

Design of Scratch-Based Learning Media on Systems of Linear Equations in Three Variables

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Abstract

SPLTV is a crucial topic for high school students. However, findings indicate low student learning outcomes in this subject. Therefore, this study aims to design Scratch-based learning media for SPLTV. This research employs the MDLC model, which consists of six stages: concept, design, material collecting, assembly, testing, and distribution. The research participants consisted of 10 pre-service mathematics teachers. The instruments used were validation sheets from media and content experts, open-ended and closed-ended questionnaires, and interviews to obtain deeper data. The results of the expert validation showed an average score of 95,4%, categorizing the media as Very Feasible. Furthermore, the developed learning media received an excellent response from students, with an average percentage of 95.7% from the closed-ended questionnaire and 100% from the open-ended questionnaire across all indicators: display, programming, content, language, interest, and usefulness. Interview results further strengthened these findings, where participants rated the learning media as attractive, easy to use, and capable of assisting in understanding concepts and applying SPLTV to real-life situations. Furthermore, the study identified several suggestions not captured in the questionnaires, such as the need for user instructions and bug fixes. In conclusion, the Scratch-based learning media for SPLTV is declared feasible, engaging, and beneficial for classroom use, with the potential to enhance students' interest and conceptual understanding.

Keywords: Learning Media; Scratch; SPLTV; MDLC; School Mathematics.

Abstrak

SPLTV merupakan materi yang krusial untuk siswa SMA. Namun, ditemukan rendahnya hasil belajar siswa pada materi tersebut. Sehingga tujuan penelitian ini adalah mendesain media pembelajaran berbasis Scratch pada Sistem Persamaan Linear Tiga Variabel (SPLTV). Penelitian ini menggunakan MDLC yang meliputi enam tahap, yaitu *concept*, *design*, *material collecting*, *assembly*, *testing*, dan *distribution*. Partisipan penelitian terdiri dari 10 mahasiswa calon guru pendidikan matematika. Instrumen yang digunakan berupa lembar validasi ahli media dan ahli materi, angket terbuka dan tertutup serta wawancara untuk memperoleh data yang lebih mendalam. Hasil validasi ahli menunjukkan bahwa media yang dikembangkan memperoleh rata-rata persentase sebesar 95,4% dengan kategori Sangat Layak. Sejalan dengan hal tersebut, hasil respons mahasiswa menunjukkan bahwa media pembelajaran memperoleh respons sangat baik dengan rata-rata persentase angket tertutup sebesar 95,7% dan angket terbuka sebesar 100% pada seluruh indikator, yaitu tampilan, pemrograman, materi, bahasa, minat, dan kebermanfaatan. Hasil wawancara

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juga memperkuat temuan tersebut, di mana partisipan menilai media pembelajaran menarik, mudah digunakan, serta mampu membantu pemahaman konsep dan penerapan SPLTV dalam kehidupan nyata. Selain itu, ditemukan beberapa masukan yang tidak terungkap dalam angket, seperti perlunya penambahan petunjuk penggunaan dan perbaikan bug pada media. Dengan demikian, media pembelajaran berbasis Scratch pada materi SPLTV yang dikembangkan dinyatakan layak, menarik, dan bermanfaat untuk digunakan dalam pembelajaran, serta berpotensi meningkatkan minat dan pemahaman siswa.

Kata Kunci: Media Pembelajaran; Scratch; SPLTV; MDLC; Matematika Sekolah.

INTRODUCTION

Mathematics has a fundamental role in education at all levels, because through mathematics learning students are trained to develop logical, analytical, systematic, critical, and creative reasoning (Pratama & Waskitoningtyas, 2020). Algebraic reasoning is the ability to understand the information in a problem, present it in a mathematical form such as a table, diagram, or equation, and use the results to solve other similar problems by utilizing the right symbols and mathematical tools (Herbert & Brown, 1997). One of them is the Three-Variable Linear Equation System (SPLTV) which has a close relationship with daily life to solve various problems (Sumiatik et al., 2019). Problem-solving is a common goal of mathematics learning, the core process of the mathematics curriculum, and the basic ability to learn mathematics.

Learning media is a means used to help deliver material so that learning goals can be achieved optimally. However, teachers also need to adapt the media to the level of cognitive development of students. At the secondary school level, students' formal thinking skills have not been developed comprehensively, so the use of semi-concrete media is still needed to help students understand abstract concepts more meaningfully (Widodo & Wahyudin, 2018).

Various studies show that one of the difficulties students in SPLTV material arises in the early stages, namely in building a mathematical model of story problems. Students often make mistakes in determining variables and constructing mathematical models in the context of problems (Supartinah &

Hidayat, 2021). Solving algebraic story problems requires comprehensive competencies, not only mastery of concepts, but also the ability to read, build mathematical models, apply procedures correctly, and reflect critically on results (Ario et al., 2025). It was found that 78% of students were unable to represent information to mathematical models on SPLTV topics (Kuswanti et al., 2018). Therefore, there needs to be a learning media that helps students understand SPLTV material well.

One alternative solution that can be used to overcome the problem of SPLTV is the use of technology-based interactive learning media. Scratch, built by the Massachusetts Institute of Technology (MIT), a digital game, can be used as an effective means to develop logic skills and problem-solving understanding (Nuraeni L et al., 2021) Easy to use (Imawati & Shubchan, 2018), and support the mathematization process, (Çakıroğlu & Muştuoğlu, 2025). The development of Scratch learning media on the Two-Variable Linear Equation System (SPLDV) material shows valid, practical, and effective results in increasing student engagement and understanding (Ihsan Zulfikar et al., 2022). There are various other studies that have been carried out to make Scratch media with various mathematical materials such as the presentation of functions (Libryanti & Sudihartinih, 2023), dilation (Sifa & Sudihartinih, 2025), and one-variable linear equations (Lestari & Eyus Sudihartinih, 2022). Research on the development of Scratch-based media that specifically focuses on SPLTV material is still limited. Therefore, this study aims to describe the results of Scratch design on SPLTV through the exploration of the relationship between variables conceptually so as to improve students' mathematical modeling skills in forming an equation system from contextual problems.

RESEARCH METHODS

This research uses the Multimedia Development Life Cycle (MDLC) design. MDLC has six stages: concept, design, material collection, assembly, testing, and distribution. In the concept stage, researchers focused on determining the objectives, audience, and type of program. In the design stage, researchers

planned the program's appearance using a storyboard. In the material collection stage, researchers collected or assembled the necessary materials. In the assembly stage, researchers compiled or created the program. In the testing stage, the program was checked. In the final stage, distribution, the program was stored on a storage medium. An outline of the stages in the MDLC model is presented in:

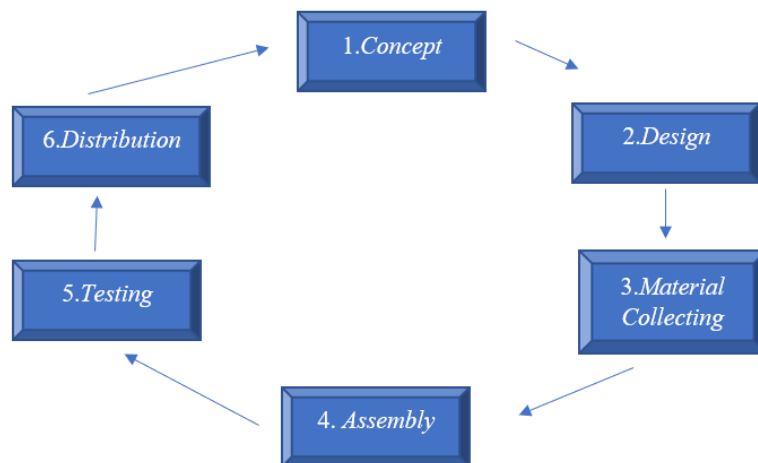


Figure 1. MDLC Model Stages

The program produced by the researcher is a Scratch-based learning media on the Three Variable Linear Equation System (SPLTV) material for high school (SMA) students. This learning media was developed by five people, namely three students and two lecturers. This learning media was developed in the Mathematics Education Study Program at one of the universities in West Java for one semester. The participants of this study are ten Prospective Teacher Students of the Mathematics Education Study Program at one of the universities in West Java with nine women and one man. With the user acceptance test, this study was carried out to see user responses to learning media that have been designed with the aim of seeing the suitability of the program with needs. The user acceptance test was carried out to students of the Mathematics Education study program to obtain more complete feedback about this learning media, both in terms of material and media quality. This test was carried out by interviews and the distribution of Google Form questionnaires.

Table 1. Indicators, Questions and Statements

No.	Indicators	Questions	Statements
1.	Appearance	What is the overall appearance of this learning media?	In my opinion, the display of this learning media is not attractive.
2.	Programming	How easy is it to use?	I think this learning media is easy to use.
3.	Material	Does this learning media help you understand the SPLTV material?	I think this learning media can help me understand the SPLTV material.
4.	Language	How is the language used in this learning media? Is it clear and easy to understand?	I think the language in this learning media is easy to understand.
5.	Interest	How interested are you in using this learning media to learn SPLTV material?	I think this program has increased my interest in learning SPLTV.
6.	Usefulness	Is this learning media useful for SPLTV material?	I think this program has helped me understand SPLTV.

The questionnaire in this test is an open and closed questionnaire (Lestari & Eyus Sudihartinih, 2022). The questionnaire consisted of six questions for the open questionnaire and six statements for the closed questionnaire with six indicators, namely display indicators (Meri Lidya Olga Nauli Hutabarat, 2024), programming (Hamria Hamka, 2022), material (Setiawan et al., 2021), language (Meri Lidya Olga Nauli Hutabarat, 2024), interest (Aulia et al., 2024), and benefits (Hamria Hamka, 2022). The indicators and questions used in the questionnaire are shown in Table 1.

The closed questionnaire contains responses that include several statements with four scoring alternatives 1, 2, 3 and 4. The data is then calculated based on the scores listed in Table 2 (Pratiwi & Bernard, 2021). Data from the closed questionnaire will be analyzed on a likert scale using Equation 1 ((Kartikawati & Wibawa in (Sifa & Sudihartinih, 2025)).

$$\text{Percentage (\%)} = \frac{\text{Total score}}{\text{highest score}} \times 100\%$$

Table 2. Scoring Guidelines

No	Criteria	Score	
		Positive	Negative
1	Strongly Agree (SS)	4	1
2	Agree (S)	3	2
3	Disagree (TS)	2	3
4	Strongly Disagree (STS)	1	4

Table 3. Positive Statement Categories

Persentase (%)	Category
$p > 80$	Excellent
$60 < p \leq 80$	Good
$40 < p \leq 60$	Fair
$20 < p \leq 40$	Poor
$p \leq 20$	Very Poor

Meanwhile, data from the open questionnaire will be analyzed by categorizing responses into two, namely positive and negative. To obtain more detailed information regarding user responses, interviews were conducted with two randomly selected participants, one female and one male. Calculation of the percentage of positive data using Equation 2 (Akdon & Riduwan in (Libryanti & Sudihartinih, 2023)).

$$\text{Percentage of Po Statements} = \frac{\text{Total score of positive statements}}{\text{Number of respondents}} \times 100\%$$

The percentage of positive data of the open questionnaire and the score of the closed questionnaire were classified by changing the categories based on the effectiveness criteria listed in Table 3 (Pratama & Waskitoningtyas, 2020) In this case, the value p represents the percentage.

The learning media developed was validated by media experts and subject matter experts with categories that can be seen in Table 4.

Table 4. Media Eligibility Categories by Experts

Percentage of Achievement (%)	Category
Score > 80%	Very Feasible (can be used without revision)
$60\% < \text{Score} \leq 80\%$	Feasible (can be used with minor revision)
$40\% < \text{Score} \leq 60\%$	Less Feasible (not recommended for use due to many revisions)
$20\% < \text{Score} \leq 40\%$	Not Feasible (not recommended for use due to many revisions)
Score $\leq 20\%$	Very Feasible (not suitable for use)

Adaptation (Asep Gunawan et al., 2025)

RESULTS AND DISCUSSION

Development of Scratch-Based Learning Media

Using the Multimedia Development Life Cycle (MDLC) model, the following is the process of developing Scratch learning media on SPLTV materials:

1. Concept

At the *concept stage*, we compiled the concept of learning media to be made, namely interactive learning media that can be used to facilitate the understanding of concepts regarding the Three Variable Linear Equation System (SPLTV) material and educational games to increase the learning interest of grade XI high school students with indicators, namely, understanding the concept of three-variable linear equations and their benefits in daily life, making mathematical forms/sentences/models from problems contextual, and compile a three-variable linear equation system.

2. Design

This *design stage* is an outline design of the appearance of learning media by making *a storyboard*. Storyboards are created using Microsoft Word that contains the initial view, main menu, creator profile, learning objectives, learning benefits, materials, and quizzes or *games*. In Figure 2, you can see one of the *storyboard designs* that have been made at this stage for learning media.

The complete storyboard is four pages on A4 paper regarding SPLTV materials and quizzes.

VISUAL	SKETSA	AUDIO
Dalam frame ini terdapat background layer dengan resolusi 1024x768, berisikan tujuan pembelajaran dan capaian pembelajaran.	Indikator Tujuan Pembelajaran: 1. Memahami konsep persamaan linear tiga variabel dan manfaatnya dalam kehidupan sehari-hari 2. Membuat bentuk / kalimat / model matematika dari masalah kontekstual 3. Menyusun sistem persamaan linear tiga variabel 	Fun music

Figure 2. Learning Media Storyboard Design Results

3. Material Collecting

At this stage of material collection, the maker searches and collects materials for the preparation of learning materials about SPLTV obtained through the Mathematics package book for SMA/MA Class X (Susanto et al., 2023). In addition to the materials, the creators also collect materials needed for learning media needs such as images or designs for the background of each page, images for sprites, and *backgrounds* that are officially downloaded on the internet through Canva and YouTube.

4. Assembly

This *Assembly* stage is the stage of creating learning media using Scratch adapted to the storyboard that has been made. The learning media is titled Smart Shopper Math, the initial appearance of this learning media can be seen in Figure 3(a). After the Start button is clicked, a menu display will appear as shown in Figure 3(b).



Figure 3. Media Home and Main Menu

On the material menu, a story of shopping at a minimarket will be presented as an initial stimulus for the discussion of the material. After that, the form of a three-variable linear equation system and three-variable linear equation is displayed, as well as an explanation of the components and elements in SPLTV such as Variables, Constants, and Coefficients. Here are some views on the Smart Shopper Math learning media seen in Figure 4.



Figure 4. Material Display

Figure 5(a) is the initial view of the quiz in the form of a choice of shopping vouchers from one to five that can be chosen by students accompanied by a supporting background. After selecting the question, a multiple-choice question display will appear as shown in Figure 5(b). If the student chooses the wrong answer, they will return to the question selection menu accompanied by a background that supports and is marked as correct wrong with green or red. If the student answers correctly, a shopping voucher will appear as shown in Figure 5(c).

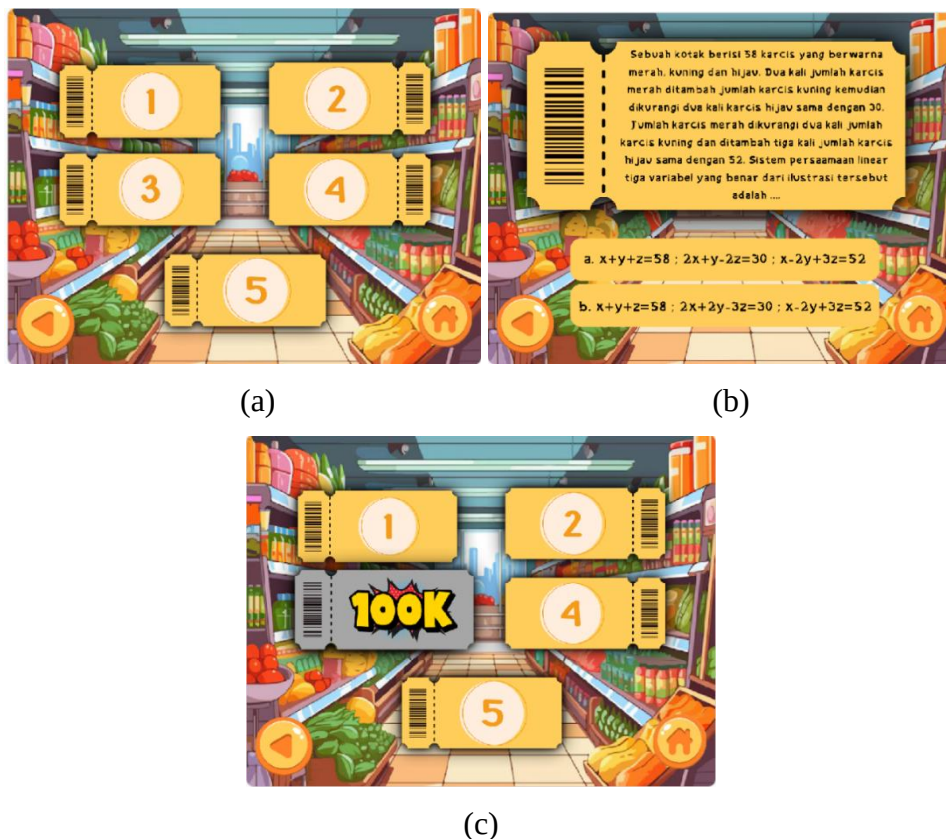


Figure 5. Quiz View

5. Testing

The *testing* stage is a check of the learning media program as a whole, namely, checking all sprites, *backgrounds*, materials, and code blocks in the learning media program to see if the program is appropriate and improvements are made if there are deficiencies. Its validity and accuracy are ensured by repeated checking.

6. Distribution

At this stage, the learning media is stored on a storage facility, namely the Scratch website. This Smart Shopper Math learning media can be accessed online by *registering* or *logging in* to the Scratch website. Here are the links to the learning media that we have saved:
<https://scratch.mit.edu/projects/1152469976/>.

Expert Validation and Student Responses of SPLTV Material Learning Media

Scratch learning media with the Three Variable Linear Equation System material that has been developed based on the MDLC stage was validated by media experts and material experts, then distributed along with a survey related to the response to the learning media, the survey was distributed to 10 participants. The results of the expert validation are presented in Table 5.

Table 5. Expert Validation Summary Results

Indicators	Percentage	Category
Appearance	100%	Very Eligible
Programming	93.75%	Very Eligible
Material	91.6%	Very Eligible
Language	87.5%	Very Eligible
Interest	100%	Very Eligible
Usefulness	100%	Very Eligible
Average	95.4%	Category

The results of the closed and open questionnaire of the SPLTV learning media survey are presented in Table 6 and Table 7.

Table 6. Closed Questionnaire Results

Indicators	Percentage	Category
Appearance	97.5%	Excellent
Programming	90%	Excellent
Material	95%	Excellent
Language	95%	Excellent
Interest	97.5%	Excellent
Usefulness	97.5%	Excellent
Average	95.7%	Excellent

Based on Table 6, the results of the closed questionnaire for six indicators of learning media with the category of excellent and obtained an average of 95.7% in each indicator. From these results, Mathematics Education students showed a very good attitude towards the learning media that had been developed.

Table 7. Open Questionnaire Results

Indicators	Percentage	Category
Appearance	100%	Excellent
Programming	100%	Excellent
Material	100%	Excellent
Language	100%	Excellent
Interest	100%	Excellent
Usefulness	100%	Excellent
Average	100%	Excellent

This SPLTV learning media obtained 100% results on all indicators. Based on these results, this media is categorized as Very Good.



Figure 6. Interview documentation

To validate the results of the research that have been obtained by conducting interviews with a sample of two participants. The following are the results of interviews by the interviewer (S) with participants labeled P1 and L2. Interview documentation is in Figure 6.

- I : How does the overall appearance of this learning media look?
P1 : It's very interesting, especially since it's in game form and there are stages listed in it, making it even more interesting.
L2 : The colors are nice, to my eye, like striking and attractive pastels.

- I : How easy is it to use this learning media?
- P1 : It's quite easy, but perhaps you could add commands like this that require dragging to answer, as I was a bit confused earlier.
- L2 : In my opinion, it's quite good. However, there needs to be further development, such as fixing bugs. Hopefully, these can be fixed in the future.
- I : Did this learning media help you understand the SPLTV material?
- P1 : It helped you understand the material better, such as the differences between coefficients, variables, and constants.
- L2 : Yes, especially for high school students, they definitely understand it well because they can imagine real-world scenarios in mathematics.
- I : How is the language used in this learning media? Is it clear and easy to understand?
- P1 : The language is understandable so far, and it's safe.
- L2 : The language is okay, enough, I don't think there's anything difficult.
- I : How interested are you in using this learning media to learn SPLTV material?
- P1 : As for interest, it's definitely more because the game makes it more fun. Moreover, today's children tend to be interested in games, so their interest is sure to increase. Furthermore, if interspersed with material, there's bound to be something to remember.
- L2 : It's more interesting, especially with the drag-and-drop mechanic, which is quite engaging. Perhaps it could be further developed, such as showing what's entered during shopping and how it can be withdrawn.
- I : Is this learning media useful for SPLTV material?
- P1 : It's very useful because we're given the material first and there's an interactive Q&A. If we make a mistake, we can identify the error. So, if we're still wrong in the first step, we can't move on to the next, which helps us understand better.
- L2 : It's very useful. This learning media provides an interesting scenario for applying SPLTV in the real world, such as shopping at a supermarket (milk, bread, etc.). The product images and elements are really cool.

The results of the confirmation through interviews showed that there were several findings that were not fully described in the questionnaire. P1 stated that the overall appearance of learning media is very interesting, especially because it is packaged in the form of a game with clear stages. In line with that, L2 also considers the appearance of the media to be good, especially in terms of color

selection that attracts attention. However, P1 reveals that there is still a bit of confusion in usage, so it is recommended to add clearer instructions, such as drag and drop instructions. Meanwhile, L2 highlighted technical obstacles in the form of bugs that still need to be fixed and further developed. Overall, P1 and L2 agreed that this learning media is very useful because it is equipped with materials, interactions, and feedback when mistakes occur, thus helping users understand the material more deeply. These findings strengthen the results of the questionnaire while providing additional and more specific input for the development of learning media in the future.

CONCLUSION

Based on the results of the study, Scratch-based learning media regarding the Three-Variable Linear Equation System (SPLTV) using the MDLC development model has been proven to meet the criteria of being very feasible and effective as a teaching material, although there are several things that can be improved or improved. This is supported by the validation results of media experts and material experts who gave an average score of 95.4% in the Very Feasible category. This validity is also reflected in the positive responses of the participants in the open and closed questionnaires which resulted in excellent categories. Learning media like this is considered interesting, increases students' interest, and understanding in learning SPLTV. However, there are things that need to be improved, namely the addition of clearer and more detailed instructions for use, and technical improvements to overcome bug issues in the program. In general, this learning media has a great opportunity to become an innovative and alternative digital solution in an effort to improve student learning outcomes in SPLTV materials. Therefore, further research on the effectiveness of the use of Scratch-based learning media in classroom learning activities is needed.

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