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DEVELOPMENT OF INDONESIAN CULTURE-BASED MATHEMATICS LEARNING E-COMICS INTEGRATED WITH IMAM SYAFI'I'S EDUCATIONAL VALUES TO IMPROVE STUDENTS' MATHEMATICAL PROBLEM-SOLVING ABILITY

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ABSTRACT
This research aims to develop a mathematics learning medium in the form of an Indonesian culture-based e-comic integrated with the educational values of Imam Syafi'i on the topic of Two-Variable Linear Equation Systems (SPLDV) to improve the mathematical problem-solving skills of students at SMP IT Al Maidani. The urgency of this research is based on the low mathematical problem-solving abilities of junior high school students, as well as the lack of contextual, engaging, and Islamic character-infused learning media. The development model used was the 4D model (Define, Design, Develop, Disseminate). The research subjects consisted of 30 students in the first trial and 32 students in the second trial. Validation was conducted by media experts, material experts, religious experts, and cultural experts. The validation results indicated that the developed learning medium was valid with an average score of 4.3 (media experts), 4.2 (material experts), 4.4 (religious experts), and 4.5 (cultural experts). The first trial resulted in an increase in the average score from 76.9 (pretest) to 83.73 (posttest), with an N-Gain of 0.32 (moderate category). Based on the reflection results of the first trial, revisions were made, including improvements to the interface, the addition of sample verification questions, and additional contextual exercises. After revisions, the second trial showed a significant increase, with an average score from 77.4 to 94.25 and an N-Gain of 0.78 (high category). A total of 87.5% of students achieved classical learning completion. The results of the study demonstrate that the developed e-comic media is valid, practical, and effective in improving students' mathematical problem-solving skills and instilling Islamic character values aligned with the educational values of Imam Syafi'i.
Keywords: E-comic, Mathematical Problem-Solving, SPLDV

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PRELIMINARY

Mathematics education plays a very important role in equipping students with critical, logical, and systematic thinking skills, as well as problem-solving abilities that are applicable in everyday life. In the context of both national and international curricula, mathematical problem-solving skills are among the key competencies that 21st-century students must possess (Vásquez et al., 2022). This aligns with the results of the 2018 PISA survey, which emphasized that students are expected not only to master mathematical concepts but also to be skilled in applying those concepts to solve real-life contextual problems (OECD, 2019).

However, the reality in the field shows that junior high school students in Indonesia still demonstrate low levels of mathematical problem-solving ability. Many students struggle when faced with word problems, especially in the topic of Systems of Linear Equations in Two Variables (SPLDV). These difficulties include understanding the problem, designing mathematical models, performing calculations, and interpreting the obtained solutions. According to research by Koderi et al. (2020), most junior high school students tend to merely memorize formulas without understanding the process of solving them. As a result, when confronted with variations of problems, they become confused and unable to solve them independently.

This condition is worsened by the limited availability of engaging, interactive learning media that align with the characteristics of the digital generation. Conventional learning media, such as textbooks and blackboards, are often perceived as monotonous and less motivating for students. In response to the growing disengagement caused by repetitive, text-heavy teaching tools—especially during remote learning—the use of interactive digital comics has proven effective in enhancing student engagement and learning outcomes in elementary school settings (Khotimah et al., 2020). Therefore, innovation in learning media is needed to create an enjoyable, contextual, and easily understood learning experience. One relevant alternative is the use of e-comics. Comics, as visual media, have a unique appeal because they present learning material in the form of illustrated stories that are communicative and closely related to students' lives. Research has shown that the use of comics in mathematics learning can improve students' motivation, conceptual understanding, and creative thinking skills (Syafmen et al., 2024). Furthermore, digital comics or e-comics can be more easily accessed through technological devices, making them suitable for today's generation that is familiar with digital technology (Setiawan & Cahyaningtyas, 2025).

In addition to visual and technological aspects, mathematics learning also needs to be integrated with cultural and religious values to provide deeper meaning. Education based on local culture can enhance student engagement because they feel more connected to the material being studied (Hafida, 2024). Meanwhile, the integration of Islamic values, particularly those based on the education of Imam Shafi'i, can strengthen the affective and spiritual aspects of students. Imam Shafi'i is known for emphasizing the importance of good manners, noble character, and the spirit of seeking beneficial knowledge. Integrating these values into learning media is expected to foster religious character while also enhancing the quality of mathematics education (Trisnawati et al., 2024).

SMP IT Al Maidani, as an Islamic-based school, has a vision of forming a generation that is knowledgeable, well-mannered, and of noble character. Therefore, the development of learning media that combines elements of mathematics, Indonesian culture, and the educational values of Imam Shafi'i is highly relevant. This approach is well-aligned with modern interpretations of Islamic education inspired by Imam As-Shafi'i, which emphasize a balanced integration of Sharia knowledge, rational thought, and character formation through dialogic and critical learning (Pahrurroji, 2025). In addition, embedding Indonesian cultural values supports the ideals of Islamic religion education in a multicultural context—enabling students to develop tolerance, respect for diversity, and democratic attitudes (Wahfiuddin Al Musyarrofi & Mohammad Rofiq, 2025). Moreover, this aligns seamlessly with the principles of Islam Nusantara, which advocates preserving local customs while upholding Islamic valuesmaking the media contextually relevant and culturally rooted. Through this e-comic media, students not only learn SPLDV conceptually but also gain examples of local cultural values and Islamic morals that are aligned with their needs. Furthermore, e-comic–based learning has been shown to enhance students' problem-solving abilities by presenting SPLDV concepts through visual narratives and context-rich scenarios, enabling them to identify information, model problems into mathematical forms, and apply appropriate solution strategies more effectively.

Several previous studies support the importance of developing comic-based learning media integrated with Islamic values. For instance, research by Herwanti et al. (2024) demonstrated that a Problem-Based Learning model aided by digital comic media significantly enhanced students' critical thinking skills, with experimental group post-test means of 85 versus 72 in the control group. Furthermore, Hasyanah et al. (2023) revealed that digital comics grounded in Realistic Mathematics Education (RME) effectively improve students' mathematical problem-solving abilities, as shown by statistically significant pre-post test improvements (Sig < 0.05). Moreover, the integration of Islamic values in mathematics learning has proven effective in shaping character and increasing students' learning motivation (Imamuddin & Isnaniah, 2023).

Thus, the development of an Indonesian-culture-based mathematics e-comic integrated with Imam Shafi'i's educational values is expected to be an innovative solution to enhance students' mathematical problem-solving abilities. This media is not only valid in terms of content and design but also practical for use in the classroom and effective in achieving learning mastery. Furthermore, this media has the potential to serve as a means of

Islamic character education, shaping students to be knowledgeable, well-mannered, and of noble character in line with the goals of Islamic education.

Based on the above explanation, this study focuses on developing a mathematics e-comic based on Indonesian culture with the integration of Imam Shafi'i's educational values to improve the mathematical problem-solving abilities of students at SMP IT Al Maidani**.** The main focus of the research is to assess the validity, practicality, and effectiveness of the developed learning media so that it can provide a meaningful contribution to more meaningful mathematics learning innovation.

METHODS

This research is categorized as Research and Development (R&D). The process of investigating, designing, producing, and testing validity in order to develop a new product or improve an existing one can be accounted for scientifically. The development model used in this study is the 4D model (Define, Design, Develop, Disseminate) by Thiagarajan (Murwaningsih & Fauziah, 2021). This model was chosen because it is suitable for developing learning media that are valid, practical, and effective. The subjects of the study were eighth-grade students of SMP IT Al Maidani, consisting of 30 students in the first trial and 32 students in the second trial. The product developed is a mathematics learning medium in the form of an e-comic based on Indonesian culture and the educational values of Imam Shafi'i, focusing on the topic of Systems of Linear Equations in Two Variables (SPLDV). To ensure that the module can be installed, used, and tested properly, the researcher first conducts validation after designing and compiling the teaching materials. The validation is carried out by expert validators: a subject matter expert, a media expert, a religious (Islamic) education expert, and a cultural expert. The rating scale used in the validation sheets refers to the following table:

Table 1. Validity Score Criteria

Score Range (Va)	Criteria
$4{,}5 \leq Va \leq 5{,}0$	VeryValid
$3{,}5 \leq Va < 4{,}5$	Valid
$2{,}5 \leq Va < 3{,}5$	Quite Valid
$1{,}5 \leq Va < 2{,}5$	Less Valid

(Neira et al., 2024)

The completed validation sheets are then used to determine the percentage of validation using the following formula:

$$V_a = \frac{\sum_{i=1}^{n} V_i}{n}$$

This formula is used to determine the level of agreement among experts regarding the quality of the product. After validation is achieved, the analysis proceeds to the practicality phase, measured using teacher and student response questionnaires. The percentage of practicality is calculated using the following formula:

$$P = \frac{Skor\ Perolehan}{Skor\ Maksimal} \times 100\%$$

To interpret the practicality scores, the following classification table is used:

Table 2. Practicality Criteria

Interval	Practicality Level
86% - 100%	Very Practical
76% - 85%	Practical
60% - 75%	Quiet Practical
40% - 59%	Less Practical
0% - 39%	Not Practical

(Prasetyo et al., 2024)

Next, to measure how far the media helps students meet the expected standards, the classical completeness formula is used:

$$P = \frac{The\ Total\ of\ Students\ who\ Completed}{The\ Total\ of\ Students} \times 100\%$$

This formula ensures that at least 85% of students achieve a score ≥ the minimum mastery criterion (KKM), which is 75. The final stage of the analysis is measuring effectiveness through improvement in students' problem-solving ability, calculated using the N-Gain formula:

$$N - Gain = \frac{S_{posttest} - S_{pretest}}{S_{Maksimal} - S_{pretest}}$$

This formula categorizes learning improvement into high, moderate, or low. These stages of data analysis are interconnected media that are valid and practical are then tested for effectiveness using valid, and the effectiveness is determined based on students' N-Gain scores.

RESULT AND DISCUSSION

In the first stage, Define, the researcher analyzed the needs and problems in mathematics learning at the junior high school level, particularly on the topic of Systems of Linear Equations in Two Variables (SPLDV). The analysis revealed that students still struggle to understand the basic concepts of SPLDV and require innovative and contextual learning media. The subject of Systems of Linear Equations in Two Variables is highly contextualized to everyday life. SPLDV discusses the relationship between two interdependent variables and can be presented in real-world problem situations, such as calculating the price of goods, comparing quantities, or simple financial analysis. This material also requires students to understand the relationship between verbal, numerical, symbolic, and graphical representations.

These characteristics of SPLDV make it highly suitable for development in digital comics. Through the comic format, SPLDV problems can be visualized in the form of stories or dialogues that depict real-life situations for example, conversations about purchasing goods, comparing production results, or calculating two types of values. This visualization helps students understand the steps of constructing mathematical models (determining variables, creating systems of equations, and solving using substitution, elimination, or graphical methods) in a more concrete and engaging way.

Furthermore, SPLDV has a systematic and gradual solution flow, starting from understanding the problem to finding a solution. This narrative structure aligns with the storyline in the comic, so that each stage of SPLDV's solution can be visualized in educational comic scenes. Thus, the presentation of SPLDV in the form of an e-comic based on Indonesian culture and the educational values of Imam Syafi'i not only facilitates understanding of the concept but also fosters learning motivation and strengthens religious character through moral messages inserted in each story.

In the second stage, Design, the researcher designed an interactive digital comic that features illustrations of Indonesian culture**,** Islamic characters, and character values based on Imam Shafi'i's educational principles. The developed learning package includes:

1. Teaching modules
2. Student worksheets (LKPD)
3. Mathematical problem-solving tests (pretest–posttest)
4. Teacher and student response questionnaires

The designed product was then validated by experts (media, content, religious, and cultural experts). This is part of the Development stage, where before the learning media is

used in field trials, it must first undergo expert validation to ensure its quality and feasibility. The validation process involved four areas of assessment: learning media expert**,** subject matter expert**,** religious expert**,** and cultural expert**.** Each expert assessed the developed e-comic product based on their respective field of expertise.

1. The media expert assessed aspects such as visuals, design, and readability.
2. The subject matter expert evaluated the content's alignment with core competencies and the accuracy of mathematical concepts**.**
3. The religious expert reviewed the appropriateness of the integrated educational values of Imam Shafi'i**.**
4. The cultural expert assessed the integration of Indonesian cultural elements presented in the e-comic narrative.

The assessments from all four experts were then summarized in a recap table, as shown in Table 3.

Table 3. Summary of Expert Validation

Validator	Average Score	Criteria
Media Expert	4,3	Valid
Content Expert	4,2	Valid
Religious Expert	4,4	Valid
Cultural Expert	4,5	Very Valid

Based on the validation results from the experts, the average score obtained from the Learning Media Expert was 4.3 with the Valid category, the Learning Material Expert was 4.2 with the Valid category, the Religious Expert was 4.4 with the Valid category, and the Cultural Expert was 4.5 with the Very Valid category. Overall, these results indicate that the developed product has met the feasibility aspects from various expert perspectives, both in terms of media, materials, religion, and culture, so it can be declared suitable for use in learning.

Table 4. Comparison of E-Comic Before and After Expert Validation

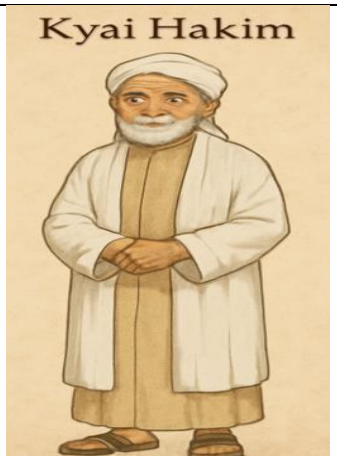
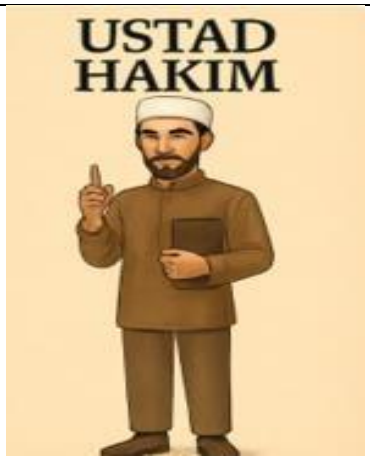
No	Suggestion	Before Revision	After Revision
1	The term and illustration of *Kyai* should be replaced with *Ustadz*, because the title *Kyai* is typically used in Javanese culture, while the culture adopted in this e-comic is Malay culture.		
2	The use of language should be adjusted to follow proper and standard Indonesian grammar and usage.		
3	The application of Imam Shafi'i's educational method in each meeting/session must be clearly developed and explained.		

Table 4 illustrates the comparison of the e-comic interface before and after expert validation. Based on the validators' feedback, several aspects of the media design were revised to improve its visual appeal, usability, and alignment with cultural and religious integration. Revisions focused primarily on improving readability, enhancing navigation buttons for easier access, and integrating more Indonesian cultural elements throughout the story. Additionally, reflections and quotes inspired by Imam Shafi'i's educational values were consistently inserted at the end of each episode to strengthen moral and character formation.These improvements contributed to the overall increase in the validity score from experts, ensuring that the developed e-comic not only met the pedagogical and cultural requirements but also became more user-friendly and engaging for students and teachers during implementation.

After the learning media has been validated by experts and the author has completed the revisions given by the experts, the learning media is declared valid for use, the next stage is the Dissemination Stage to obtain the practicality of the learning media. This stage aims to determine the extent to which the e-comic learning media is easy to use, understand, and provides an effective, interactive, interesting, efficient, and creative learning experience for both teachers and students. Practicality is assessed through a response questionnaire given after the learning trial is conducted. Teacher and student responses in trial I and trial II are then compared to see any improvement in media quality from the results of the revisions that have been made. The results of the teacher and student response questionnaires regarding the practicality of the learning media can be seen in Table 4 and Table 5. Teachers' assessment of the practicality of learning media increased from trial I to trial II.

Table 5. Teacher Response Questionnaire Results on Practicality

Aspect of	Trial I (%)	Criteria	Trial II (%)	Criteria
Effective	76,0	Practical	90,4	Very Practical
Interactive	83,0	Practical	88,6	Very Practical
Interesting	68,8	Quiet Practical	87,5	Very Practical
Effiecent	79,2	Practical	83,3	Practical
Creatif	80,0	Practical	87,5	Very Practical
Average	77,4	Praktis	87,5	Very Practical

Based on the data in Table 5, the results of teacher assessments of the practicality of e-comic learning media showed a significant increase from the first trial to the second trial. In trial I, the average practicality level was at 77.4%, categorized as Practical, while in trial II it increased to 87.5%, categorized as Very Practical. This increase was seen evenly across all assessment aspects, particularly in the interesting aspect, which increased from 68.8% to 87.5% and the effective aspect, which increased from 76.0% to 90.4%. The interactive and creative aspects also showed an increase from the Practical to Very Practical category, while the efficient aspect remained in the Practical category, with a score increasing from 79.2% to 83.3%. This indicates that the revisions made after the first trial succeeded in correcting several shortcomings of the media, particularly in the interface display, completeness of questions, and interactivity of the content.

Consistent improvements in all aspects of practicality indicate that the developed e-comic media is easy for teachers to use in the learning process, both in terms of navigation, visual appearance, and integration with teaching and learning activities. Teachers stated that this media expedites the process of delivering material, facilitates providing contextual

examples to students, and increases student engagement during the learning process. Thus, these results provide an empirical basis for concluding that the developed e-comic learning media falls into the "very practical" and "easy to use" categories, in accordance with the established practicality criteria (Tarigan et al., 2024).

Practical Student responses also showed an increase from trial I to trial II.

Table 6. Student Response Questionnaire Results on Practicality

Aspect	Trial I (%)	Criteria	Trial II (%)	Criteria
Effective	74.2	Fairly Practical	78.0	Practical
Interactive	74.6	Fairly Practical	79.3	Practical
Attractive	72.3	Fairly Practical	76.8	Practical
Efficient	76.0	Practical	79.9	Practical
Creative	74.8	Fairly Practical	75.6	Fairly Practical
Average	74.3	Fairly Practical	78.0	Practical

After the e-comic learning media was declared valid and practical based on evaluations from experts, teachers, and student responses, the next stage was an effectiveness test. This test was conducted to determine the extent to which the media could improve students' mathematical problem-solving abilities. Effectiveness was assessed through classical learning completeness, which is the comparison between the number of students achieving scores ≥ the Minimum Competency Criteria (KKM) and the total number of students in Trial I and Trial II. The analysis was carried out by comparing pretest and posttest results, so that any increase in the number of students achieving completeness after using the learning media could be observed. A recap of classical completeness is presented in Table 7.

The test results on problem-solving ability showed an increase in completeness from Trial I to Trial II.

Table 7. Classical Completeness of Problem-Solving Ability

Category	Trial I		Trial I	
	Pretest	Posttest	Pretest	Posttest
Complete	18 (60%)	22 (73.3%)	20 (62.5%)	28 (87.5%)
Incomplete	12 (40%)	8 (26.7%)	12 (37.5%)	4 (12.5%)
Total	30 (100%)	30 (100%)	32 (100%)	32 (100%)

1. Improvement in Students' Learning Completeness

Based on the data presented in Table 7, students' learning completeness showed an increase in both trials. In Trial I, the number of students who achieved completeness increased from 18 students (60%) in the pretest to 22 students (73.3%) in the posttest. Meanwhile, the number of students who did not achieve completeness decreased from 12 students (40%) to 8 students (26.7%). In Trial II, the improvement was even more significant. The number of students who met the completeness criteria rose from 20 students (62.5%) to 28 students (87.5%), while those who were incomplete decreased from 12 students (37.5%) to 4 students (12.5%). This consistent improvement indicates that the Indonesian culture-based e-comic integrated with Imam Shafi'i's educational values had a positive impact on students' learning achievement.

2. Interpretation of Effectiveness Results

The improvement in learning completeness across both trials demonstrates that the developed learning media is effective for classroom implementation. The classical completeness percentage in Trial II reached 87.5%, surpassing the minimum standard of 85% for mastery learning. This result shows that most students successfully achieved the Minimum Mastery Criteria (KKM). Therefore, it can be concluded that the e-comic learning media is effective in enhancing students' mathematical problem-solving ability and fulfills the criteria for an effective instructional medium.

This study's findings align with Mamolo & Wang (2019) who developed digital interactive math comics (DIMaC) for high school general mathematics and demonstrated their potential in enhancing student engagement and learning outcomes. Furthermore, Sipayung et al. (2020) reported that the comic-based realistic mathematics approach significantly improved students' learning motivation and conceptual understanding, reinforcing the effectiveness of e-comic formats grounded in realistic contexts.

In addition to being analyzed based on classical completeness, the effectiveness of the learning media was also evaluated from the level of improvement in students' mathematical problem-solving abilities. This improvement was measured using N-Gain Score analysis, which compares pretest and posttest scores to determine the magnitude of learning improvement obtained by students after using the learning media. This analysis is important because it not only shows whether students achieve completeness or not, but also illustrates the extent of improvement in ability in each trial. The results of the N-Gain Score

analysis can be seen in Table 8. The N-Gain Score analysis indicates an improvement in students' problem-solving abilities.

Table 8. Results of N-Gain Score Analysis

Trial	N-Gain Score	Interpretation	N-Gain Score (%)	Effectiveness Interpretation
I	0.32	Medium	32%	Not Effective
II	0.78	High	78%	Effective

Based on the N-Gain analysis, in Trial I a score of 0.32 was obtained with a medium category, or equivalent to 32%, which is interpreted as not effective. Meanwhile, in Trial II, the N-Gain score was 0.78 with a high category, or equivalent to 78%, which falls into the effective category. Thus, it can be concluded that the effectiveness of the learning product increased from the first trial to the second trial. This indicates that after improvements and refinements were made, the developed product became more optimal and was able to have a positive impact on students' learning outcomes.

After conducting the classical completeness analysis and calculating the N-Gain, the next stage is to describe in more detail the results of students' mathematical problem-solving tests. This description aims to provide a clear picture of students' score achievements, including the highest score, lowest score, and average learning outcomes in Trial I and Trial II. By comparing the pretest and posttest results, it is possible to see in more detail how the improvement in problem-solving ability occurred at each stage of the trials. Similar approaches can be found in prior research. For instance, Ramadhan & Sumarni (2025) reported detailed pretest, posttest, and N-Gain results showing significant improvement in students' problem-solving skills following intervention with an interactive STEM-PBL worksheet. The comparison of these results is summarized in Table 8.

Table 9. Comparison of Test Results from Trial I and II

Description	Trial I		Trial I	
	Pretest	Posttest	Pretest	Posttest
Highest Score	90	96	90	100
Lowest Score	60	72	60	72
Average	76.9	83.73	77.4	94.25

Based on the conducted trials, in Trial I the highest score obtained was 90 in the pretest and increased to 96 in the posttest. The lowest score also increased from 60 in the pretest to 72 in the posttest. The average learning outcome of students in Trial I improved from 76.9 to 83.73. Furthermore, in Trial II, the highest student score increased from 90 in

the pretest to 100 in the posttest. The lowest score remained the same at 60 in the pretest but increased to 72 in the posttest. The average learning outcome of students in Trial II also experienced a significant increase, from 77.4 in the pretest to 94.25 in the posttest. Thus, both in Trial I and Trial II, the results show an improvement in students' scores after the treatment, indicating that the developed learning product is effective in enhancing students' learning outcomes.

The developed Indonesian-culture-based e-comics learning media, grounded in Imam Shafi'i Education, has met the validity criteria based on expert evaluations. Validation by media experts (4.3), content experts (4.2), religious experts (4.4), and cultural experts (4.5) indicates that the learning media aligns with the learning needs of SPLDV for 8th-grade junior high school students. This is supported by research by Armiadi et al. (2021), who applied the 4D model to develop culture-based interactive mathematics media, yielding extremely positive validation scores from media, content, and instructional design experts while significantly improving student learning outcomes. The integration of Indonesian culture in the e-comics learning media has proven to be authentic and representative based on cultural expert validation, which received the highest score (4.5).The use of Malay cultural characters and settings, along with the integration of Imam Shafi'i educational values, provides meaningful learning contexts for students.

The practicality test results showed a significant improvement from Trial I to Trial II, both in terms of teacher and student responses. Teacher responses increased from 77.4% (practical) to 87.5% (very practical), while student responses increased from 74.3% (fairly practical) to 78% (practical). This improvement occurred due to enhancements in the learning media based on the evaluation of Trial I, particularly the addition of verification or proof in each example problem and the inclusion of extra practice exercises.

The learning media proved effective in improving students' mathematical problem-solving abilities. Classical completeness in Trial II reached 87.5%, surpassing the minimum criterion of 85%. The N-Gain Score also showed an increase from 0.32 (medium) in Trial I to 0.78 (high) in Trial II. The effectiveness of this learning media is supported by several factors:

1. Visualization of SPLDV material through engaging illustrated stories

The SPLDV (Systems of Linear Equations in Two Variables) topic is conceptually abstract, as it involves symbolic representation and algebraic reasoning. Through the e-comic format, each concept is visualized in the form of a storyline that demonstrates real-

life situations requiring linear relationships—such as comparing prices, calculating quantities, or analyzing daily transactions.

Figure 1. Contextual Scene of SPLDV in the E-Comic

2. Indonesian cultural context familiar to students

   The e-comic incorporates Indonesian cultural settings, such as traditional markets, local characters, and Batik-inspired backgrounds. This familiar context fosters emotional connection and cultural relevance, allowing students to see mathematics as part of their daily lives rather than a separate, abstract discipline.

3. Integration of Imam Shafi'i educational values that encourage learning motivation

   Each chapter of the e-comic embeds Islamic moral and educational values inspired by Imam Shafi'i, emphasizing diligence in seeking knowledge (*thalabul 'ilm*), honesty, humility, and respect for teachers. These values are presented through the dialogue of characters and reflective quotes appearing at the end of each scene.

4. Systematic problem-solving approach

   The storyline in each comic episode follows Polya (1957) four stages of problem solving understanding the problem, devising a plan, carrying out the plan, and looking back. Each step is represented by visual cues and short explanations, guiding students to think systematically and reflectively.

This assertion is further supported by recent evidence. A systematic review by Gultom et al. (2025) found that interactive digital media often leveraging tools like GeoGebra and Lectora Inspire within contextual and constructivist frameworks significantly enhances students' understanding of mathematical concepts and problem-solving abilities.

Additionally, research by Sekarwangi et al. (2021) demonstrated that Problem-Based Learning combined with interactive multimedia is highly effective in elementary education, offering learners contextual, interactive experiences that bolster their problem-solving skills. In the context of the comic *Rumah Ilmu di Kampung Pematang Cengal*, the effectiveness of the medium emerges not from interactive digital features, but from its strong visual storytelling, cultural settings, and narrative explanations. The comic presents mathematical problems through relatable daily-life scenarios, culturally grounded characters, and step-by-step visual demonstrations of SPLDV concepts. These elements help reduce abstraction, guide students through the reasoning process, and make mathematical ideas more concrete and meaningful, allowing learners to stay engaged even in a non-interactive, static comic format.

Furthermore, several other studies reinforce the effectiveness of e-comic and interactive multimedia in mathematics learning. For example, Harisman et al. (2023) found that digital comics significantly improved students' conceptual understanding and motivation in algebra learning. Similarly, Reyes (2020) reported that multimedia-based learning modules increased engagement and supported higher-order thinking skills. A quasi-experimental study by Ulfiana et al. (2019) also showed that interactive comic-based media boosted students' problem-solving abilities and reduced mathematics anxiety. Collectively, these findings provide more robust empirical support for the claim that e-comic and interactive multimedia can effectively improve students' mathematical understanding, motivation, and problem-solving capacity.

The improvement in students' mathematical problem-solving skills is clearly seen from the comparison of pretest and posttest results in both trials. The average posttest score in Trial II reached 94.25, significantly higher than Trial I (83.73). The distribution of students in the "very high" category also increased from 6.7% (Trial I) to 87.5% (Trial II). This improvement occurred because the e-comics media presents contextual problems close to students' daily lives, accompanied by systematic problem-solving steps following Polya's (1957) theory.

CONCLUSION

Based on the results of the development research on Indonesian-culture-based e-comics learning media grounded in Imam Shafi'i Education to improve students' mathematical problem-solving abilities, it can be concluded that:

1. The developed learning media meets the validity criteria with expert validation scores of 4.3 from media experts, 4.2 from content experts, 4.4 from religious experts, and 4.5 from cultural experts. The integration of Indonesian culture and Imam Shafi'i educational values has proven to be appropriate for teaching SPLDV mathematics.
2. The learning media meets the practicality criteria based on teacher responses (87.5% – very practical) and student responses (78% – practical) in Trial II. The increase in practicality occurred after media improvements based on the results of Trial I.
3. The learning media is proven effective in improving students' mathematical problem-solving abilities, as indicated by:
   1) Classical completeness reaching 87.5% (exceeding the minimum criterion of 85%)
   2) N-Gain Score of 0.78 (high) with an effectiveness percentage of 78%
   3) An increase in the average score from 77.4 (pretest) to 94.25 (posttest)
4. There was a significant improvement in students' mathematical problem-solving abilities from Trial I to Trial II, with the N-Gain Score increasing from 0.32 (medium) to 0.78 (high).
5. The 4-D Thiagarajan model is proven effective in developing e-comics learning media that is valid, practical, and effective.

This study has several limitations. First, the implementation of e-comics was only conducted in one school with a limited number of subjects, so generalization of the results should be done with caution. Second, this study did not assess long-term retention or the durability of improvements in problem-solving skills after using e-comics. Third, the effectiveness analysis still focused on quantitative results; further research is recommended to explore the affective impact and religious character of students through a qualitative approach.

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