Mathematics e-comic in cultural context to improve student motivation and learning outcomes

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Abstract

Introduction: Learning media is a key factor that influences student motivation and learning outcomes. The learning media used should be relevant to students' daily lives, including cultural aspects. One example is the use of digital comics (e-comics) in mathematics, particularly in a cultural context, for teaching material on Systems of Linear Equations in Two Variables (SLETV).

Aim: This study aimed to determine the characteristics of mathematical e-comics in a cultural context that are valid, practical, and effective in increasing motivation and learning outcomes among junior high school students.

Method: The research used a development method based on the Plomp model, which consists of an initial investigation, design, and assessment stage. The subjects were class VIII students at an Islamic junior high school in West Aceh, Indonesia.

Result: The validity scores for the content and media were 4.70 and 4.64, respectively, showing a very high level of validity. Practicality was measured by teacher responses (4.43) and implementation levels (4.21), both indicating very feasible use. The effectiveness was assessed through a Learning Outcomes Test (LOT), student responses, and motivation questionnaires. LOT results showed 82.05% of students achieved the Minimum Mastery Criteria (KKM), 80.19% of students gave positive responses, and motivation scores reached 83.86%, indicating very good levels.

Conclusion: This research developed a culturally relevant mathematical e-comic for SLETV material, which was found to be valid, practical, and effective in enhancing student motivation and learning outcomes in junior high school. The results suggest that incorporating cultural contexts in digital learning media can positively impact student engagement and achievement.

INTRODUCTION

Learning media is crucial in influencing learning outcomes and student motivation (Talysheva et al., 2021; Yu et al., 2020). It serves as a tool that facilitates the transmission of information from teachers to students, offering engaging stimuli and making it easier for students to process information (Kusumaningtyas et al., 2018), ultimately increasing their interest and motivation to learn (Gaol & Sitepu, 2020). Moreover, innovations in current teaching methods are necessary to improve student engagement, understanding, collaboration, and motivation (Gil-Doménech & Berbegal-Mirabent, 2019); innovations

include the use of technology or updated learning media. Kristanto et al. (2017) highlighted that companies increasingly develop digital learning media, such as e-learning, in response to global trends. As educational technology evolves, students are becoming more adept at engaging with these new tools (Stošić & Stošić, 2015). Incorporating technology into education will likely capture students' attention and boost their engagement (Haleem et al., 2022).

Providing learning media that meets the demands of 21st-century education involves not only ensuring ease of access and affordability but also enhancing students' motivation and engagement. Modern education emphasizes integrating digital technology into learning, moving away from traditional methods, and encouraging interactive and engaging tools (Haleem et al., 2022), one of which is e-comics. E-comics, which use visual imagery such as cartoons to present fictional and non-fictional content (Oliwe & Chao, 2022; Toh et al., 2017), are an example of digital media that conveys important information in an accessible format. These electronic versions of comics offer advantages such as accessibility, durability, and interactivity (Berger et al., 2023). Combining text and images, e-comics help enhance understanding (Missiou & Tapsis, 2023). They are entertaining, educational, and effective in stimulating students' reading motivation, as Ramliyana (2016) demonstrated. Additionally, Comic books can influence cognition by encouraging debate and social interaction with peers, simplifying complex reading problems, posing questions, and conveying any major concept (Tassell et al., 2019).

Comics and e-comics are practical learning tools being developed for various subjects, educational levels, and learning objectives. This is largely a response to the growing disinterest among students in conventional textbooks, which are often viewed as unengaging, while visually enriched books like comics are much preferred. Offering textbooks with appealing visual presentations, such as comics, addresses this issue. E-comics can be effective learning media if the content includes educational elements that boost motivation, stimulate learning, and psychologically impact students (Buchori & Setyawati, 2015; Haleem et al., 2022). Research by Toh et al. (2017) showed that using e-comics in mathematics education enhances student skills and interest in learning. E-comics also make learning more enjoyable and reduce mathematics anxiety. Even abstract school mathematical concepts can be presented in an engaging, light-hearted way that captures students' interest without compromising the mathematical content (Toh et al., 2019).

When designing e-comics, anchoring the content in relevant themes or contexts is essential. This ensures that the story resonates with students, aligning with cognitive flexibility theory and emphasizing context's importance in effective learning (Siqi-Liu & Egner, 2020). Context-based learning in mathematics can increase student motivation and interest, enabling students to engage directly with mathematical problems (Papadakis et al., 2021). One real-world context is the local community's customs, wisdom, or culture. We can create a meaningful environment that offers relevant learning experiences by integrating real-life contexts into mathematics learning. This approach

helps students recognize the connection between mathematics and cultural values, applying these concepts to everyday life (Nur, 2018).

Previous studies have demonstrated the significant impact of using e-comics in improving the quality of mathematics learning, especially student motivation and learning outcomes. Cho's (2012) and Siregar et al.'s (2019) research results showed that e-comics can increase students' motivation and interest in learning, especially mathematics. E-comics can increase student motivation and learning achievement in limit (Budi et al., 2016), social arithmetic (Rahmata & Ekawati, 2021), quadratic functions (Adeliyanti et al., 2018), relations and functions (Faoziah & Azka, 2023), and System of Linear Equations in Two Variables (SLETV) (Sakinah & Hendriana, 2022).

The Aceh region, rich in culture and historical values, offers examples such as language, traditional clothing, dances, houses, weapons, and food (Kasmini & Mulyani, 2023). Acehnese cultural practices are deeply rooted in religion and customs, passed down through generations (Ghozali et al., 2024). For instance, traditional cakes are an important cultural symbol, and understanding their names and meanings is key to preserving Acehnese heritage (Wahdah et al., 2022).

Mathematics e-comics can combine cultural values, offering entertainment, education, and cultural messages. Cultural-context e-comics, which feature elements like traditional Acehnese cakes, can depict daily life scenarios such as buying and selling, which relate to mathematical concepts. Research supports that integrating cultural values into mathematics education helps students connect abstract concepts to real-world experiences, enhancing learning (D'Ambrosio, 2016). Culturally relevant e-comics can give students a more engaging and contextually meaningful way to grasp mathematical concepts (Nti-Asante, 2022).

Cultural integration in e-comics provides a platform for exploring the relationship between mathematics and culture. Preliminary studies reveal that Acehnese teachers believe in the potential of integrating cultural values into mathematics education. However, the application of this approach, particularly in SLETV material, remains limited. Culture-based mathematics learning supports understanding and fosters students' sense of identity and belonging (Meng & Liu, 2022). Mastering SLETV is crucial for students, as it forms the foundation for understanding more complex mathematical concepts, such as matrices, determinants, and three-variable systems of linear equations (Latifah & Luritawaty, 2020; Mubarokah et al., 2021). Thus, the availability of culturally relevant learning media for this topic is critical to supporting an effective learning process.

Observations and interviews reveal that most students enjoy using comics, though the learning resources available for SLETV are limited to textbooks, hardcopy modules, and teacher-provided materials. While some students are familiar with digital comics or e-comics in PDF format, using comic-based learning resources—particularly technology-based mathematics e-comics for SLETV—remains limited.

Previous research into comics and e-comics in mathematics education has been conducted in countries like Singapore and Germany. In Singapore, studies show that comics and cartoons significantly increase student motivation and interest in

mathematics (Toh et al., 2017). Similarly, research in Germany reveals that comics enhance the learning experience in science classes, making learning more enjoyable (Affeldt et al., 2018). Mamolo (2019) also found that mathematics e-comics received positive student feedback for their engaging and unique approach. Azizi and Fauzan (2020) report that comics improve students' conceptual understanding and problem-solving abilities in mathematics.

Despite these positive findings, a significant gap exists in exploring e-comics incorporating local cultural contexts into mathematics education. While research demonstrates the effectiveness of e-comics in enhancing engagement and comprehension, little attention has been paid to how culturally relevant content can further improve learning outcomes. For instance, developing ethnomathematics-based comics in Indonesia, as applied to cubes and blocks (Nida et al., 2017), underscores the potential of integrating local culture. However, this approach has not yet been widely applied to other mathematical topics. Further research is needed to explore how incorporating local cultural elements into e-comics, especially in topics like SLETV, can enhance student comprehension and motivation. Addressing this gap could provide valuable insights into the effectiveness of culturally relevant e-comics in diverse educational contexts.

Mathematics e-comics with a cultural context for SLETV are essential, yet their availability is limited. Therefore, this research aims to identify the characteristics of culturally relevant mathematics e-comics that can improve student motivation and learning outcomes in junior high schools. The e-comics developed will be evaluated for validity, practicality, and effectiveness. Validity was measured through expert evaluations of content, cultural relevance, and instructional design. Practicality was assessed through teacher and student feedback on the usability of the e-comics in classroom settings. Effectiveness was evaluated by comparing students' motivation and learning outcomes before and after using the e-comics, pre- and post-tests, and motivation surveys.

METHODS

Design:

This study employed a research and development (R&D) approach using the Plomp (2013) development model, which consists of three stages: 1) preliminary research, 2) prototyping phase, and 3) assessment phase. The Plomp model was selected due to its clear, systematic procedure and adaptability to diverse educational contexts. Compared to other development models, such as ADDIE or Dick and Carey, the Plomp model offers greater flexibility, allowing researchers to iterate and adjust each phase to meet specific needs, including the integration of cultural elements into learning materials (Nieveen, 2013). This flexibility makes it particularly suited for this study, enabling the seamless incorporation of local cultural contexts into the design of e-comics and ensuring that the final product is culturally relevant and contextually appropriate for students in Aceh. The model's adaptability allows researchers to align development with both educational

objectives and cultural relevance, making it an ideal choice for this project. The flowchart of the development is presented in Figure 1.

Participants:

The participants in this study were Year 8 students from an Islamic public junior high school in West Aceh, Indonesia. In the small group trial, 15 students were selected through purposive sampling to represent a range of abilities—high, medium, and low—ensuring that the developed media could address diverse learning needs. For the field trial stage, 39 students were randomly selected to participate, offering a broader evaluation of the effectiveness and practicality of the comic across a more representative sample of the student population.

Instruments:

Various instruments were used to collect data on the learning media's validity, practicality, and effectiveness. These instruments included: 1) a material expert validation sheet, 2) a media expert validation sheet, 3) a practicality test sheet, 4) a learning implementation sheet, 5) a learning outcomes test, 6) a student learning motivation questionnaire, and 7) a student response questionnaire.

Figure 1. Development flowchart

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Data Analysis:

Validity was analyzed using the indicators proposed by Nieveen (1999): 1) the tool developed is based on a strong theoretical rationale, and 2) there is internal consistency. The e-comic is considered practical if it meets several criteria Nieveen (1999) described, including 1) observers or practitioners indicating that the developed tool can be applied and 2) evidence showing that it can be implemented in practice. In this study, practicality was defined by the following criteria: 1) the teacher states that e-comics can be implemented in the classroom, and 2) the level of implementation is rated in the high category. The validity and practicality of the e-comics were analyzed and concluded based on the ideal assessment criteria per aspect, as outlined by Widoyoko (2016), which is presented in Table 1.

Table 1. Validity Criteria for E-Comics

Average Score Range	Criteria
>4.20 s/d 5.00	Very high
>3.40 s/d 4.20	High
>2.60 s/d 3.40	Moderate
>1.80 s/d 2.60	Poor
1.00 s/d 1.80	Very Poor

E-comics are said to be effective if they meet the indicators developed by Nieveen (1999), namely (1) practitioners, based on their experience, state that the product is effective, and (2) operationally, the product provides results as expected. In this research, the criterion for effectiveness is if students give more than 50% positive responses and achieve the desired learning outcomes. The learning outcomes achieved must meet the Minimum Criteria of Mastery Learning (known as KKM) applied by the school, namely 75. Questionnaire analysis is based on each indicator statement's average score and score interval. Calculating student responses and motivation uses the following formula.

$$\text{Average } score = \frac{Total\ score\ obtained}{Maximum\ total\ score}$$

The average score obtained is then categorized based on the criteria. According to Arikunto (2006), as shown in Table 2,

Table 2. Criteria for Assessment of Response and Learning Motivation

Score Intervals	Criteria
81-100	Very good
61-80	Good
41-60	Moderate
21-40	Poor
0-20	Very poor

In this research, student responses and motivation are said to be positive if the criteria given by students are in the "very good" and "good" categories.

RESULTS AND DISCUSSION

Result

This research aimed to evaluate the development of a valid, practical, and effective cultural-context mathematics e-comic focused on SLETV (System of Linear Equations in Two Variables) material. The development process followed the three stages of the Plomp model: preliminary research, prototyping stage, and assessment phase, described below.

Preliminary Research

During this stage, the curriculum, literature, learning resources, and student needs were analyzed.

School Curriculum Analysis

The curriculum analysis was performed for junior high school mathematics subjects, referencing the Kurikulum 2013 for Years 8 and 9 and the Kurikulum Merdeka for Year 7. The basic competency for the knowledge dimension of SLETV includes explaining the system of linear equations in two variables and its solution to contextual problems. The skill dimension involves solving problems related to the system of linear equations in two variables. The indicators set for the development of comic media were: (a) stating SLETV in the context of real-world problems, (b) explaining the concept of SLETV, and (c) solving real-world problems involving SLETV. These competencies and indicators were based on the Kurikulum 2013 syllabus for SLETV material. Additionally, the comic media incorporated these indicators into the learning process.

Literature and Learning Resources Analysis

The analysis revealed that learning resources for SLETV are primarily textbooks and online materials, with printed modules used in regular instruction. Students typically rely on textbooks, worksheets, and materials provided by teachers. Some students, however, are familiar with comics and e-comics accessed in PDF format via the internet. Although teachers acknowledge the potential for independent student learning with technological support, they rarely incorporate technology or software. Nevertheless, teachers responded positively to the development of mathematics e-comics, believing they would enhance student motivation and learning. Similarly, students expressed a positive attitude toward the planned development of the mathematics e-comic.

Student Needs Analysis

The needs analysis revealed that comics are rarely used as learning resources, particularly in SLETV mathematics. To address this gap, researchers considered developing mathematics e-comics to facilitate learning. The e-comic was designed to be self-instructional, user-friendly, flexible, and equipped with preliminary assessments. It was intended for independent use by students, with easy access at any time and place. The design also took into account the technology-savvy nature of today's students.

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Prototyping Stage

The cultural-context mathematics e-comic was designed using computers and specialized software, with input from graphic design and multimedia experts. The detailed development steps are outlined below.

Identifying and Formulating Learning Objectives

The comic media included material and practice questions aligned with the learning objectives. These objectives made it easier for researchers to assess the students' cognitive abilities after engaging with the cultural-context e-comic in SLETV material. The desired learning outcomes were for students to (a) correctly state SLETV in everyday contexts, (b) accurately explain the concept of SLETV, and (c) solve real-world SLETV-related problems using the substitution method.

Designing Comic Media

The comic development process involved the following stages:
  a) Scenario Design: Themes, storylines, and scenarios were developed to align with the material and cultural context, ensuring suitability for junior high school students.
  b) Storyboard Preparation: Graphic designers created storyboards using pen tablets, which improved efficiency over traditional mouse-based drawing methods.
  c) Comic Creation: The initial sketches were refined using Paint Tool SAI software, which added dialogue balloons, backgrounds, and colors to enhance the comic's authenticity.
  d) Digital Formatting: Multimedia experts converted the comics into a digital format (JPG) using specialized software after completing the illustration and coloring.

The result of this stage was a mathematics e-comic with a cultural context for SLETV material, referred to as Prototype I. A validation instrument was required to assess the learning media's content, format, language, and appearance, ensuring the comic media met the established learning objectives and was effective.

Designing Learning Outcome Test (LOT) Questions

LOT items are formulated based on indicators of the learning objectives. The test items' formulation results in five test questions that cover the entire SLETV material studied.

The Validity of E-Comic

Following the development of Prototype I, the next steps involved validation and small group testing. The validation process included five validators—four mathematics education lecturers and one mathematics teacher—who reviewed the e-comic for content, construct, language, and appearance. They also validated the learning outcome test questions, assessing the construction, language, and material. The validation results provided a basis for revisions before conducting limited trials. The validation analysis results are presented in Table 3.

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Table 3. E-comic Validation Results
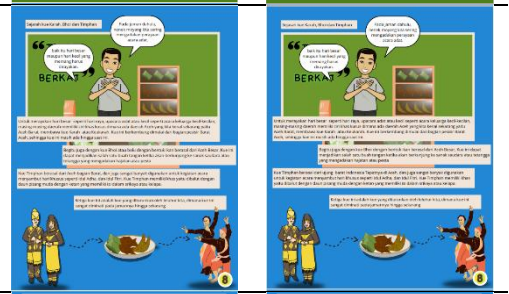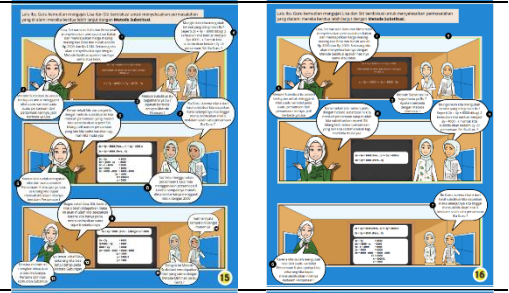
Type of Validation	Validation Aspect	Validator					Average Aspect	Average Validity
		V1	V2	V3	V4	V5		
Material	Contents	4.83	4.50	4.50			4.61	4.36
	Construct	4.14	4.00	4.14			4.09	
	Language	4.67	4.00	3.67			4.11	
	Appearance	4.73	4.54	4.64			4.64	
Media	Technical				4.50	4.50	4.50	4.64
	Appearance				4.82	4.64	4.73	
	Contents				4.83	4.83	4.83	
	Language				4.33	4.67	4.50	

The results of the e-comic validation analysis indicate that the average material validity score of 4.36 falls within the "very valid" criteria, and the average media validity score of 4.64 also meets the "very valid" criteria. In terms of content, the e-comic achieved a content validity score of 4.61, classified as "very valid," a construct validity score of 4.09, classified as "valid," a language validity score of 4.11, classified as "very valid," and an appearance validity score of 4.64, which is considered "very valid." Additionally, the e-comic media attained a technical validity score of 4.50, classified as "very valid," an appearance validity score of 4.73, classified as "very valid," a content validity score of 4.83, also classified as "very valid," and a language validity score of 4.50, classified as "very valid."

The revision process for the e-comic was thorough and comprehensive, consisting of three stages. Each stage was conducted in response to feedback and input from the validators, ensuring their suggestions were taken seriously and the e-comic was improved accordingly. The specific parts of the e-comic that were revised during the first stage are presented in Table 4.

Table 4. Stage-1 Revision Based on Validation Results
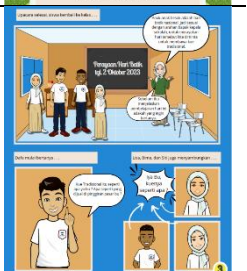
Validator Suggestions	Before Revision	After Revision
Regarding material, the instrument still does not use Kurikulum 2013 or Kurikulum Merdeka. If the RPP for the Kurikulum 2013 has been prepared, the instrument should no longer be linked to Capaian Pembelajaran (CP) in Kurikulum Merdeka.	Instruments related to learning outcomes in *Kurikulum Merdeka*.	Instruments are not linked to learning outcomes in *Kurikulum Merdeka*.
Add a foreword page before entering the first page of the comic.	*(no 'preface of the comic')*	
Some students do not wear the hijab on the comic's first page. Please change to wearing a hijab and wearing a long skirt.		
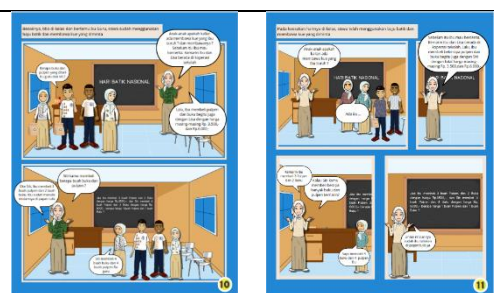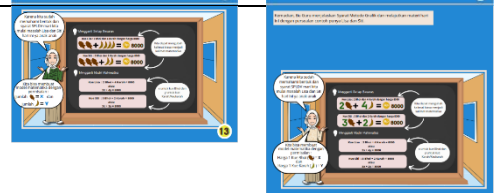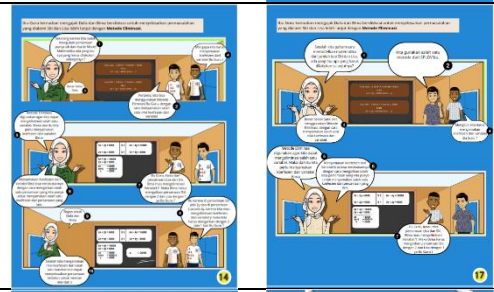
On page 5 of the comic, a student walking around is unclear whether he is a girl or a boy.		
Page 5 of the comic explains that timphan cake is typical of West Aceh, which is wrong. Please change the name to Aceh or the part of Aceh you reference.		
On page 13, there is an example of a wrong concept; before the picture of bhoi and karah cakes, add " jumlah". Like " jumlah (gambar kue) = x".		
The sentences explaining the example questions are too many and close together. Please change them so they don't look dense and boring.		
On the last page, please replace the word "love" with a more educational word.		

Based on Table 4, several parts of prototype 1 have been revised. The revision results from prototype 1 are referred to as prototype 2. Several revisions have been made based on the validation results of prototype 2. The parts of the e-comic that were revised in the second revision stage are presented in Table 5 below.

Table 5. Stage-2 Revision Based on Validation Results

Validator Suggestions	Before Revision	After Revision
Please change the cover to include an element explaining that this is a mathematics comic based on SLETV material.		

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Please add a 'Petunjuk Penggunaan Komik' page on the page after the cover to make it easier for students and teachers to use comics.	*(no 'instruction on how to use the comic')*
On the page after the instructions for use, please add the page 'KD dan Indikator'	*(no 'basic competence and indicators')*
On the foreword page, please replace the words that suit the comic.	
On page 3, please change the words accordingly.	
On page 3, please change the culture to Aceh's regional culture.	
On page 5, please change the layout of the word balloons to make it easier to read.	
Please change all the student characters to face the seller on the interaction with the seller page to look beautiful, not different.	
On page 8, if the seller tells a story, please just put the text together and change the culture to the culture of the Aceh region.	

On page 10, please correct the words so that they match and replace the batik clothes; don't just stick them on.	
On page 13, there is an example of an incorrect concept; please replace it with the correct concept.	
In explaining the example questions, the sentences are too dense. Please change it so it doesn't look solid, and maybe it can be changed into just 2 parts.	
On the last page, please replace it with correct and easier-to-understand words.	

Based on Table 5, several parts have been revised in prototype 2. The revision results from prototype 2 are referred to as prototype 3. Based on the validation results, prototype 3 has no improvements. So, prototype 3 is a valid research product and can be carried out in individual and small group trials. The cultural context mathematics e-comic that has been developed can be accessed via the following link: https://online.fliphtml5.com/hhckb/hjce/.

The Validity of LOT Questions

The validation results for the five LOT questions range from 4.20 to 5.00, so they meet the valid criteria. The revised parts of the LOT based on validator suggestions are presented in Table 6 below.

Table 6. Revision of LOT Questions Based on Validation Results

Validator Suggestions	Before Revision	After Revision
Use command sentences that require students to explain the answer; do not use the word 'berapa' because it does not require a detailed answer.	*How old are each of them?*	*Determine the ages of Dody and Ari using one of the SLETV solution methods.*
Use a more effective sentence in the question sentence for question number 3: *Determine the price of 2 dozen candies A and 4 dozen candies*	*How much is the price of 2 dozen candies A and 4 dozen candies B? Solve using the*	*Determine the price of 2 dozen candies A and 4 dozen candies B using the*

B using the elimination and substitution methods.	elimination and substitution methods.	elimination and substitution methods.

The results of the revision of prototype 1 LOT question are referred to as prototype 2. The researcher asked the validator to re-validate prototype 2 LOT questions, but there was no improvement, so prototype 2 LOT questions could be used at the next stage.

Small Group Trial Results

The purpose of conducting small group trials is to test the product's practicality by users. In the small group trial, the subjects chosen were students consisting of 15 students. The selection was done with high, medium, and low representation estimates. The analysis results on small group trials are presented in Table 7.

Table 7. E-Comics Implementation Analysis Results

Implementation Assessment Aspects	Average
The use of math e-comics is easy to understand.	3.71
The math e-comic is simple to use.	4.07
The use of mathematics e-comics supports the achievement of learning objectives.	4.43
The use of mathematics e-comics can streamline the implementation of learning.	4.21
The use of mathematics e-comics can make learning time more effective.	4.21
The use of mathematics e-comics can increase learning motivation.	4.57
The use of mathematics e-comics can facilitate learning.	4.21
The questions and materials used can be understood easily.	4.29
Total Average	**4.21**
Criteria	**Very High**

In Table 7, the average value of media implementation is 4.21. This shows a very high level of implementation, so cultural context mathematics e-comics are very suitable for learning.

Assessment Phase

At the field trial stage, 39 students were selected after consultation with lecturers and upon observing that the school did not yet have e-comic learning media. Mathematics teachers acted as instructors, while researchers served as observers. This trial evaluated the practicality and effectiveness of the e-comics and the Learning Outcome Test (LOT) questions. The trial spanned five meetings, four of which used e-comic media, with the final meeting dedicated to the LOT. Data was meticulously collected from practicality assessments, student LOT results, student response questionnaires on learning, and student motivation questionnaires, ensuring a comprehensive evaluation.

The Practicality of E-comics

One of the researchers, acting as the observer, collected data on the practicality of the e-comic media, with scores ranging from 1 to 5. The data collected represents the average score for each assessed aspect. Details of the practicality assessment of the e-comic media are presented in Table 8.

Table 8. E-Comics Implementation Analysis Results

Aspect	Practitioners		Average of Aspect	Total Average
	P1	P2		
User Practicality	4.43	4.57	4.50	
Content	4.28	4.43	4.35	4.31
Language	3.67	4.33	4.00	
Appearance	4.40	4.40	4.40	

The results of the practicality analysis show an average practicality score of 4.31. This means that the cultural context of mathematics e-comic media is highly suitable for use.

The Effectiveness of E-comics
The criteria for the effectiveness of the product being developed are obtained from the results of the analysis of (1) student learning outcome data, (2) student response data, and (3) student learning motivation data. A description of the analysis to determine the product effectiveness criteria is presented as follows.

a) Students' Learning Outcome
Based on student score data, it can be seen that from 39 students, 32 students met the KKM, and 7 students did not meet the KKM. This shows that 82.05% of students achieved the KKM on the learning outcomes test after using cultural context mathematics e-comic media. Based on the 2013 curriculum completeness rules, it can be concluded that KKM for student learning outcomes has been achieved.

b) Students' Response Analysis
Student response data was obtained from the Technology Acceptance Model (TAM) questionnaire, which consists of six indicators: Perceived Usefulness (PU), Perceived Ease of Use (PEU), Attitude toward its Use (AU), Intention to Use (IU), Content quality (CQ), and Experience (EXP). The results of the analysis of student responses are presented in Table 9.

Table 9. Students' Response Results

Indicators	Average	Criteria
Perceived Usefulness	72.21	Good
Perceived Ease of Use	80.32	Very Good
Attitude towards it Use	82.56	Very Good
Intention to Use	79.15	Good
Content Quality	84.10	Very Good
Experience	82.77	Very Good
Overall	80.19	**Very Good**

The analysis of student responses to learning using e-comic media with cultural contexts shows that most students strongly agree on many indicators and several other indicators. Students strongly agree that mathematics e-comics with a cultural context are easy to use, are an appropriate teaching media idea, have quality material, and provide a good learning experience. Furthermore, students agree that this e-comic has useful value and will use it continuously in the future. The student response questionnaire assessment showed that learning using e-comics in mathematics in a cultural context received a

positive response, with student responses reaching 80.19%. This shows that this media is very useful and useful as a learning tool, providing students with a common experience regarding events in their environment. Students can use and reflect on their knowledge and skills by discussing problems the teacher presents. Thus, the student response questionnaire results concluded that the response to the learning process using mathematics e-comics in a cultural context was very positive.

c) Students' Learning Motivation Analysis

Student learning motivation data was analyzed based on motivation indicators adapted from Sardiman (2012), namely (1) diligent in facing tasks, (2) tenacious in facing difficulties, (3) showing interest in various problems, (4) preferring to work alone, (5) gets bored quickly with routine tasks, (6) can defend opinions, (7) doesn't easily give up things he wants, and (8) likes searching for and solving problems. The results of the analysis of student learning motivation are presented in Table 10.

Table 10. Students' Learning Motivation Results

Indicators	Average
Diligent in facing tasks	84.87
Tenacious in facing difficulties	84.10
Showing interest in various problems	83.85
Preferring to work alone	82.91
Gets bored quickly with routine tasks	81.54
Can defend opinions	82.05
Doesn't easily give up things he wants	85.13
Likes searching for and solving problems	86.41
Total Average	**83.86**

The results of the analysis of student learning motivation towards learning using e-comic media with a cultural context show that the average student learning motivation is 83.86, which is within the very good criteria.

Discussion

This research has produced a valid, practical, and effective cultural-context mathematical e-comic focused on SLETV material. The development of this e-comic aligns with the requirements of the Kurikulum 2013, which emphasizes the use of context, including cultural contexts, in mathematics education. Furthermore, its use can be extended to the current Kurikulum Merdeka, as the curriculum integrates diverse cultural contexts and regional characteristics.

Incorporating cultural context into mathematics learning makes mathematical concepts more relevant to student's daily lives, enhancing their motivation and interest in the subject while fostering a sense of ownership in their learning. Students who connect mathematical concepts to their cultural experiences tend to achieve deeper understanding (Aprilyani & Hakim, 2020; Kim et al., 2010; Prahmana & D'Ambrosio, 2020). The mathematical e-comic with a cultural context can deepen students' comprehension of SLETV material, which is often challenging due to difficulties in modeling problems in mathematical form (Sumbandari et al., 2021). As SLETV serves

as a foundation for algebra, students' failure to grasp it can result in further struggles with algebraic problems (Damayanti et al., 2022; Nihayah, 2021). Thus, cultural-context mathematics e-comics can potentially enhance students' understanding of algebra.

Characteristics of Mathematics E-Comic with Cultural Context

The cultural-context mathematical e-comic developed in this study combines visual narrative media with mathematical concepts grounded in students' daily cultural experiences, specifically those of Acehnese culture. A key feature of this product is its ability to bridge the gap between mathematical language and students' cultural backgrounds. Through images, stories, and cultural elements, this e-comic presents engaging and relevant narratives (Akcanca, 2020; Mamolo, 2022). The results of this research align with previous findings, suggesting that well-designed e-comics enhance student engagement and stimulate creativity in solving mathematical problems (Fianto et al., 2023).

Another characteristic of this e-comic is its real-life context for mathematical concepts. By framing math problems in culturally familiar situations, students can better understand how mathematical concepts apply to their everyday lives (Acharya et al., 2021). This approach strengthens conceptual understanding and motivates students to see mathematics as relevant to their daily experiences.

In addition, the e-comic fosters representation of Acehnese culture, offering students insights into their heritage. By incorporating cultural elements, this e-comic broadens students' perspectives on mathematics, illustrating that the subject can be viewed through diverse cultural lenses (Andarukmi et al., 2024). This encourages diversity in mathematical understanding while fostering a learning environment that values different perspectives.

From a technological standpoint, the e-comic leverages the advantages of digital media. Using narration, images, and interactivity makes mathematical concepts more engaging and accessible (Akcanca, 2020; Mamolo, 2022), providing a modern, dynamic, and responsive learning experience (Wijayanti et al., 2024). The cultural-context mathematical e-comic creates a fun, relevant, and inclusive learning experience. It harnesses the power of storytelling and cultural representation to inspire and enhance students' understanding.

Strengths and Weaknesses of Mathematics E-Comic with Cultural Context

The e-comic has demonstrated strengths in improving student motivation and learning outcomes. It effectively engages students, encouraging them to actively participate in learning by asking questions, responding to others, solving problems, and contributing to discussions. This active involvement has led to improved learning outcomes. Presenting material through appealing visuals and everyday language in the e-comic makes it easier for students to grasp concepts and fosters creative thinking (Astuti et al., 2018). Research by Fitrianingsih et al. (2019) supports the notion that learning media helps clarify and simplify material presentation. Learning through e-comics enhances the effectiveness of instruction and sharpens students' thinking (Afifah & Putri, 2021).

However, the e-comic also has limitations. It is currently limited to SLETV material, which restricts its use for other mathematical topics. Nevertheless, teachers could use it as a model to develop similar e-comics for other content areas.

Learning through e-comics in this context requires more time than originally planned, as students often become deeply engrossed in reading. To maintain learning efficiency, teachers could set clear activity time limits, narrow the scope of material covered, or encourage students to complete reading the e-comic before class. These strategies will help ensure that learning remains effective.

Implication
The findings of this research demonstrate that the cultural-context mathematical e-comic on SLETV material is valid, practical, and effective in improving junior high school students' motivation and learning outcomes. To maximize its benefits, the researcher offers several recommendations: (1) mathematics teachers and students can use the e-comic as a learning tool for SLETV material; (2) the e-comic can also serve as a resource for independent learning, accessible anytime and anywhere.

Limitations and Suggestions for Further Research
While the cultural-context mathematical e-comic has been developed, further refinements are needed to enhance its practicality and effectiveness. The need for more comprehensive data on its impact and to guide future development is evident. This research faced certain limitations, such as inadequate internet access for some students with smartphones, which required the provision of a personal hotspot. Some improvements are also needed, such as refining the images, correcting typographical errors, and clarifying dialogue for better understanding. These limitations offer opportunities for future researchers to explore similar studies carefully considering these factors, highlighting the importance of their potential contributions.

CONCLUSIONS
This study has successfully developed a cultural-context mathematical e-comic on SLETV material, which has proven to be a valuable tool for enhancing junior high school students' motivation and learning outcomes. The e-comic was found to be valid, practical, and effective. Teacher assessments of practicality and implementation further confirm the comic's suitability for use. The effectiveness of the e-comic was demonstrated through student learning outcomes, responses, and motivation, with a significant percentage of students achieving the Minimum Criteria of Mastery Learning (KKM), an average student response score, and a motivation percentage.

AUTHOR CONTRIBUTION STATEMENTS
DF, MI, and EE formulated the research design. DF collected and analyzed the data. DF wrote the first draft of the article. MI enriched the discussion. EE proofread the whole article, evaluated references, revised it, and submitted it via the Online Journal System (OJS).

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