



Development of an Ethnomathematics-Based E-Comic Using the Cheng Hoo Mosque Context to Enhance Students' Mathematical Literacy

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ABSTRACT

Mathematical literacy is an essential 21st-century competency that enables students to formulate, use, and interpret mathematical concepts in various real-life contexts. However, Indonesian students' mathematical literacy remains relatively low, highlighting the need for innovative learning media to support its development effectively. This study aimed to develop and evaluate an ethnomathematics-based e-comic integrating the cultural context of the Cheng Hoo Mosque in Jember to enhance students' mathematical literacy. This Research and Development (R&D) study employed the ADDIE model, consisting of the Analysis, Design, Development, Implementation, and Evaluation stages. The participants included expert validators, teachers, and eighth-grade students of Al-Falah Silo Junior High School, Jember, Indonesia. Data were collected through expert validation sheets, teacher and student response questionnaires, and mathematical literacy tests. The developed e-comic achieved material and media validation scores of 95.40% and 94.45%, respectively, indicating high validity. Student and teacher responses reached 95.21% and 91.67%, respectively, demonstrating high practicality. Furthermore, students' mathematical literacy improved significantly, as indicated by the results of an independent-samples t-test ($p < 0.001$) and a high N-gain score of 0.72. These findings indicate that the ethnomathematics-based e-comic is a valid, practical, and effective learning medium for enhancing students' mathematical literacy.

Keywords: Cheng Hoo mosque, e-comic, ethnomathematics, mathematical literacy

ABSTRAK

Literasi matematika merupakan kompetensi penting abad ke-21 yang memungkinkan siswa merumuskan, menggunakan, dan menginterpretasikan konsep matematika dalam berbagai konteks kehidupan nyata. Namun, kemampuan literasi matematika siswa di Indonesia masih tergolong rendah sehingga diperlukan media pembelajaran yang inovatif untuk mendukung pengembangannya secara efektif. Penelitian ini bertujuan mengembangkan dan mengevaluasi e-comic berbasis etnomatematika yang mengintegrasikan konteks budaya Masjid Cheng Hoo Jember untuk meningkatkan literasi matematika siswa. Penelitian ini menggunakan pendekatan Research and Development (R&D) dengan model ADDIE yang meliputi tahap Analysis, Design, Development, Implementation, dan Evaluation. Partisipan penelitian terdiri atas validator ahli, guru, dan siswa kelas VIII SMP Al-Falah Silo, Jember, Indonesia. Data dikumpulkan melalui lembar validasi ahli, angket respons guru dan siswa, serta tes literasi matematika. E-comic yang dikembangkan memperoleh skor validasi ahli materi sebesar 95.40% dan ahli media sebesar 94,45%, yang menunjukkan tingkat validitas tinggi. Respons siswa sebesar 95.21% dan guru sebesar 91.67% menunjukkan tingkat kepraktisan yang tinggi. Selain itu, literasi matematika siswa meningkat secara signifikan berdasarkan hasil uji independent-samples t-test ($p < 0.001$) dan skor N-gain sebesar 0.72 yang termasuk kategori tinggi. Temuan ini menunjukkan bahwa e-comic berbasis etnomatematika merupakan media pembelajaran yang valid, praktis, dan efektif untuk meningkatkan literasi matematika siswa.

Kata Kunci: masjid Cheng Hoo, e-comic, etnomatematika, literasi matematis

INTRODUCTION

Mathematical literacy is an important competency that enables individuals to use mathematics to understand phenomena, make decisions, and solve various problems in everyday life (OECD, 2023). The Organisation for Economic Co-operation and Development (OECD) defines mathematical literacy as the ability to formulate, employ, and interpret mathematics in various contexts using mathematical concepts, procedures, facts and reasoning (Kolar & Hodnik, 2021; OECD, 2019). In the context of 21st-century education, this competency is an indicator of students' readiness to face increasingly complex social, economic, and technological changes (Kappassova et al., 2025). Therefore, mathematics learning is not only oriented towards mastering procedures and calculation skills, but also needs to enable students to apply mathematical knowledge meaningfully in various real situations.

Nevertheless, various empirical findings indicate that Indonesian students' mathematical literacy remains relatively low (Annizar et al., 2020). Results from the Programme for International Student Assessment (PISA) from 2000 to 2022 show that Indonesia's mathematics performance has consistently fallen below the OECD average in every assessment cycle (Bilad et al., 2024). As shown in Figure 1.

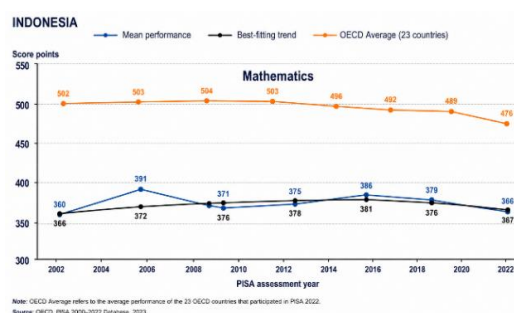


Figure 1. Indonesia's PISA Scores

Indonesia's mathematics scores have fluctuated from year to year but have not yet shown a significant improvement. In the 2022 assessment, Indonesia scored 366 points and ranked 69th out of 81 participating countries (Bilad et al., 2024; Kandira & Aini, 2025; OECD, 2023). These findings indicate that many students still struggle to understand contextual problems, interpret mathematical information, select appropriate problem-solving strategies, and apply mathematical concepts in real-life situations (Kolar & Hodnik, 2021).

Low mathematical literacy is also evident in geometry learning, particularly in the topic of polyhedra. This topic requires students to develop spatial visualisation, conceptual understanding, and the ability to translate real-world situations into mathematical representations. These competencies are essential for interpreting geometric information, relating three-dimensional objects to contextual situations, and solving problems appropriately (Ilhan & Aslaner, 2021; Žakelj & Klančar, 2022). However, a needs analysis conducted through interviews with mathematics

teachers at Al-Falah Silo Junior High School revealed that many eighth-grade students still struggle to understand geometric concepts and solve contextual problems related to polyhedra. Students tend to rely on memorising formulas rather than developing conceptual understanding, while their interest in mathematics remains relatively low. Teachers also reported that classroom instruction is predominantly teacher-centred, relying heavily on textbooks and conventional teaching methods, with limited use of interactive digital media and culture-based learning approaches. These findings highlight the need for innovative learning interventions that actively engage students and better support the development of mathematical literacy.

The development of information and communication technology provides opportunities to deliver more interactive, engaging, and student-centred learning. One digital medium that has potential for use in mathematics learning is electronic comics (e-comics). E-comics are digital comics that combine visual illustrations, text, dialogue, and storylines to convey learning materials in an engaging and communicative manner (Fahreza et al., 2022; Suwarno et al., 2025). Previous studies have shown that the use of e-comics can increase learning motivation, student engagement, conceptual understanding, and mathematics learning outcomes (Azizah et al., 2025; Farhan et al., 2024; Gardose et al., 2025). The visual and narrative characteristics of e-comics allow abstract mathematical concepts to be presented in a more concrete and understandable manner. Furthermore, presenting material through illustrated stories can increase reading interest and encourage active student participation during the learning process (Cahyono et al., 2025). Therefore, e-comics have the potential to become an alternative learning medium that suits students in the digital era.

In addition to utilising digital technology, mathematics instruction must also take into account the social and cultural contexts that are relevant to students' lives, as connecting mathematical concepts with students' sociocultural experiences can create more meaningful, relevant, and contextual learning experiences (Khasanah et al., 2025; Rosa et al., 2016). In mathematics education, the relationship between culture and mathematics is referred to as ethnomathematics. This approach views mathematical knowledge as emerging from the cultural practices of communities, enabling mathematical concepts to be explored through artefacts, traditions, belief systems, and everyday cultural activities (Batiibwe, 2024). Previous studies have indicated that ethnomathematics promotes student engagement, strengthens appreciation of local culture, and supports the development of mathematical literacy through authentic problems grounded in students' lived experiences (Nadjamuddin et al., 2025; Pratama & Yelken, 2024). Furthermore, according to Annizar et al. (2021) one way to facilitate students' understanding of mathematical concepts is by connecting mathematics to their surrounding environment and culture, an approach commonly known as ethnomathematics.

One local cultural context can be integrated into mathematics learning is the architecture of the Cheng Hoo Mosque in Jember. This mosque symbolises the acculturation of Chinese, Islamic,

and local Indonesian cultures, reflected in its form and structure (Saputra et al., 2024). Various architectural elements of the mosque represent geometric concepts, particularly flat-sided solids such as cubes, cuboids, prisms, and pyramids. Utilising this context can help students connect mathematical concepts with real-world objects in their environment, making learning more relevant and meaningful.

Although extensive research on e-comics and ethnomathematics has been conducted, several limitations remain. Most e-comic research focuses on improving learning motivation, learning outcomes, creative thinking skills, or numeracy literacy. Meanwhile, ethnomathematics research has utilised various cultural contexts as a source for mathematics learning, but has not explored the architecture of the Cheng Hoo Mosque in Jember. Moreover, studies specifically integrate ethnomathematics-based e-comics to foster students' mathematical literacy in learning polyhedra remain scarce. This gap indicates the need to develop learning media that integrate digital technology, local culture, and the development of mathematical literacy.

To address this gap, this study developed an ethnomathematics-based e-comic learning media that integrates the architectural context of the Cheng Hoo Mosque in Jember on the subject of flat-sided spatial structures. The novelty of this research lies not only in the integration of digital learning media with the local cultural context, but also in the systematic design of the e-comic to facilitate three mathematical literacy processes, namely formulate, employ, and interpret, as defined in the OECD mathematical literacy framework. In addition, this study provides comprehensive empirical evidence regarding the validity, practicality, and effectiveness of the developed learning media. Therefore, this research not only contributes to presenting contextual learning media, but also offers a learning design that is able to support the development of mathematical literacy through meaningful, contextual, and culturally relevant mathematics learning.

Based on these descriptions, this research aims to develop an ethnomathematics-based e-comic learning medium by integrating the architectural context of the Cheng Hoo Mosque in Jember with material on flat-sided geometric shapes, and to evaluate the validity, practicality, and effectiveness of this medium in improving students' mathematical literacy.

METHOD

This study employs the Research and Development (R&D) method. The development model used in this study is the ADDIE model, popularised by Robert M. Branch. The ADDIE model consists of five phases: Analysis, Design, Development, Implementation, and Evaluation (Adeoye et al., 2024). The ADDIE model was chosen because it is more suitable for product development, is structured systematically, incorporates expert evaluation, and allows for revisions at each stage, thereby minimising the risk of product invalidity (Spaitioti et al., 2022). The overall research procedure following the ADDIE model is illustrated in Figure 2.

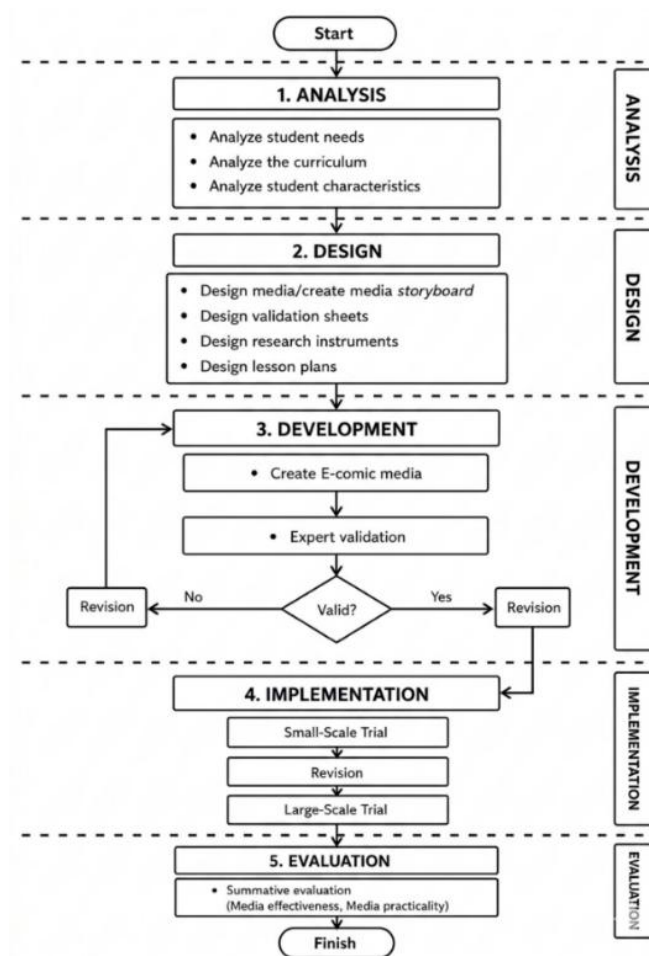


Figure 2. Stage of the ADDIE Model

This study was conducted at Al-Falah Junior High School in Silo, Jember Regency, East Java, Indonesia. The study participants included subject-matter experts, media experts, mathematics teachers, and eighth-grade students at Al-Falah Junior High School. Participants were selected through purposive sampling based on the validators' expertise and the suitability of students' characteristics. The field-testing phase consisted of a small-scale trial involving six students and a large-scale trial involving Class VIII-B as the control class and Class VIII-C as the experimental class.

Data were collected using expert validation sheets, student and teacher response questionnaires, and mathematical literacy tests administered as pre-tests and post-tests. The collected data were analysed to determine the validity, practicality, and effectiveness of the developed e-comic learning media. Validity was assessed through expert evaluations; practicality was determined based on responses from teachers and students; and effectiveness was measured using the results of the mathematical literacy tests, with an independent-samples t-test and N-gain analysis.

Product Validity

The validity of the instructional media is determined by the assessment results from subject-matter and media experts. The validity percentage is calculated using the following formula (Panerus et al., 2024).

$$V_a = \frac{T_{se}}{T_{sh}} \times 100\%$$

Notes:

V_a : Expert Validator

T_{se} : Total Empirical Score

T_{sh} : Total Maximum Score

After obtaining the expert validation result, the validity percentage was interpreted according to the product validity criteria presented in Table 1.

Table 1. Product Validity Criteria (Safitri et al., 2025)

Percentage	Category
$85\% < x \leq 100\%$	Highly Valid
$70\% < x \leq 85\%$	Valid
$50\% < x \leq 70\%$	Less valid
$0\% \leq x \leq 50\%$	Not valid

Product Practicality

The practicality of the media is derived from the results of the student and teacher response questionnaires after using the e-comic learning media. The media Practicality percentage is calculated as follows (Uno et al., 2024).

$$P_{qr} = \frac{\sum x}{S_{max}} \times 100\%$$

Notes:

P_{qr} : Percentage of questionnaire responses

$\sum x$: Total score obtained

S_{max} : Maximum score

After calculating the practicality percentage, the level of practicality was interpreted using the product practicality criteria presented in Table 2.

Table 2. Product Practicality Criteria (Safitri et al., 2025)

Percentage	Category
$85\% < x \leq 100\%$	Highly Practical
$70\% < x \leq 85\%$	Practical
$50\% < x \leq 70\%$	Less Practical
$0\% \leq x \leq 50\%$	Not Practical

Product Effectiveness

The effectiveness of the instructional media was analysed using an independent samples t-test to determine differences in mathematical literacy skills between the experimental and control classes. The media was deemed effective if the test results showed a significance level (sig. < 0.05).

Additionally, the improvement in students' mathematical literacy skills was analysed using the N-Gain formula as follows (Wahab et al., 2021).

$$N - gain(g) = \frac{Posttest\ Score - Pretest\ Score}{Maksimum\ Score - Pretest\ Score}$$

The obtained N-gain values were interpreted using the N-Gain classification criteria presented in Table 3 to determine the effectiveness level of the developed media (Mukhlis & Annizar, 2025).

Table 3. N-gain Classification Criteria

N-gain Score	Category
$g > 0.70$	High
$0.30 \leq g \leq 0.7$	Middle
$g < 0.30$	Low

RESULT AND DISCUSSION

Result

This study aims to develop an ethnomathematics-based e-comic learning medium at the Cheng Hoo Mosque in Jember to improve students' mathematical literacy by meeting the criteria of validity, practicality, and effectiveness. The research process was based on the ADDIE model, which consists of the analysis, design, development, and implementation stages, followed by evaluation. The results of the study are described as follows.

Analysis

The analysis stage is the first stage carried out by the researcher. At this stage, three types of analysis are conducted: needs analysis, curriculum analysis, and student characteristics analysis. These serve as a reference for the researcher in developing the product. First, the needs analysis in this study was conducted based on the results of interviews and observations. Based on interviews with eighth-grade mathematics teachers at Al-Falah Junior High School, it was found that the learning process often still relies on textbooks and direct explanations from teachers, meaning that the use of technology-based learning media has not yet been optimised. This situation results in less interactive and engaging learning. Additionally, observations found that most students are more interested in learning media that include images and other visual elements than in standard textbooks.

Furthermore, the curriculum analysis, found that the curriculum implemented at Al-Falah Junior High School in Silo is the Merdeka Curriculum. In its implementation, instruction utilises teaching materials in the form of instructional modules designed based on Learning Outcomes, Learning Objectives, and Learning Objective Sequences in accordance with government policies. In the instruction on flat-sided three-dimensional shapes at Al-Falah Junior High School, the focus is on students' ability to identify the elements of flat-sided three-dimensional shapes, determine the surface area of flat sides, and solve contextual problems related to daily life.

Finally, based on an analysis of student characteristics, the average age of eighth-grade students ranges from 12 to 15 years, placing them in early adolescence. During this phase, students tend to be more interested in visual media that include images, illustrations, colours, and attractive designs. Additionally, students at Al-Falah Junior High School have a strong connection to the local culture of their surroundings. Students are quite familiar with and enjoy various activities, traditions, and customs of the local community that are still practised in daily life.

Based on the results of the above analysis, it can be concluded that visual and technology-based learning media are needed that align with student characteristics and the requirements of the Merdeka Curriculum so that the learning process becomes more interactive, engaging, and targeted. In addition, learning media also need to be presented in a contextualised way, integrating elements of local culture to help students understand mathematical concepts related to daily life. Therefore, the researcher developed an e-comic learning medium based on the ethnomathematics of the Cheng Hoo Mosque in Jember to help improve students' mathematical literacy regarding flat-sided three-dimensional shapes.

Design

During the design phase, the researcher carried out several activities, namely designing the learning media, developing research instruments, and drafting a Lesson Plan. First, the e-comic learning media to be developed by the researcher was designed for eighth-grade junior high school students on the topic of flat-sided three-dimensional shapes. The design of this media took into account the results of the needs analysis, the analysis of student characteristics, and alignment with the current curriculum. The developed e-comic learning material was designed to include the following elements: 1) e-comic cover, 2) foreword, 3) learning outcomes and objectives, 4) character introductions, 5) learning content, 6) practice questions, and 7) conclusion.

Next, the researcher designed research instruments to assess the validity, practicality, and effectiveness of the developed product. The instrument for measuring product validity consisted of two parts: a validation form for subject-matter experts and a validation form for media experts. The instrument for measuring the product's practicality used student and teacher response questionnaires. The instrument for measuring the product's effectiveness was used to assess the extent to which the developed media could improve students' mathematical literacy. This instrument consisted of pre-tests and post-tests.

This was followed by the design of the Lesson Plan, which served as a guide for implementing instruction, ensuring the learning process proceeded systematically and effectively. The Lesson Plan (RPP) was designed in two parts: one for the control class and one for the experimental class, both using the same learning model. Before implementing the RPP in the classroom, the researcher sought validation from experts to ensure the developed RPP could be applied accurately, systematically, and effectively.

Development

The third stage in the ADDIE research model is the Development stage. In this stage, the design developed in the previous stage is implemented as a tangible product using Canva and several other supporting applications. Afterwards, the researcher conducts a validation process to assess the feasibility of the developed media, research instruments, and lesson plans previously developed.

Development of Instruction Media

At this stage, the researcher developed e-comic learning materials based on the design created in the previous stage. The development process was carried out using Canva and several other supporting applications to produce learning media that is interactive, visually appealing, and easily accessible to students. The developed media contains material on flat-sided three-dimensional shapes presented as a picture story that integrates ethnomathematical elements from the Cheng Hoo Mosque in Jember, thereby providing a more contextual and meaningful learning experience. The final product can be accessed by scanning the QR code presented in [Figure 3](#).



Figure 3. Barcode E-Comic

Expert Validation Result

Once the product has been successfully developed, the next step is validation to assess the instructional media's suitability before it is implemented in the learning process. The validation process involves two validators: a media expert and a subject matter expert. The assessment results from both validators serve as the basis for determining the product's validity and as a reference for revising and refining the developed media. The results of the expert validation are presented in [Table 4](#).

Table 4. Result of Expert Validation

Validator	Percentage	Criteria
Media validator	94.93%	Highly Valid
Expert validator	94.45%	Highly Valid
Average	94.69%	Highly Valid

Based on [Table 4](#), the percentage of validation results from media experts was 94.93%, meeting the "Highly Valid" criterion, while the percentage from content experts was 94.45%, also meeting the "Highly Valid" criterion. Based on the combined validity calculation of all these assessment results, a percentage of 94.69% was obtained, which falls under the "Highly Valid" criterion. Thus, the ethnomathematics-based e-comic learning media developed for the Cheng Hoo Mosque in Jember can be deemed suitable for use in learning to improve students' mathematical literacy.

Although the learning materials developed have been deemed suitable and received a “highly valid” rating from each validator, some criticisms and suggestions were still offered to help refine the product before its implementation in a field trial. This feedback was used to improve the quality of the materials, making them more effective in both content and presentation. The suggestions for improvement provided by the validators included: 1) adding information about the school level on the cover, 2) adjusting the placement of the author’s name on the cover, 3) increasing the text size in dialogues or conversations to make them easier to read, 4) increasing the text size in the conclusion section, and 5) adding a discussion of the ethnomathematics of the Cheng Hoo Mosque in Jember through a more integrated storyline within the e-comic.

Implementation

The Implementation Phase is the product testing phase that takes place after the product has been deemed viable by experts, in order to assess the practicality and effectiveness of the developed medium. During this phase, two product tests are conducted: a small-scale trial and a large-scale trial.

Small-scale Trial

After the media had been validated by experts and revised based on the feedback, the next step was to conduct a pilot test with a small group. This stage aims to gauge students’ responses to the quality of the e-comic media product before it is distributed on a large scale. The small-scale pilot test was conducted with 6 eighth-grade students at Al-Falah Silo Junior High School. During the test, students were asked to read and observe the developed e-comic media. Afterwards, the students filled out a response questionnaire covering several evaluation aspects, namely content and media. In addition, the students were also given the opportunity to provide feedback and suggestions regarding the e-comic learning material. This was done to gather feedback that could be used as a basis for improving or revising the product. The results of the small-scale practicality test are presented in [Table 5](#).

Table 5. Result of the Small-scale Practicality Test			
Aspect	Score	Percentage	Criteria
Media	172	90.28%	Highly Practical
Expert	130	89.58%	Highly Practical
Average	151	89.93%	Highly Practical

Based on [Table 5](#), the practicality assessment results for the learning media developed during the small-group pilot test were 89.93%, placing it in the “Highly practical” category. These results indicate that the e-comic media developed is easy to use and was well received by users. However, there are still several suggestions still need to be considered for product refinement before a large-scale pilot test is conducted. The suggestions for improvement include: 1) the text size in dialogues or conversations needs to be enlarged to make it easier for students to read, and 2) there are minor errors in the solutions to the math literacy problems in the “formulate” stage that need to be corrected.

Large-scale Trial

After the e-comic learning material underwent a small-scale pilot test and was deemed suitable for use, the next step was to conduct a larger-scale pilot test. The large-scale pilot test was conducted with two eighth-grade classes at Al-Falah Silo Junior High School: Class VIII-B served as the control group, and Class VIII-C served as the experimental group. During the large-scale pilot test phase, the researchers carried out several steps, namely: 1) administering a pre-test, 2) implementing the instruction for the control and experimental classes, 3) administering a post-test, and 4) distributing a feedback questionnaire.

The first phase of this large-scale pilot study involved administering a pre-test to the experimental and control groups to assess the students' early mathematical literacy skills. The pre-test consisted of open-ended questions developed based on the OECD PISA mathematical literacy framework. Details of the pre-test instrument are presented in [Table 6](#).

Table 6. Blueprint of the Pre-test

Indicators	Item Indicators
Formulate	Students are able to identify relevant information, determine what is known and asked, and formulate a mathematical model related to the surface area of an open-top cube in the context of a water reservoir at Cheng Hoo Mosque, Jember.
Employ	Students are able to apply the formula for the surface area of an open-top cube and determine the number of tiles and the required cost using appropriate procedures.
Interpret & Evaluate	Students are able to interpret the calculation results, evaluate the sufficiency of the available budget for purchasing the tiles, and draw conclusions based on the given context.

After the pre-test, learning activities were conducted in both groups according to the predetermined treatments. Students in the experimental class learned using ethnomathematics-based e-comic media from the Cheng Hoo Mosque in Jember, while students in the control class learned using the conventional method typically used by mathematics teachers. The learning process in both classes was conducted with the same material, time allocation, and learning objectives so that any differences in learning outcomes could be attributed to the use of the learning media used.

The next step was to administer a post-test to students in the experimental and control classes after the entire learning sequence had been completed. The post-test aims to measure students' mathematical literacy skills after receiving the instructional intervention and to evaluate the effectiveness of the developed e-comic. The post-test instrument consists of open-ended questions based on the OECD PISA mathematical literacy framework. Details of the post-test instrument are presented in [Table 7](#).

Table 7. Blueprint of the Post-test

Indicators	Item Indicators
Formulate	Students are able to identify relevant information, determine what is known and asked, and formulate a mathematical model related to the surface area of a rectangular prism in the context of seating facilities at Cheng Hoo Mosque, Jember.

Indicators	Item Indicators
Employ	Students are able to apply the formula for the surface area of a rectangular prism and calculate the amount of paint required using appropriate procedures.
Interpret & Evaluate	Students are able to interpret the calculation results within the problem context, evaluate the sufficiency of the available paint, and draw appropriate conclusions based on the given situation.

In the final stage, the researchers distributed response questionnaires to students in the experimental class and to the mathematics teachers. The response questionnaires were used to gather information on the practicality of the developed e-comic learning media, including ease of use, visual appeal, usefulness in supporting the learning process, and the media's suitability for students' needs. The data obtained from the questionnaires were analysed to determine the level of practicality of the e-comic learning medium.

Evaluation

This study employed a summative evaluation to assess the quality of the developed instructional media. The summative evaluation assessed the media's effectiveness through students' pre-test and post-test scores and its practicality based on students' and teacher's responses.

The Practicality of E-Comic

The practicality of the ethnomathematics-based e-comic learning medium at the Cheng Hoo Mosque in Jember is based on the results of a student response questionnaire administered after students used the ethnomathematics-based e-comic learning medium developed by the researcher. In addition, the practicality of the learning medium was also determined based on the results of a questionnaire completed by an 8th-grade mathematics teacher at Al-Falah Junior High School in Silo. The practicality results obtained from both questionnaires are presented in [Table 8](#).

Table 8. Practicality Result of the Developed E-comic		
Respondents	Percentage	Criteria
Students	95.21%	Highly Practical
Teacher	88.89%	Highly Practical

Based on [Table 8](#), the percentage score from the student questionnaire responses was 95.21%, meeting the "very practical" criterion, while the percentage score for the level of practicality in the teacher questionnaire responses was 88.89%, also meeting the "very practical" criterion. Thus, it can be concluded that the ethnomathematics-based e-comic learning medium developed by the Cheng Hoo Mosque in Jember is practical for use in learning.

The Effectiveness E-Comic

The effectiveness of the e-comic learning media developed in this study was determined based on the pre-test and post-test results by comparing the experimental and control groups. The data were analysed using an independent samples t-test to examine whether there was a significant difference between the two groups after the intervention, as well as N-Gain analysis to measure the level of improvement in students' mathematical literacy skills.

The independent-samples *t*-test was used to determine whether there was a significant difference in mean mathematical literacy scores between students in the experimental and control classes after they received different treatments. In this study, the experimental class received instruction using ethnomathematics-based e-comic media, while the control class received conventional instruction. The test was conducted using IBM SPSS Statistics software based on the post-test results of both groups. The results of the independent-samples *t*-test are presented in [Table 9](#).

Table 9. Result of the Independent Sample <i>t</i> -Test		
Sig. Levene	Sig. (2-tailed)	Criteria
0.614	< 0.001	Sig. < 0.05

Based on [Table 9](#), the Levene's test produced a significance value of 0.614, indicating that the variances of the two groups were homogeneous because the significance value was greater than 0.05. Furthermore, the independent-samples *t*-test yielded a significance (2-tailed) value of < 0.001. Since this value was lower than 0.05, the null hypothesis H_0 was rejected, indicating a statistically significant difference in students' mathematical literacy between the experimental and control groups after the intervention. These findings indicate that the ethnomathematics-based e-comic integrating the cultural context of the Cheng Hoo Mosque in Jember was more effective than conventional instruction in improving students' mathematical literacy.

Next, an N-Gain analysis was conducted to determine the extent of improvement in students' mathematical literacy skills after they were taught using ethnomathematics-based e-comics. The N-Gain calculation was based on the difference between the students' pre-test and post-test scores in the experimental class. This analysis was used to measure the effectiveness of the instruction in improving students' mathematical literacy skills. Based on the calculation results, the N-Gain value was 0.72. These results indicate that the mathematical literacy skills of students in the experimental class improved significantly after using the ethnomathematics-based e-comic learning medium developed by the Muhammad Cheng Hoo Mosque in Jember. Thus, the e-comic learning medium developed was able to improve students' mathematical literacy skills by a high degree, making it effective for use in mathematics instruction on the topic of flat-sided three-dimensional shapes.

Discussion

This study aims to develop an ethnomathematics-based e-comic that integrates the cultural context of the Cheng Hoo Mosque in Jember to improve students' mathematical literacy. The learning medium developed is expected to meet the criteria of validity, practicality, and effectiveness, making it suitable for use in mathematics instruction.

Validity of the Developed E-Comic

The expert validation results showed that the developed e-comic achieved the “Highly Valid” category. This finding indicates that the developed learning media fulfilled the required quality standards in terms of content accuracy, instructional design, language appropriateness, visual presentation, and technical aspects. In other words, the developed e-comic was considered suitable for supporting mathematics learning before being implemented in the classroom.

The high validity obtained in this study is closely related to the systematic development process adopted through the ADDIE model. During the development phase, the initial product underwent expert review by both media and subject-matter experts. The suggestions provided by the validators were then used to revise several components of the e-comic before classroom implementation. This iterative validation process ensured that the final product aligned with curriculum objectives, accurately represented mathematical concepts, and met appropriate instructional and technical standards. Therefore, the high validity score reflects not only the quality of the final product but also the effectiveness of the systematic development procedure employed in this study.

These findings are in agreement with [Farhan et al. \(2024\)](#) who reported that an ethnomathematics-based e-comic achieved a highly valid category after expert evaluation. The consistency of these findings suggests that expert validation plays a crucial role in ensuring the quality and feasibility of digital instructional media before they are implemented in learning. However, unlike previous studies, the present research demonstrates that a systematically developed e-comic can be validated as an instructional medium specifically designed to facilitate students' mathematical literacy through contextual mathematics learning.

Practicality of the Developed E-Comic

Based on the results of the student and teacher questionnaire responses, the developed e-comic was categorized as “Very Practical.” This finding indicates that the e-comic is suitable for implementation in mathematics learning and can support the effective implementation of the learning process in the classroom. Positive assessments from both students and teachers indicate that the developed media is easy to use, well-structured, and suitable for facilitating mathematics learning activities.

The high level of practicality of the developed e-comic can be explained by the learning design applied to the media. The e-comic integrates visual illustrations, a sequential storyline, contextual mathematics problems, and guided learning activities in a single digital learning medium. This presentation allows students to follow the learning process more systematically, while also helping teachers implement learning activities more efficiently. Furthermore, the digital format of the e-comic allows the media to be easily accessed via smartphones and other digital devices, providing flexibility for teachers and students to use it both inside and outside the classroom.

The results of the student questionnaire also showed that most students enjoyed using the e-comic, remained engaged throughout the learning process, and found it easier to understand the mathematics concepts being studied. These findings indicate that the practicality of e-comics is reflected not only in their ease of use but also in their ability to present learning materials in a coherent, systematic, and easy-to-understand manner. Furthermore, teacher assessments indicate that e-comics can be integrated into learning without requiring significant changes to existing teaching strategies, thus supporting more efficient classroom learning.

These findings align with those reported by [Purwoko et al. \(2024\)](#), who found that ethnomathematics-based e-comics achieved a practical category based on student and teacher evaluations. This study demonstrates that integrating digital comics with cultural contexts can produce a viable and easily implemented learning medium in mathematics classrooms. Similarly, [Rasmet et al. \(2025\)](#) reported that e-comic-based learning increased student engagement, reduced boredom, and facilitated conceptual understanding through the visual and sequential presentation of learning materials. Furthermore [Rahmata and Ekawati \(2021\)](#) argue that ethnomathematics-based e-comics provide a more meaningful learning experience than conventional textbooks because they integrate contextual mathematical situations with engaging visual representations, enabling students to grasp mathematical concepts more easily.

The consistency between the current findings and previous studies strengthens the evidence that the practicality of e-comics is determined not only by their digital format or visual appeal, but also by their instructional design, which systematically organizes learning materials, contextual activities, and visual communication into an integrated learning medium. Based on previous findings, this study suggests that ethnomathematics-based e-comics that integrate the cultural context of the Cheng Hoo Mosque in Jember can also be practically implemented in junior high school mathematics lessons while supporting an organized and meaningful classroom learning process.

Effectiveness of the Developed E-Comic

The effectiveness analysis indicated that the developed e-comic was effective in improving students' mathematical literacy, as evidenced by the significant difference between the experimental and control groups and the high N-gain score. These findings demonstrate that the developed e-comic not only functions as an attractive digital learning medium but also effectively facilitates students in understanding and applying mathematical concepts within contextual situations.

This finding is supported by Mayer's Cognitive Theory of Multimedia Learning, which states that students learn more deeply when information is presented through both words and pictures rather than words alone ([Faisal et al., 2024](#)). In the developed e-comic, mathematical concepts are represented simultaneously through illustrations, dialogues, and contextual problem situations. This combination encourages deeper cognitive processing and facilitates students'

conceptual understanding. Similarly, Paivio's Dual Coding Theory explains that learning becomes more effective when information is processed through verbal and visual channels simultaneously (Wahidin, 2025). Therefore, the integration of images, narratives, and mathematical representations in the developed e-comic provides multiple cognitive pathways that support students in understanding mathematical concepts more meaningfully.

Further analysis of students' work revealed that the greatest improvement occurred in the formulate indicator, with an increase of 63 points, followed by interpret and evaluate (40 points) and employ (14 points), as presented in Table 10.

Table 10. Improvement in Students' Mathematical Literacy Scores in the Experimental Class

Mathematical Literacy Indicator	Pre-test	Post-test	Improvement
Formulate	26	89	63
Employ	71	85	14
Interpret & Evaluation	40	80	40

The substantial improvement in the formulate indicator indicates that the developed e-comic effectively supported students in understanding contextual situations and translating them into mathematical models. This finding is reasonable because the storyline of the e-comic consistently introduces mathematical concepts through authentic contextual problems before guiding students toward mathematical representation. Consequently, students become more accustomed to identifying relevant information, recognizing mathematical relationships, and expressing real-world situations using mathematical language. This finding is consistent with (Fitriyani et al., 2021), who reported that students learning with e-comic media were better able to understand contextual problems and express them in mathematical form (*horizontal mathematization*) than students receiving conventional instruction.

In contrast, the employ indicator showed the smallest improvement. This finding suggests that although the developed e-comic successfully assisted students in recognizing contextual problems, some students still experienced difficulties in selecting appropriate mathematical procedures and carrying out calculations accurately. The relatively smaller improvement indicates that procedural fluency requires more intensive and continuous practice than conceptual understanding. Therefore, future development of the e-comic may include additional guided exercises focusing on procedural problem-solving to further strengthen students' mathematical literacy.

Overall, these findings extend previous studies by demonstrating not only that e-comics are effective digital learning media but also how specific instructional characteristics of e-comics contribute differently to each mathematical literacy process. The developed e-comic appears to be particularly effective in strengthening students' ability to formulate contextual mathematical problems, thereby supporting one of the fundamental competencies emphasized in the OECD mathematical literacy framework.

CONCLUSION

This study concludes that the ethnomathematics-based e-comic learning media, which integrates the architectural context of the Cheng Hoo Mosque in Jember, meets the criteria of being highly valid, highly practical, and highly effective in improving students' mathematical literacy skills in the topic of flat-sided geometric shapes. The developed media is able to integrate the local cultural context with digital learning, helping students connect mathematical concepts to real-world situations and improving their abilities to formulate, employ, and interpret mathematical concepts.

This research contributes to mathematics learning by presenting a learning media that combines an ethnomathematics approach and digital technology to support the development of students' mathematical literacy. The results indicate that using local culture as a learning context can make abstract geometric concepts easier to understand, increase student engagement in the learning process, and provide teachers with an alternative way to integrate local wisdom into mathematics instruction.

However, this study still has several limitations. The media implementation was only conducted in one school with a relatively limited number of subjects and focused on the topic of flat-sided geometric shapes. Furthermore, the effectiveness of the media was only evaluated over a relatively short period of time, thus failing to demonstrate its long-term impact on students' mathematical literacy development. Therefore, further research is recommended involving a broader and more diverse sample, applying the media to different mathematical materials, using ethnomathematics contexts from other local cultures, and examining the media's effectiveness over a longer period of time so that its application can be tested in various learning contexts.

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