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Developing Android-Based Math Comic with Gamification Based on Mathematics Literacy

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Abstract

This research is intended to develop a media of comic math learning based on android and mathematics literacy for the materials of linear equations system in two variables. This study is a research and development by using ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The instruments are validation sheet, students' response sheet and students' and teachers' interview guideline. The subjects of research are 27 students of grade VIII Sornsasana Sasanupathum School. The object of research is media of Math Comic for the material of linear equations system in two variables. Technique of data collection in the research was questionnair, distribution, observation and interview, meanwhile the researcher analyzed the questionnaire and interview result data quantitatively by changing the qualitative data to be quantitative data to find out the appropriateness of math comic media. The data analysis combined descriptive quantitative methods by converting qualitative responses into numerical scores and descriptive qualitative analysis to interpret observation notes and open-ended interview responses. The assessment results in the research of math comic media were achieved by the assessment done by content expert with "very excellent" category, while the media expert assessed the media with "very excellent" category and the questionnaire response of students was categorized as "very excellent". All assessments that included assessments of content expert, media expert, and students' response were "very excellent". Based on the result of the assessments, it can be concluded that math comic learning media based on android and mathematics literacy for the materials of linear equations system in two variables is appropriate to use in the math learning teaching.

Keywords: *Digital Comic Media; Android; Mathematics Literacy*

1. Introduction

Education today has aligned with technological advancements in the era of the Industrial Revolution 4.0, making the use of technology an integral part of the learning process. Technology serves as a medium to deliver learning content, especially in mathematics, where learning media are essential to clarify concepts, enhance understanding, and develop students' skills and character in solving real-world problems (Sefriyanti, 2019). In mathematics education, students are expected not only to possess computational abilities, but also logical reasoning and critical thinking skills to comprehend mathematical concepts and apply them in everyday situations (Sari, 2018).

Mathematics often involves terminology that must be defined precisely and accurately. Therefore, to understand mathematical concepts, students must have strong literacy skills and mathematical thinking abilities (Kahar, 2017). Mathematical literacy refers to the capacity to explore, estimate, and reason logically using effective mathematical strategies to solve problems (Abidin et al.,

2021). In this study, mathematical literacy is applied in the context of students' daily lives through comic-based storytelling, where learners are expected to understand and utilize mathematics to solve contextual problems.

Mathematical literacy plays a vital role in educational quality and is a benchmark used globally. One such international assessment is the Programme for International Student Assessment (PISA), conducted every three years by the Organization for Economic Cooperation and Development (OECD). The PISA 2022 results reveal that many ASEAN countries still face significant challenges in mathematical literacy. Of the 81 participating countries, only Singapore ranked at the top globally with an average mathematics score of 575. Other ASEAN countries, such as Thailand (419), Malaysia (409), Indonesia (379), and the Philippines (355), scored well below the OECD average of 472 (OECD, 2023). This indicates that the majority of students in Southeast Asia struggle to apply mathematical concepts in contextual and functional ways.

One mathematical topic that requires both conceptual understanding and contextual application is the System of Linear Equations in Two Variables (SPLDV). This material is often perceived as difficult by students due to its abstract nature and limited connection to real-life situations. Traditional, teacher-centered approaches and the lack of innovative media further hinder students' comprehension of this material. Mastery of SPLDV necessitates both mathematical literacy and reasoning skills, particularly when solving word problems linked to everyday life (Indriyani, 2018).

In this study, SPLDV is the subject matter chosen for the development of an Android-based Math Comic integrating mathematical literacy. SPLDV is well-suited for this approach as it naturally relates to real-life situations, making it ideal for creating illustrated narratives containing relatable problems, similar to those found in mathematical word problems. Previous studies have shown that students frequently make errors in solving SPLDV word problems, highlighting the need for more supportive instructional media (Resa et al., 2018). Learning media plays an essential role in educational activities. Choosing appropriate learning media can develop an interest in studying (Mirnawati, 2024).

The rapid growth of digital technology presents a promising opportunity to address these learning challenges through Android-based learning media. These platforms offer accessibility, flexibility, and the ability to present interactive content. One such innovative format is digital comics, which convey mathematical concepts through engaging, visual storytelling that is relatable and easy to understand (Setiawan et al., 2021). Comics as visual media have also proven effective in increasing reading interest and conceptual understanding among elementary and secondary school students.

Moreover, integrating gamification into educational media is a powerful strategy to enhance student engagement. Gamification refers to the use of game design elements such as points, badges, leaderboards, and challenges in non-game contexts, especially in educational settings, to enhance students' motivation, engagement, and learning outcomes (Coelho, Silva, & Santos, 2025). When it is combined with mathematical literacy, these typical media not only increase motivation but also reinforce students' ability to connect mathematics with real-life contexts.

In a preliminary observation, the researcher administered a test of five multiple-choice questions via Google Form to assess mathematical literacy related to SPLDV among eighth-grade students at Sornsasana Sasanupathum School. The results showed an average score of 3.39 out of 10.00, indicating low performance. Follow-up interviews revealed that students had difficulty understanding problems embedded in real-life contexts. The test involved 23 out of 27 students, and the findings were consistent with similar observations at Sornsasana Sasanupathum School in Bangkok, where many students also struggled to solve contextual word problems.

This development research began with a needs analysis through observations and interviews with students and teachers at Sornsasana Sasanupathum School. Data were collected on current classroom conditions and media usage. During distance learning, the school had not implemented any Android-based learning applications. Teachers mostly used lecture methods supported by PowerPoint, WhatsApp groups, Google Meet, and Google Forms. However, these tools were insufficient due to time limitations, content retention issues, and lack of student engagement. Both teachers and students reported the need for more innovative, interactive, and impactful learning media.

Learning media act as tools that support and facilitate the teaching and learning process, helping teachers effectively deliver material and achieve instructional goals (Hamid et al., 2020). These media can take the form of audio, images, video, or other illustrations that make learning more engaging and less monotonous (Salsabila et al., 2020). Digital comics are two-dimensional illustrated stories

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packaged as software or mobile applications (Batubara, 2021). There were a lot of previous research discussing about instructional media of Mathematic with gamification based, but only few of these media is android based. To fill in the gap, the researcher conducted this study. Interactive multimedia helps students develop a deeper understanding of classroom learning. Therefore, improving teachers' ability to develop media using technology is strongly supported by the Thai government (Fahmi, 2024).

In this study, the researcher aims to develop digital comics presented with simple language and sequential storytelling to enhance students' recall and understanding of the subject matter.

Based on the discussion above, the goal of this study is to develop an Android-based Math Comic learning media that incorporates mathematical literacy and to evaluate its feasibility in supporting the teaching of SPLDV. This media is expected to help students more effectively understand the concept and applications of SPLDV in real-life contexts.

2. Method

This study is a development research (Research and Development) aimed at developing a learning media and evaluating the feasibility of the resulting product. The development model used in this research is the ADDIE model consisting five phases; Analyze, Design, Development, Implementation, and Evaluation. The ADDIE development procedure is illustrated in the following figure:

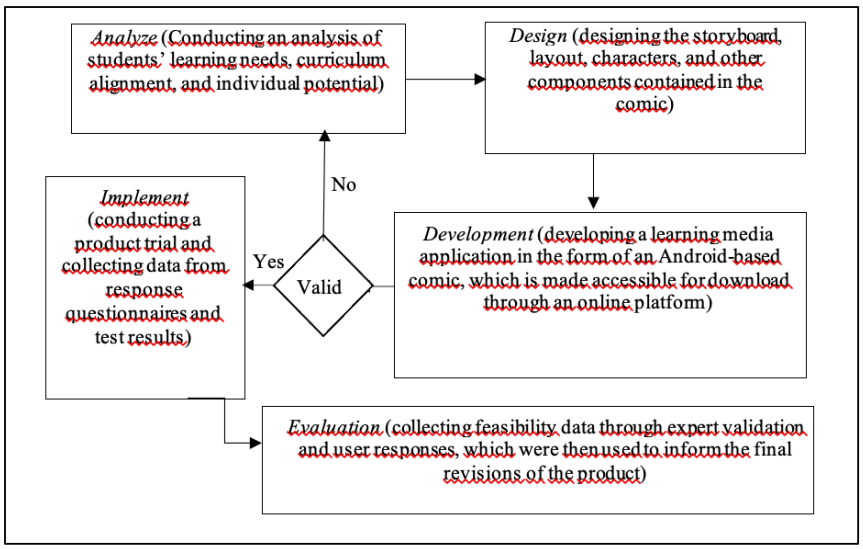

Figure 1 ADDIE development procedure

The subjects of this research were 27 students from Sornsasana Sasanupathum School in Bangkok. The product trial was conducted in two stages: a small-scale trial involving 9 students chosen randomly, followed by a large-scale trial involving all eighth-grade students. The researchers collected the data through interviews and questionnaires distribution. Interviews were conducted to gather information regarding mathematics topics perceived as difficult by students, students' learning situations during mathematics instruction, the technologies utilized during learning, and the types of instructional media needed by both students and teachers. On the other hand, the questionnaires were employed to assess the feasibility of the developed learning media.

This study used both qualitative and quantitative data analysis techniques. Qualitative data were obtained from interview responses and open-ended feedback from teachers and students. Quantitative data were collected through expert validation questionnaires and student response questionnaires related to the developed product. The data gathered then analyzed to measure the feasibility and acceptance level of the developed Android-based Math Comic learning media from both expert and student perspectives. The qualitative data from open-ended responses were transformed into quantitative data for further analysis. On the other hand the quantitative data were analyzed using Likert scale with five categories explained below.

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Table 1 Assessment Aspects of Expert Validation Sheet and Student Responses

Criteria	Score
Very Good	5
Good	4
Fair	3
Poor	2
Very Poor	1

Based on the assessment aspect table, the average results of expert validation and student responses were then calculated using the following formula (Sudaryono, 2016):

$$\bar{X} = \frac{\sum X}{N}$$

Explanation:
$\bar{X}$: Average score
$\sum X$: Total score
N : Total respondent

After obtaining the average score, the validation criteria from experts and the student response questionnaire were determined using Table 2 below (Yupinus et al., 2020):

Tabel 2 Assessment Criteria for Expert Validation Sheets and Student Response Questionnaires with a Five-Point Scale

Score Range	Criteria
$\bar{X} > Mi + 1{,}8\ SBi$	Very Good
$Mi + 0{,}6\ SBi < \bar{X} \leq Mi + 1{,}8\ SBi$	Good
$Mi - 0{,}6\ SBi < \bar{X} \leq Mi + 0{,}6$	Fair
$Mi - 1{,}8\ SBi < \bar{X} \leq Mi - 0{,}6\ SBi$	Poor
$\bar{X} \leq Mi + 1{,}8\ SBi$	Very Poor

Explanation:
$Mi = \frac{1}{2}(\text{Ideal Maximum Score} + \text{Ideal Minimum Score})$
$SBi = \frac{1}{6}(\text{Ideal Maximum Score} - \text{Ideal Minimum Score}$
$\bar{X}$ = Total Score
SDi = Ideal Score Standard Deviation
Mi = Ideal Mean

The learning media developed by the researcher can be considered feasible if the Math Comic media receives a rating of at least "fairly good" based on the criteria in the expert validation sheet and student response questionnaire as shown in Table 2. Subsequently, an overall evaluation of the learning media is conducted to determine whether the Math Comic is suitable or not suitable for use in mathematics learning.

During the research process, the researcher was assisted by a translator to support the implementation of the study. The translator played an important role in translating the content of the learning media and instructional materials into Thai, ensuring that the media could be well understood by students at Sornsasana Sasanupathum School in Bangkok. This assistance was essential for maintaining the clarity and accuracy of the learning materials in the target language, and for facilitating effective communication during the data collection and trial phases. Sornsasana Sasanupathum is an Islamic secondary school located in Bangkok. The students at this school are also able to speak Malay, as it is one of the commonly used languages in their community alongside Thai. This linguistic background facilitated communication during the research, especially when using translations and explanations in both Malay and Thai.

3. Results and Discussion

3.1 Results

In the development research of the Android-based Math Comic media integrating mathematical literacy on the topic of systems of linear equations in two variables, several research stages were carried out using the ADDIE development model. These stages are as follows:

3.1.1 Analysis

The analysis phase is the initial stage of this study, which aims to provide an overview by analyzing the needs necessary to design the Math Comic learning media according to the actual requirements. The researcher analyzed the students' needs, the learning material, classroom conditions during the mathematics learning process, as well as the technology used. Needs analysis was conducted to identify the teaching materials and learning media required by both students and teachers in the classroom. The researcher conducted observations using interviews with teachers and distributed questionnaires to students at Sornsasana Sasanupathum Bangkok.

The results of these observations indicated that both students and teachers needed learning media that included teaching materials presented in an engaging format, such as illustrated comics, packaged in either digital or printed form, to help prevent boredom when learning mathematics.

The researcher also analyzed the material used in the Math Comic media by reviewing the observation data gathered through teacher interviews. The data revealed that within the algebra topic area, students continued to experience difficulties in understanding problems related to systems of linear equations in two variables, which are typically presented as word problems. Understanding this material requires the ability to translate real-life problems into mathematical models using variables.

In addition, in analyzing the material, the researcher assessed the classroom situation and student conditions during mathematics lessons. The findings include:

a. All Grade VIII students at Sornsasana Sasanupathum Bangkok already own personal smartphones;
b. The students primarily use their smartphones for communication with parents, booking transportation online, searching for learning materials, or playing games; and
c. Smartphone use during lessons remains suboptimal.

Following the analysis of needs, materials, and classroom conditions, the researcher also evaluated the technology to be used. This technology analysis aimed to identify suitable software applications for developing the Android-based Math Comic learning media in accordance with the researcher's technical skills. Based on the conducted analysis, the researcher utilized several tools:

a. Medibang Paint Pro to create comic sketch illustrations,
b. Articulate Storyline 3 to design the Math Comic media with interactive features, and
c. Website 2 APK Builder Pro to convert .html files into Android applications so they can be accessed on Android smartphones in .apk format.

3.1.2 Design

After completing the analysis phase, the researcher proceeded to the design phase, where the product was planned and conceptualized. In this stage, the researcher developed several design elements including a flowchart, comic sketches, and a storyboard for the Math Comic learning media. The following represents the flowchart of the Math Comic media:

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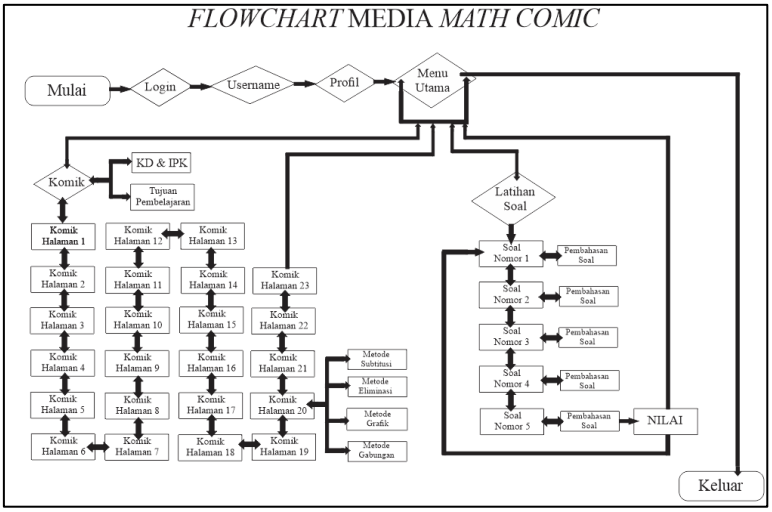

Figure 2 Media Math Comic flowchart

3.1.3 Development

The next stage is the development phase, which involves realizing and producing the product based on the previously designed plan. In this stage, the development of the product is carried out along with the validation process by subject matter experts and media experts.

3.1.3.1 Product Development

The Math Comic media was developed by first sketching comic illustrations manually in a drawing book. These sketches were then digitally redrawn in color using the MediBang Paint Pro application. The researcher also designed the title illustrations, interface, and navigation buttons using the same application. The completed comic illustrations were compiled into a landscape layout using Articulate Storyline 3. With this application, the researcher arranged the interface design, audio, and interactive triggers in accordance with the planned product and storyboard. Once the design was finalized, the media was exported in .html format to be packaged into an Android application using Website 2 APK Builder. The final output of the Math Comic media is an .apk file that can be installed on Android smartphones. The application has a file size of approximately 12 MB. The following is a display of the Math Comic media that has been developed by the researcher:

Figure 3 Cover of Math Comic

The Math Comic cover serves as the initial screen displayed when users open the application. On this opening screen, there is a Start button that allows users to begin using the application.

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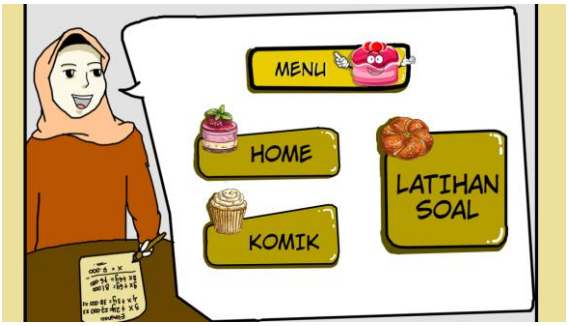

Figure 4 Menu Page

The menu page contains several buttons that navigate to the application's cover page (Home), the comic page, and the practice question page.

Figure 5 Cover of the Comic

On the SPLDV comic cover page, there is a title, Basic Competencies, learning objectives, Indicators of Competency Achievement, and reading instructions. Users can press the buttons to view the KD, learning objectives, IPK, and instructions for reading the comic.

Figure 6 Comic Page

On the first page of the comic, each character is introduced with their name and hobby. In this comic, the researcher created four characters: Siska, Rani, Dimas, and Anton. The story presents dialogues between the characters that depict real-life problems related to the topic of Systems of Linear Equations in Two Variables (SPLDV). The comic includes stages of mathematical literacy that are closely related to SPLDV concepts, particularly mathematical modeling and processes. This involves formulating real-life problems into mathematical language. The comic illustrates stages of mathematical literacy, where a problem originating from daily life is translated into a mathematical context for

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resolution, and the solution is then interpreted back into the original real-life context. Below is an image of the comic depicting aspects of mathematical literacy skills:

Figure 7 Comic Page 9

Figure 8 Comic Page 10

Figure 9 Comic Page 14

On Figures 7,8 and 9, explanations are provided regarding real-life problems presented through comic-style dialogues that are directly related to the topic of Systems of Linear Equations in Two Variables (SPLDV).

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Figure 10 Comic Page 17

Figure 11 Comic Page 19

On Figures 10 and 11, the stages of problem formulation are presented, including constructing, simplifying, and creating a mathematical model based on the problem depicted in the comic storyline.

Figure 12 Comic Page 18

Figure 13 Comic Page 21

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Students can view the solution to the problem presented in the comic by clicking one of the method buttons (substitution method, elimination method, graphical method, or combined method). Students can read the complete solution by scrolling down, as shown in Figure 12. Figures 12 and 13 include the mathematical literacy stage of using mathematics, in which students solve the mathematical model after constructing it. Furthermore, page 18 and 21 represent the interpreting, presenting, and evaluating solutions stage of mathematical literacy, where students obtain a mathematical solution using appropriate concepts, facts, and procedures. This solution is then interpreted in its original context and validated for accuracy.

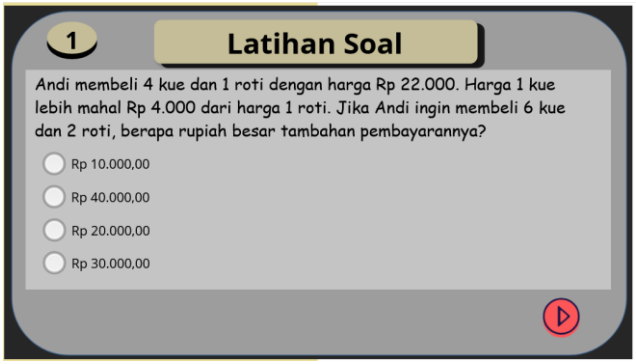

Figure 14 Exercises Display

The researcher created five multiple-choice practice questions, each accompanied by a detailed explanation and the score obtained by the student after completing the questions.

3.1.3.2 Product Validity

After developing the Math Comic media, the product was then validated by media experts and subject matter experts. The purpose of this validation was to review the initial product developed by the researcher and to receive input from the experts regarding any deficiencies or areas for improvement. The media and subject matter experts involved in the development of the Math Comic media included a Mathematics Education lecturer from Universitas Ahmad Dahlan and a mathematics teacher for Grade VIII at Sornsasana Sasanupathum Bangkok.

3.1.4 Implementation

After completing the development phase, the researcher proceeded to conduct trials of the Math Comic application. The trials were carried out in two stages: a small-scale trial and a large-scale trial, both conducted in Grade VIII at Sornsasana Sasanupathum Bangkok. The class selection used in the research was based on recommendations from the mathematics subject teacher.

The small-scale trial was conducted to gauge students' initial responses to the Math Comic application before implementing it in the larger class setting. This trial was conducted online and involved nine students, randomly selected by the researcher from Grade VIII at Sornsasana Sasanupathum Bangkok. The large-scale trial was conducted offline, following the completion of the small-scale trial.

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Figure 15 Explanation by the teacher prior to the implementation of the large-class trial

3.1.5 Evaluation

The final stage of the ADDIE model is the Evaluation stage. This stage is used to determine the feasibility and quality of the Math Comic learning media that has been developed. The product evaluation is conducted based on four aspects: content/material, media, student responses, and overall evaluation.

The results of this research serve as a reference to determine whether the Math Comic media is suitable for use in mathematics learning. The following are the evaluation results of the product based on the aspects of content, media, student responses, and the overall assessment:

Table 3 Calculation Result of the Subject Matter Expert Feasibility Questionnaire Based on Aspects.

No	Aspect	Average	Criteria
1	Content Feasibility	4,68	Very Good
2	Language Feasibility	5,00	Very Good
3	Display Feasibility	4,75	Very Good

Table 4 Total Results of the Subject Matter Expert Eligibility Questionnaire Calculation.

No	Material Expert	Average	Criteria
1	Material Expert 1	4,63	Very Good
2	Material Expert 2	4,89	Very Good
Total Average		4,76	Very Good

Based on Table 4, an average score of **4.76** out of a maximum score of **5.00** was obtained from the assessments of **Content Expert 1** and **Content Expert 2**. These results indicate that the *Math Comic* learning media developed meets the qualification of being **feasible in terms of content**, as the average score falls within the **"very good"** category.

Table 5 Results of Media Expert Feasibility Questionnaire Calculation Based on Aspects

No	Aspect	Average	Criteria
1	Display Feasibility	4,61	Very Good
2	Advantage	5,00	Very Good

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Table 6 Total Results of the Media Expert Feasibility Questionnaire Calculation.

No	Material Expert	Average	Criteria
1	Material Expert 1	4,64	Very Good
2	Material Expert 2	4,86	Very Good
Total Average		4,80	Very Good

Based on Table 6, an average score of 4.80 out of a maximum score of 5.00 was obtained. These results indicate that the Math Comic media developed meets the qualification of being feasible in terms of media aspects, as the average score falls within the "very good" category.

Table 7 Results of Student Response Questionnaire Calculation Based on Aspects

No	Aspect	Small Scale Trial		Wide Scale Trial	
		Average	Criteria	Average	Criteria
1	Overall Appearance	4,21	Very Good	4,28	Very Good
2	Material Display	4,30	Very Good	4,47	Very Good
3	Advantage	4,25	Very Good	4,33	Very Good

Table 8 Overall Results of Student Response Questionnaire Calculation.

No	Trial Sampling	Average	Criteria
1	Small Scale Trial	4,24	Very Good
2	Wide Scale Trial	4,34	Very Good
Total Average		4,29	Very Good

Based on Table 8, the results of the student responses during the small group trial showed an average score of 4.24, indicating that the Math Comic learning media developed meets the "very good" criteria and qualifies as practical. Meanwhile, the results of the student responses during the large group trial showed an average score of 4.34, also within the "very good" category, thereby reinforcing its qualification as practical. From these findings, the overall average score from the student response questionnaires was 4.29, confirming that the Math Comic media is practical as it achieves a very good rating.

3.2 Discussion

The *Math Comic* learning media, which is Android-based and incorporates mathematical literacy on the topic of systems of linear equations in two variables (SPLDV), has several advantages. It can be used offline, has a small application size of only 13 MB, and contains a gamified storyline with mathematical literacy components related to SPLDV. The application enables students to study anytime and anywhere, and allows them to enhance their learning through practice questions, which are immediately scored upon completion. This app helps students develop mathematical literacy skills by reading comics aligned with the SPLDV material.

However, the *Math Comic* media also has some limitations. It does not include animated visuals, videos, or audio explanations. Additionally, the media is not yet compatible with iOS devices and is not currently available on the Google Play Store.

The development and implementation of the *Math Comic* media was not only aimed at enhancing student engagement but also at improving students' mathematical literacy, which is defined as "an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts" (OECD, 2018, p. 4). A trial conducted with 27 eighth-grade students at Sornsasana Sasanupathum School in Bangkok revealed an average mathematical literacy score of 3.41 out of 4.00, which falls into the "good" category, approaching "very good." The results were analyzed using the three key aspects of

mathematical literacy. In the formulating aspect, students achieved the highest scores. They successfully identified relevant mathematical information from the comic narrative and translated it into structured mathematical models, particularly systems of linear equations in two variables. In the employing aspect, students showed adequate procedural fluency in applying strategies such as substitution or elimination to solve SPLDV problems. The interpreting aspect yielded slightly lower scores, suggesting that while students could compute mathematical solutions, some had difficulty connecting these results back to real-life scenarios depicted in the comic storyline.

These findings are in line with Utami (2023), who noted that "mathematical comic media is effective in improving students' mathematical literacy, especially by presenting real-life contexts with engaging narratives and direct integration of SPLDV content". Likewise, Marbun and Dewi (2023) stated that "the use of mathematical comics designed with realistic problems encourages students to formulate and solve linear systems more effectively". Furthermore, Coelho, Silva, and Santos (2025) emphasized that "when combined, gamification elements such as points, badges, and challenges significantly improve students' cognitive engagement, emotional response, and motivation", which supports the positive student outcomes observed in this study.

4. Conclusion

The development of the Math Comic learning media, integrating gamification, Android-based delivery, and mathematical literacy on the topic of systems of linear equations in two variables (SPLDV), was carried out using the ADDIE development model (Analyze, Design, Development, Implementation, and Evaluation).

Feasibility and practicality were proven through a combination of expert validation and field testing. The subject matter experts and media experts assessed the content quality, usability, and design, while student responses were gathered via questionnaires after media implementation. In addition, observations during classroom trials confirmed that students were actively engaged and able to follow the storyline and complete tasks with minimal guidance. The media obtained an overall average score of 4.34 out of 5.00, placing it in the "very good" category, thus confirming its suitability for classroom use.

Although the media has some limitations, such as the absence of animations, videos, or audio explanations, it shows promise for future enhancement. The researchers suggest incorporating these multimedia elements to further increase student comprehension and engagement.

The development of the Math Comic learning media, integrating gamification, Android-based delivery, and mathematical literacy on the topic of systems of linear equations in two variables (SPLDV), was carried out using the ADDIE development model (Analyze, Design, Development, Implementation, and Evaluation).

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