included content quality, learning objective suitability, feedback,

adaptability, and learning motivation. Student responses were used to assess the practicality of the media based on creativity, effectiveness, efficiency, interactivity, and appeal. The questionnaire used a five-point Likert scale ranging from 1 (very poor) to 5 (very good). The obtained scores were then converted into percentage values to determine the feasibility and practicality categories of the developed media.

The data were analyzed using qualitative and quantitative descriptive analysis. Input from validators was described to improve the product, while assessment scores were calculated in the form of achievement percentages to determine the category of media feasibility and practicality. Learning effectiveness was determined through the N-Gain value obtained from the pretest and posttest scores, and reviewed based on the average achievement of each mathematical understanding indicator to see the aspects of understanding that had improved. Mathematically, the percentage of achievement was calculated using the following formula.

$$Achievement\ Percentage = \frac{Total\ Score\ Obtained}{Ideal\ Score} \times 100\% \tag{1}$$

Based on the calculation of the average score above, the percentage score obtained from the study is then described according to the media feasibility percentage qualification criteria presented in the following table.

Table 1. Media Validity Criteria

Percentage	Category
81% - 100%	Very Valid
61% - 80%	Valid
41% - 60%	Fairly Valid
21% - 40%	Less Valid
0% - 20%	Very Invalid

Source: Caesar & Wiratama (Suharti, 2025)

Table 2. Media Practicality Criteria

Percentage	Category
81% - 100%	Very Practical
61% - 80%	Practical
41% - 60%	Fairly Practical
21% - 40%	Less Practical
0% - 20%	Very Impractical

Source: Caesar & Wiratama (Suharti, 2025)

Effectiveness assessment is calculated using N-Gain, with the following formula:

$$N - Gain = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximum Score} - \text{Pretest Score}} \quad (2)$$

Then, the results of the N-Gain formula calculation are represented in the N-Gain criteria, which can be seen in Table 3.

Table 3. N-Gain Criteria

N-Gain	Category
$g \geq 0.7$	High
$0.3 \leq g < 0.7$	Moderate
$0 < g \leq 0.3$	Low

Source: (Wahab et al., 2021)

The improvement analysis was also reviewed based on the average score of each mathematical understanding indicator to obtain an overview of the aspects of understanding that had improved.

RESULTS AND DISCUSSION

This study produced Google Sites-based mathematics learning media that integrates the Predict-Observe-Explain (POE) stages in the Three Variable Linear Equation System (SPLTV) material. The development process followed the ADDIE flow, but its implementation was not merely a matter of carrying out technical procedures; rather, it was tailored to the learning needs found in schools.

Analysis

The analysis stage was carried out through learning observations and interviews with students and teachers at the school where the research was conducted. The observation results showed that mathematics learning was still dominated by teacher explanations and the use of textbooks, while the use of digital learning media was not yet optimal. This condition caused some students to have difficulty understanding mathematical concepts, especially in SPLTV material, which requires conceptual understanding and interrelationships between equations.

The interview results showed that although students were accustomed to using digital devices, they had never used them as a means of learning mathematics. Teachers also said that there were no structured digital media available to help students learn independently. These findings became the basis for the development of web-based media that is easily accessible and enables learning interaction.

Google Sites was chosen because it is easily accessible via a single link, flexible to use, and allows for the integration of various learning content. This platform enables

teachers to organize learning materials, videos, worksheets, and evaluation activities in one integrated digital environment, making it easier for students to access learning resources anytime and anywhere. Previous studies also report that web-based learning platforms such as Google Sites can support interactive learning environments and facilitate students in exploring learning materials independently (Harpeningtyas et al., 2025). Through this digital environment, students can interact with learning content more actively, which helps them build conceptual understanding rather than merely memorizing procedures.

The integration of the Predict-Observe-Explain (POE) model further strengthens the pedagogical function of the media. In the prediction stage, students are encouraged to activate their prior knowledge when responding to contextual problems. During the observation stage, students examine the results of problem-solving activities or visual representations provided in the media. Finally, in the explanation stage, students reflect on the relationship between their predictions and the obtained results. This process encourages cognitive conflict and conceptual restructuring, which are essential processes in developing mathematical understanding. Therefore, the integration of Google Sites with the POE stages not only provides technological support but also facilitates a structured learning process that promotes active conceptual construction.

Design

The results of the needs analysis formed the basis for the design of the learning media. At the design stage, the researchers compiled learning objectives, SPLTV material, sample questions, exercises, and evaluations tailored to the curriculum and characteristics of 10th-grade high school students. The design of the media also took into account the integration between the content of the material and the stages of the Predict-Observe-Explain (POE) model so that the learning process ran systematically and supported the strengthening of conceptual understanding.

The structure of the Google Sites-based learning media is designed with several main menus, namely the home page, learning materials, POE-based worksheets, evaluation, and reflection. The materials menu serves to present the SPLTV concept explanation in stages, while the worksheet menu is designed to facilitate prediction, observation, and explanation activities through structured tasks. The evaluation menu is used to measure students' understanding after participating in learning, while the reflection menu provides space for students to reflect on the learning process that has been carried out. This design is expected to help students build their understanding of SPLTV concepts

in a gradual, active, and structured manner in accordance with the characteristics of the POE model.

Development

The development stage produced Google Sites-based mathematics learning media integrated with the Predict-Observe-Explain (POE) model in SPLTV material. The learning media was developed based on the design stage, taking into account the flow of use, menu structure, and the integration of learning activities with the POE stages.



Figure 1. Home Menu

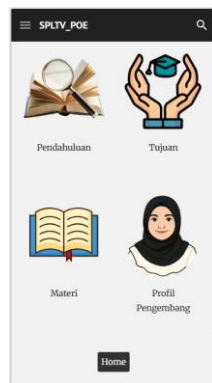


Figure 2. Main Menu

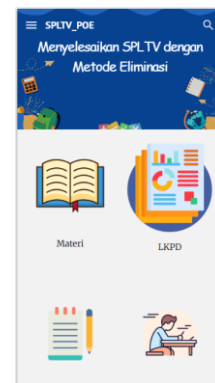


Figure 3. Material Menu

The developed Google Sites-based learning media consists of several integrated menus, including introduction, learning objectives, learning materials, POE-based worksheets, evaluation, reflection, and developer profile features, as shown in Figures 1–3. The media was designed to facilitate students in accessing SPLTV materials systematically through the Predict, Observe, and Explain stages. Contextual problems, worksheets, and reflection activities were integrated into the media to support students’ conceptual understanding and active participation during learning.

The validity of the learning media developed was then tested through expert assessment before being trialed with students. Validation was carried out by three subject matter experts, namely high school mathematics teachers who had experience teaching SPLTV material. The subject matter expert validation aimed to assess the feasibility of the learning media in terms of content and learning objectives. The aspects assessed included content and material quality, learning objective suitability, feedback and adaptation, and student learning motivation. The results of the subject matter expert validation of the developed learning media are presented in Table 4.

Table 4. Results of Material Expert Validation

Aspect	Ideal Score	Validator			Achievement Percentage (%)
		1	2	3	

Content/Material Quality	60	18	19	17	90.0
Learning Objectives	60	19	18	19	93.3
Feedback and Adaptation	30	9	8	9	86.7
Motivation	15	4	5	4	86.7
Total Achievement	165	50	50	49	90.3

Table 4 shows that the developed Google Sites-based learning media achieved a validity percentage of 90.3%, indicating that the media met the validity criteria in terms of content, learning objectives, feedback, and student motivation. The high validity score indicates that the developed media aligns with the SPLTV curriculum, learning objectives, and POE learning stages, thereby supporting meaningful learning and students' conceptual understanding.

In addition to being validated by subject matter experts, the Google Sites-based learning media developed was also validated by three media experts. Media expert validation aims to assess the feasibility of learning media in terms of learning, media, and design. The results of media expert validation of the learning media developed are presented in Table 5.

Table 5. Media Expert Validation Results

Aspect	Ideal Score	Validator			Achievement Percentage (%)
		1	2	3	
Learning	50	21	20	22	84.0
Media	50	20	21	21	82.7
Design	50	22	21	22	87.3
Total Achievement	150	63	62	65	84.7

Based on Table 5, the results of media expert validation show that the Google Sites-based learning media developed has met the eligibility criteria as learning media. The assessment from the validators indicates that the learning, media, and design aspects have been well organized and mutually supportive in facilitating the mathematics learning process. The total achievement percentage of 84.7% indicates that the learning media is valid and suitable for use in learning with minor revisions as suggested by the experts.

The positive evaluation from media experts indicates that the visual design, navigation structure, and integration of learning components in the Google Sites platform were considered effective in supporting the learning process. A clear interface and well-organized menu structure help students access learning materials more easily, which is important in digital learning environments. In addition, the integration of learning materials, worksheets, evaluation activities, and reflection features within a single platform allows students to experience a more structured and interactive learning process. These characteristics contribute to the overall feasibility of the developed learning media.

Implementation

At this stage, the learning process was carried out along with the collection of student responses to the Google Sites-based learning media integrated with the Predict-Observe-Explain (POE) model. Students accessed the learning media through their own devices by opening the link shared by the teacher. During the two learning meetings, students studied SPLTV sub-materials and carried out various learning activities provided in the developed Google Sites media. After the learning activities were completed, students filled out a response questionnaire to assess the practicality of the learning media. The results of the student response questionnaire are presented in Table 6.

Table 6. Student Feedback Questionnaire Results

Aspect	Ideal Score	Number of Achievement Scores	Achievement Percentage
Creative	432	306	70.83
Effectiveness	624	489	78.37
Efficient	192	142	73.96
Interactive	384	283	73.70
Interesting	624	476	76.28
Total Achievement	2256	1696	75.23

Table 6 shows that every aspect of the assessment of students' responses to Google Sites-based learning media is in the practical category. The average percentage of achievement for all aspects assessed is 75.23%, which falls within the practical category.

Students perceived the developed media as practical because the Google Sites platform provided easy access to learning materials, worksheets, and evaluation activities through a single interface. In addition, the integration of POE-based activities encouraged students to participate actively in prediction, observation, and explanation processes during learning.

In addition to practicality, the effectiveness of learning media was also analyzed based on the results of pretest and posttest of students' mathematical comprehension abilities after participating in learning using Google Sites-based media with the Predict-Observe-Explain (POE) model. The results of the comparison of pretest and posttest scores are presented in Table 7.

Table 7. Pretest and Posttest Results

Description	Pretest	Posttest
Average	54.20	79.60
Highest Score	65	92
Lowest Score	35	58

Based on the data presented in Table 7, there was an increase in students' mathematical comprehension abilities after using the developed learning media. The average pretest score of 54.20 increased to 79.60 on the posttest, with the highest score increasing from 65 to 92 and the lowest score from 35 to 58. To obtain a more detailed picture of students' conceptual development, the improvement in mathematical understanding was also analyzed based on each indicator of mathematical understanding. The results of this analysis are presented in Table 8.

Table 8. Improvement of Students' Mathematical Understanding Based on Each Indicator

Indicator	Average Pretest	Average Posttest	Improvement
Restating mathematical concepts	52.30	76.40	24.10
Relating mathematical concepts	55.10	80.20	25.10
Applying concepts in problem solving	55.20	82.20	27.00

As shown in Table 8, the highest improvement occurred in the indicator of applying concepts in problem solving, followed by relating mathematical concepts, while the improvement in restating mathematical concepts was relatively lower. This result suggests that the POE learning activities particularly supported students in applying mathematical concepts to problem-solving situations, rather than merely recalling definitions or procedural steps. This finding indicates that the learning activities designed in the Google Sites-based media encouraged students not only to recall mathematical concepts but also to apply them in solving contextual problems. The prediction and observation stages in the POE model helped students identify relationships between variables in SPLTV problems, while the explanation stage supported students in articulating the reasoning behind their solutions. The relatively lower improvement in the "restating concepts" indicator may indicate that students were more engaged in problem-solving and reasoning activities rather than recalling conceptual definitions. This pattern suggests that the POE learning process emphasized conceptual application and reasoning rather than memorization.

The improvement in students' scores was then analyzed using the normalized gain (N-Gain), which was calculated based on the pretest and posttest scores shown in Table 7. The calculation resulted in an average N-Gain value of 0.55, which falls into the moderate category.

The moderate N-Gain value indicates that the developed learning media was able to improve students' mathematical understanding, although the improvement was not yet in the high category. From the perspective of constructivist learning theory, this improvement

occurred because students actively constructed understanding through prediction, observation, and reflection activities during the learning process (Minarni & Napitupulu, 2020). The integration of the POE model and Google Sites platform supported conceptual understanding by encouraging students to compare their initial ideas with the obtained results, explore relationships between variables, and explain their reasoning through structured learning activities (Budiman et al., 2025). However, the improvement remained in the moderate category because the implementation was conducted in only two meetings, and some students were still adapting to digital learning and collaborative worksheet activities. These findings are consistent with previous studies showing that POE-based and technology-supported learning can facilitate deeper conceptual understanding in mathematics learning (Khodijah et al., 2020).

Evaluate

The evaluation stage was conducted by reviewing the developed media based on expert suggestions and student responses during the trial process. Several revisions were made to improve the clarity of instructions, visual appearance, and learning activities in the media so that they better supported students' understanding during POE-based learning activities. After the revision process, the developed Google Sites-based learning media was considered to meet the criteria of validity, practicality, and effectiveness as indicators of feasible learning media development (Milala et al., 2022).

CONCLUSION

This study produced Google Sites-based mathematics learning media that integrates the Predict-Observe-Explain (POE) model for the Three Variable Linear Equation System (SPLTV) material. The development results show that the media is feasible for use in mathematics learning based on three evaluation aspects, namely validity, practicality, and effectiveness.

The assessment by subject matter experts and media experts showed that the learning content was in line with the learning objectives and was supported by an adequate appearance and design. Student responses indicated that the media was easily accessible and helped them to learn more independently. In addition, the N-Gain calculation result of 0.55 (moderate category) showed an increase in students' mathematical comprehension skills after using the media.

These findings indicate that the integration of Google Sites with the POE stages can help students build a more structured understanding of SPLTV concepts. The developed

media can therefore be used as an alternative mathematics learning resource that supports active learning and promotes deeper conceptual understanding.

However, this study was conducted in a limited trial involving one class and a relatively short implementation period. Therefore, further studies are recommended to implement the developed media in broader learning contexts and over a longer period of time to obtain a more comprehensive picture of its impact on students' mathematical understanding.

ACKNOWLEDGMENT

The author would like to thank the school for providing the opportunity to conduct this research. Appreciation is also given to the subject matter experts and media experts for their input during the development process, as well as to the 10th-grade students who participated in the learning media trial.

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