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DEVELOPMENT OF COMPUTATIONAL THINKING-BASED E-COMIC TO IMPROVE NUMERACY SKILLS STUDENTS

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Abstract

This research is a development research (R&D) motivated by the low numeracy skills of students in understanding data presentation materials. The purpose of the research is to develop learning media in the form of E-Comic based on Computational Thinking (CT) to improve the numeracy skills of seventh grade students. The development model used is ADDIE, which includes five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The subjects of the research were seventh grade students of SMP Negeri 4 Kota Madiun. Data were collected using validation sheet instruments, questionnaires, and tests. The results showed that the E-Comic media obtained validation from media experts with an average percentage of 90%, categorized as very valid. In terms of practicality, this media was considered very practical with an achievement of 89.38% in limited trials and 86.42% in field trials. The effectiveness of the media was analyzed using the N-Gain score, which showed an increase in learning outcomes of 76.18% in limited trials and 77.20% in field trials, both in the high category. The implementation of CT principles in learning through E-Comics has been proven to guide students to think systematically, logically, and creatively in understanding and presenting data. Therefore, this CT-based E-Comic learning medium is valid, practical, effective, and relevant for mathematics learning, particularly data presentation, and is in line with the needs of 21st-century learning.

Keywords: Computational Thinking, Development, E-Comic, Numeracy Skills.

Abstrak

Penelitian ini merupakan penelitian pengembangan (R&D) yang dilatarbelakangi oleh rendahnya kemampuan numerasi peserta didik dalam memahami materi penyajian data. Tujuan penelitian adalah mengembangkan media pembelajaran berupa E-Comic berbasis Computational Thinking (CT) untuk meningkatkan kemampuan numerasi peserta didik kelas VII. Model pengembangan yang digunakan adalah ADDIE, yang meliputi lima tahap sistematis: Analysis, Design, Development, Implementation, dan Evaluation. Subjek penelitian adalah peserta didik kelas VII SMP Negeri 4 Kota Madiun. Data dikumpulkan menggunakan instrumen lembar validasi, kuesioner, dan tes. Hasil penelitian menunjukkan media E-Comic memperoleh validasi dari ahli media dengan rata-rata persentase 90%, masuk kategori sangat valid. Dari segi kepraktisan, media ini dinilai sangat praktis dengan capaian 89,38% pada uji coba terbatas dan 86,42% pada uji lapangan. Efektivitas media dianalisis menggunakan skor N-Gain, yang menunjukkan peningkatan hasil belajar sebesar 76,18% pada uji coba terbatas dan 77,20% pada uji lapangan, keduanya dalam kategori tinggi. Implementasi prinsip-prinsip CT dalam pembelajaran melalui E-Comic terbukti mampu mengarahkan peserta didik untuk berpikir sistematis, logis, dan kreatif dalam memahami serta menyajikan data. Dengan demikian, media pembelajaran E-Comic berbasis CT ini valid, praktis, efektif, dan relevan untuk pembelajaran matematika, khususnya materi penyajian data, serta sesuai dengan kebutuhan pembelajaran abad ke-21.

***Kata kunci**: Computational Thinking, E-Comic, Kemampuan Numerasi, Pengembangan.*

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INTRODUCTION

Mathematics is a fundamental knowledge that plays a crucial role in the advancement of education, particularly in fields like science and technology (Drijvers & Sinclair, 2024). Indeed, mathematics is often regarded as the "queen of sciences" because it underpins and connects various fields of study explored by humans (Russell, 2025). By studying mathematics, students develop critical thinking skills, become proficient in arithmetic, and gain the ability to apply fundamental mathematical concepts both within mathematics and across other subjects (Utami, 2023). Applying number concepts and counting operations in daily life requires strong numeracy skills (Rahmadani et al., 2025).

Numeracy skills refer to the ability to understand, apply, and interpret mathematical concepts in everyday life situations (Hoogland, 2023). Numeracy is more than just counting; it also includes the ability to think logically and analytically (Setyawati et al., 2025). These abilities are closely linked to data presentation materials, where students must read, interpret, and draw conclusions from tables, diagrams, and graphs. When students have weak numeracy skills, they often struggle to recognize patterns, identify relationships, and make sense of data, which ultimately affects their competence in learning data presentation.

Empirical studies show that students' numeracy levels in Indonesia remain low. According to PISA results, Indonesia's mathematics scores are significantly below the international average, highlighting weak numeracy literacy among students (Thien et al., 2015). This national trend is also evident at the research site, where preliminary observations and diagnostic tests reveal that many Grade VII students still struggle to read tables, interpret diagrams, and draw conclusions from data. These findings confirm that numeracy skills, especially in data presentation, continue to be a significant challenge that must be addressed through appropriate instructional media. They highlight the need for strategic educational interventions to enhance students' understanding and improve their numeracy skills.

Several approaches exist to improve numeracy skills, one of which is the Computational Thinking (CT) approach. CT is an analytical method that integrates mathematical thinking techniques with other forms of reasoning, such as logical reasoning, commonly applied in problem-solving processes (Maharani et al., 2020).

The main problem encountered in the field is that students' low interest in learning mathematics contributes to their weak numeracy skills, especially in understanding and interpreting data. This issue is largely due to conventional learning approaches that lack interaction. Observations at SMP Negeri 4 Madiun City reveal that mathematics instruction still relies on textbooks and one-way presentation slides, causing students to feel bored and struggle to grasp the concepts of data presentation.

Mathematics learning in schools is still hindered by low student interest and engagement due to the use of conventional, less interactive media. Observations at SMP Negeri 4 Madiun City indicate that learning is dominated by one-way instruction, causing students to become easily bored and struggle with understanding data presentation material. This situation calls for learning media that are more engaging, communicative, and aligned with the characteristics of the digital

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generation. Therefore, innovative media that combine visuals, narratives, and interactions are needed to make mathematical concepts easier to grasp. E-Comic is a relevant choice because it can present material in an interesting and enjoyable way, increasing students' motivation and comprehension. Considering the need to strengthen analytical and problem-solving skills, E-Comic was developed using a Computational Thinking approach to help students think more systematically and logically in understanding data presentation. In response to these challenges, it is essential to develop interactive learning media, namely Computational Thinking (CT)-based E-Comic.

E-Comic is a pictorial story that uses characters, plots, and electronic visuals to convey information in an engaging and interesting way (Damayanti et al., 2024). Mathematics learning in schools today continues to face challenges, particularly low student interest, largely due to the use of conventional media and minimal interaction. Observations at SMP Negeri 4 Madiun City reveal that the learning process is still dominated by textbooks and one-way presentations, causing students to frequently feel bored and struggle to understand data presentation concepts. This situation highlights the need for learning media that are more communicative, engaging, and capable of increasing student involvement.

In this context, the development of interactive learning media is an urgent necessity. One promising innovative alternative is the use of E-Comic, as this medium can present material visually, narratively, and creatively, helping students grasp abstract concepts in a more concrete and enjoyable way (Tahir & Tahir, 2024). Additionally, E-Comic has been proven to enhance students' appreciation, interest, and attention toward learning content. Specifically in mathematics, E-Comic is designed to stimulate students' numeracy skills through storytelling and visualization of concepts that are relevant to their experiences (Khasanah et al., 2026; Wondal et al., 2025).

By helping students think methodically, logically, and analytically while understanding and processing data, incorporating Computational Thinking (CT) into E-Comic further improves the quality of learning. The Merdeka Curriculum Requirements, which highlight the need for computational thinking skills in mathematics education, are met when content is presented using the CT approach, which also makes learning more engaging (Mills et al., 2025). The results of the previous study also indicate that visual and interactive E-Komik media can effectively increase students' literacy and numeracy skills (Aprilia et al., 2023; Fatma et al., 2024).

The goal of this project is to create and evaluate the level of validity, usefulness, and effectiveness of Computational Thinking (CT)-based electronic comics on data presentation materials with an emphasis on improving the numeracy skills of seventh grade students. It is believed that this research will make a significant contribution to the creation of mathematics learning materials that are more integrated, contextual, and in accordance with the demands of modern education.

METHOD

This research is Research and Development (R&D). This research used ADDIE model, consist of analysis, design, development, implementation, and evaluation are referred to as the development process. Explanation about the research's steps are:

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1. Analysis

In order to identify the problem of inadequate numeracy skills, the researcher now employed teacher interviews, preliminary diagnostic test data analysis, and classroom observation. Additionally, by examining student characteristics, learning requirements, and data presentation materials, the researcher establishes numeracy learning objectives that are relevant to the CT approach.

2. Design

The researcher generated the storyline, comic scenario, page layout, and numeracy content for the data presentation materials. At this stage, research instruments such as validation sheets, questionnaires, and learning outcome tests were developed in addition to integrating CT (decomposition, pattern recognition, abstraction, algorithmic thinking) steps into comedic activities.

3. Development

The E-Comic, which featured CT exercises, narrative text, graphics, and numeracy activities, was made by the researcher using digital design tools. The E-Comic product is modified in response to comments after being validated by media and material specialists until it is accepted as authentic.

4. Implementation

Valid items are tested on students via field tests and brief trials. At this stage, the researcher oversees the usage of E-Comic in learning to display data and collects practicality data through surveys and observations, as well as efficacy data through pretests and posttests.

5. Evaluation

The researcher reviewed all of the information gathered to assess E-Comic's effectiveness, utility, and validity. Evaluation is conducted both formatively (during the development and revision process) and summatively (based on the results of field tests) in order to reach final judgements regarding the media's viability.

The research population consists of all seventh-graders at SMP 4 Madiun City in the 2024–2025 school year. The sample consisted of 27 students from class VII E. The sampling strategy employed was probability sampling with a simple random sample procedure. This approach was selected because it produces a more equitable representation by giving each member of the population an equal chance of being selected to be included in the sample.

This research used the following instruments to get the required data:

1. E-Comic learning materials' media and content quality is evaluated using the validation sheet. The validation process was carried out by two experts who were media and material specialists. The correctness of the content, the media's ability to convey information clearly and visually, and the material's alignment with the curriculum were the main focus of the assessments.
2. A Students are required to fill out a questionnaire after engaging with e-comic media. This tool asks students about their interest in the subject, how simple it is for them to use media, and how much the media helps them understand the course material.
3. The learning outcome test is used to evaluate students' numeracy skills both before and after use E-Comic. The numeracy indicators found in the data presentation mate-rial were used to develop the pretest and posttest that make up this tool. The test results were analysed using N-Gain to determine how well the media enhanced pupils' numeracy skills.

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A few analyses carried out using the ADDIE approach during development are as follows :

1. Analysis of E-Comic Validity

The validators who will accurately evaluate the e-comic are mathematics teachers. The display, content, and language quality of the Computational Thinking (CT)-based E-Comic were evaluated. Several aspects of the E-Comic educational media are rated on a scale of 1 to 5, with 1 denoting "not good," 2 denoting "not good," 3 denoting "quite good," 4 denoting "good," and 5 denoting "very good." The validity formula is then used to sum the data, Ibrahim et al. (2022) the formula for validation that is employed is:

$$v = \frac{Skor\ obtained}{Skor\ max} \times 100\% \quad (2)$$

Using the following formula, two expert validators' combined formulas :

$$v = \frac{vah1+vah2}{2} \quad (1)$$

Remarks:
v : combined validity
vah1 : validity value of validator 1
vah2 : validity value of validator 2

Considering the validity criterion can be seen in Table 1.

Table 1. Validity categories

No.	Validity Score	Category
1	$85\% < v \leq 100\%$	Extremely valid or unrevised
2	$70\% < v \leq 85\%$	Adequately valid or usable with a few small adjustments
3	$50\% < v \leq 70\%$	It needs significant modifications, therefore it is either invalid or advised not to use
4	$v < 50\%$	Unusable or invalid

2. Analysis of the practicality of *E-Comic teaching media*

According to Xu et al. (2019) the following is the practicality formula that is applied :

$$V_p = \frac{TSEp}{S-Max} \times 100\% \quad (3)$$

Description:
Vp :Validity of practicality
TSEp :Total empirical score of practicality
S-Max :Expected Max score

After get V_p score, it can categorized based on the Table 2.

Table 2. Practicality criteria

No.	Practicality Score	Category
1	$85\% < v \leq 100\%$	Extremely useful or unrevised
2	$70\% < v \leq 85\%$	Very useful or usable with a few small adjustments
3	$50\% < v \leq 70\%$	Less useful or advised against using because significant changes are required
4	$v < 50\%$	Unsuitable for usage or impractical

3. Analysis of E-Comic effectivity

According to Wahab et al. (2021), n-gain score can be determine by the formula 4. After that, the n-gain score can be categorized based on Table 3.

$$N - Gain = \frac{\text{Skor Post Test} - \text{Skor Pre Test}}{\text{Skor Ideal} - \text{Skor Pre Test}} \times 100\% \quad (4)$$

Table 3. *N-Gain Category*

No.	N-Gain Score	Category
1	N-Gain > 70%	Height
2	30% ≤ N-Gain ≤ 70%	Medium
3	0 < N-Gain < 30%	Low
4	N-Gain ≤ 0	Fail

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RESULTS AND DISCUSSION

This study falls under the category of research and development (R&D) methodology. The five steps of the ADDIE development model analysis, design, development, implementation, and evaluation are used in this study. Each step that has been completed is described as follows:

Analysis

Needs Analysis

Based on observations and interviews with grade VII maths teachers at SMPN 4 Madiun City, it is known that traditional media like PowerPoint presentations and package books continue to dominate the learning process, making learning less interactive and more repetitive. This circumstance highlights the need for more engaging and relevant learning materials for mathematics. The analysis's findings demonstrate that teaching mathematics calls for more engaging, interactive, and technologically capable media that can be combined with instructional strategies that encourage pupils to think more methodically and analytically. To combat learning saturation, boost student engagement, and improve conceptual understanding particularly in data presentation materials his type of media is required. After taking these needs into consideration and consulting the research findings, it can be determined that E-Comic media based on Computational Thinking (CT) is particularly needed. This is because this type of media not only makes learning visually appealing and engaging, but it also helps students think computationally in order to improve their numeracy skills. Thus, E-Comic media based on Computational Thinking (CT) is required to enhance students' numeracy abilities.

Analysis of Learning Materials

It is known that the school has adopted the Independent Curriculum based on informal teacher interviews and field observations. Data presentation is one of the materials that seventh-grade pupils find difficult. Teachers of mathematics report that pupils frequently struggle to comprehend the ideas behind data display. They found that pupils typically struggle to solve problems involving the usage of tables, bar charts, line charts, and pie charts. Other contributing issues include students' inability to comprehend the fundamental ideas of each type of data display and their ignorance of whether to employ tables, bar charts, lines, or circles. Many pupils are not accustomed to seeing data visually since they struggle with reading and analysing data. When presented with data in the form of tables or graphs, students struggle to extract information or provide answers to questions.

Infrastructure Analysis

According to the researcher's investigation at SMPN 4 Madiun City, the school has sufficient technology infrastructure, such as computer rooms, WiFi networks, and Chromebook loans for every student. Its application in the educational process hasn't been fully utilised, though.

Design

Instrument preparation and initial design are included in the design.

Instrument Arrangement

1. E-Comic Validation Sheet

Thirteen assertions make up the E-Comic learning medium validation sheet in the data presentation package. Every statement evaluates the viability of the activities, language, content, implementation, and assessment. 5

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(excellent), 4 (good), 3 (acceptable), 2 (poor), and 1 (poor) are the grades on a scale of 1 to 5. At the conclusion of the assessment sheet, validators are also given the opportunity to offer comments for improvement.

2. Student Response Questionnaire Validation Sheet

Nine statements make up this questionnaire, which evaluates the language, substance, and instruction clarity. The same scale, which ranges from 1 (not good) to 5 (very good), is used for the evaluation. Additionally, validators had the chance to offer feed-back on the questionnaire instrument.

3. Student Response Questionnaire

The fifteen statements on the student response questionnaire sheet are used to observe and assess many elements of students' use of E-Comic learning materials, including language, materials, and interests. There are eight good and seven negative statements in the statement. In response, students can check the "SS" (strongly agree), "S" (agree), "KS" (disagree), or "TS" (disagree) columns.

Initial Design

The Heyzine application is used to make digital books in order to use E-Comic as a teaching tool. The purpose of this digital book is to teach Data Presentation material using a Computational Thinking method. It has several problems meant to help students develop their computational thinking abilities.

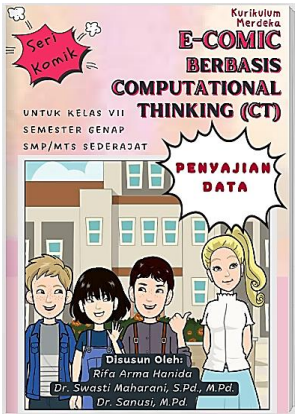

Figure 1. CT-Based E-Comic Cover Display

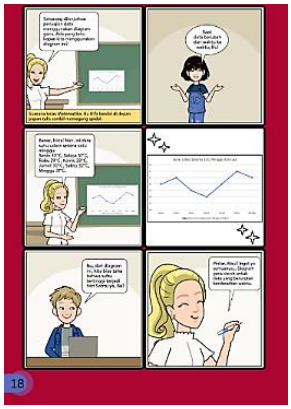

Figure 2. E-Comic display discusses Data Presentation material

The comic media is designed in digital format and can be accessed online via the link, as follows: https://heyzine.com/flipbook/167edc09be.html. This design aims to make media can be used flexibly both in face-to-face and online learning. This design stage becomes an important foundation before the media is developed and validated at the next stage.

Development

To make sure that the created media satisfies eligibility requirements, the E-Comic learning tools and media are validated. The media must be revised to meet the learning objectives if the validation findings indicate that it does not meet the requirements. Two

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experts participated in this validation process: Ayun Rahayu Lestariningsih, S.Pd., a maths teacher and learning media expert, and Putri Tirta Wangi, S.Pd., Validator I.

Media Validation of E-Comic Learning Media

The results of the assessment of E-Comic learning media are presented in Table 4.

Table 4. Results of media validation

Results	Validator	
	I	II
Total score obtained	59	59
Maximum total score	65	65
Percentage of validation	90%	90%
Combined percentage	**90%**	

Based on Table 4. that the results of the validation of *E-Comic* learning media have a validity of 90%. This value indicates that *the E-Comic* learning media is very valid or can be used without revision.

Material Validation of E-Comic Learning Media

The results of the assessment of E-Comic learning media are presented in Table 5.

Tabel 5. Results of material validation

Result	Validator	
	I	II
Total score obtained	45	47
Maximum total score	50	50
Percentage of validation	90%	94%
Combined percentage	**92%**	

Based on Table 5. that the results of the validation of *E-Comic* material have a validity of 92%. The value indicates that the *E-Comic* material is valid or can be used without revision.

Validation of Student Response Questionnaire

The results of the assessment of the student response questionnaire to E-Comic learning media are presented in Table 6.

Table 6. Validation results of the student response questionnaire

Results	Validator	
	I	II
Total score obtained	43	46
Maximum total score	50	50
Percentage of validation	86%	92%
Combined percentage	**89%**	

Based on Table 6, the results of the instrument validation by two survey experts showed that the students' response questionnaire had a validity of 89.5%. This value shows that the student response questionnaire is very valid or can be used without revision.

Validation of Pre-Test and Post-Test Questions

The data on Table 7 are the results of the validation of the Pre-Test and Post-Test by two media experts.

Table 7. Validation result of pre-test questions

Results	Validator	
	I	II
Total score obtained	44	45
Maximum total score	50	50
Percentage of validation	88%	90%
Combined percentage	**89%**	

Table 8. Validation result of post-test question

Result	Validator	
	I	II
Total score obtained	40	41
Maximum total score	45	45
Percentage of validation	88%	91%
Combined percentage	**89,5%**	

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Based on Table 7 and Table 8, the results of instrument validation by two experts *in Pre-Test* questions have a validity of 89% and *Post-Test* has a validity of 89%. The value indicates that *the Pre-Test* and *Post-Test* are valid or can be used without revision.

Implementation

1. Limited Trial

The limited trial will be held on May 19, 2025 involving eight students in grade VII H. The purpose of this trial is to evaluate the level of practicality of *E-Comic learning media* in Data Presentation materials. During the four hours of lessons, the media was used in conjunction with research instruments in the form of student response questionnaires. The delivery of data presentation material is carried out by integrating the concept *of Computational Thinking* in an appropriate context.

Table 9. *E-Comic* practicality in limited tests

No	E-Comis Practicality	Score
1	Combined T-SEP	429
2	S-Max	480
3	Combined percentage	89,38%

Based on the analysis in Table 9, the *E-Comic* learning media developed has an average percentage of practicality of 89.38% in the limited test. Practicality of 89.38% is included in the category of very practical or can be used without revision.

2. Field Trials

The effectiveness of *E-Comedy* learning media. *N-Gain* analysis can be calculated using *Microsoft Excel*. The following is a table of the results of calculating the effectiveness of *E-Comedy* learning media can be seen in Table 10.

Table 10. Field test effectiveness

No	E-Comic Effectivity	Score
1	Total Pre-Test score	1578,83
2	Total *Post-Test score*	2444,39
3	Average Presentation *N-Gain*	77,20%
	High Category	

Based on the analysis in Table 10, the *E-Comic* learning media developed has an average percentage of 77.20% in the field test. The effectiveness of 77.20% is classified as high.

The practicality of *E-Comic learning media* in the field trial is obtained from the results of the questionnaire filled out by students after participating in the field trial, the analysis of the level of practicality of the learning tool is presented in the Table 11.

Table 11. The practicality score based on students' responses in the field test

No	E-Comic Practicality	Score
1	Combined T-SEP	1400
2	S-Max	1620
3	Combined percentage	86,42%

Based on the analysis in Table 11, the *E-Comic* learning media developed has an average percentage of practicality of 80.61% in field trials. The practicality value indicates that *E-Comic* is categorized as very practical or can be used without revision.

Evaluation

1. Analysis of the Validity of E-Comic Learning Media

Pre-test and post-test questions, student response questionnaires, and e-comic learning media are examples of e-comic learning media instruments. If the validators' cumulative validation results satisfy the validity criteria, the instruments are deemed legitimate. While the student response form yielded an 89.5% validity rate, the E-Comic

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learning materials demonstrated a 90% validity rate. Both the Pre-Test and Post-Test questions had validity percentages of 89%. Based on these validity findings, the percentage of validity attained Each instrument has very valid criteria, including student response questionnaires, E-Comic learning materials, Pre-Test questions, and Post-Test questions.

2. Analysis of the Practicality of E-Comic Learning Media

Students in grade VII at SMPN 4 Madiun City complete surveys about the produced learning aids as a means of assessing the usefulness of E-Comic learning medium. In the short trial of this study, 89.38% of students completed the student response questionnaire. In contrast, the field test yielded a percentage of 86.42%. More than 75.01% of learning tools created through field and restricted testing are practical. The produced learning tools received a percentage in field tests and limited trials that are categorised as very practical, which means they may be used without needing to be improved.

3. Analysis of the Effectiveness of E-Comic Learning Media

By calculating N-Gain on the answers to the Pre-Test and Post-Test question sheets completed by students at SMPN 4 Madiun City, the efficacy of E-Comic learning materials was determined. In the conducted study, the N-Gain percentage was 76.18% in the confined trial and 77.20% in the field test. The percentage effectiveness of the learning resources created from each of these experiments has exceeded thirty percent. The percentage of limited and field trial findings that are categorised as adequate or medium is displayed in the learning resources that have been created.

The research's findings demonstrate the validity, usefulness, and efficacy of Computational Thinking (CT)-based E-Comic for learning data display. High validity shows that the media satisfies the quality of learning media principle, which states that effective media must be accurate, communicative, and consistent with the learning objectives. The high category N-Gain score demonstrates the media's efficacy in enhancing pupils' comprehension of numeracy through the use of narrative and visual aids. According to Baiduri et al. (2025) students' cognitive burden is reduced by structured narratives and visualisations, which facilitates easier conceptual understanding. Therefore, the enhancement of numeracy abilities is a logical consequence of using media that aligns with kids' cognitive processes rather than happening by accident.

The study's primary conclusion is that, in addition to being aesthetically pleasing, E-Comic uses CT integration to help students comprehend methodical problem-solving techniques. CT concepts include abstraction, pattern recognition, and breakdown, as described Ye et al. (2023) assist pupils in organising their information. Students can more easily follow the flow of data presentation and transform information into visual representations like tables or graphs when this idea is incorporated into comics. This explains why using the media causes pupils' numeracy skills to significantly improve.

Numerous factors contributed to the study's improved learning outcomes. First, kids' attention is drawn to E-Comic's eye-catching visual display, in line with the theory Mir et al. (2023) that dual coding between text and images strengthens memory and comprehension. Second, storylines make it

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easier for students to connect math materials with real experiences, according to their views Aprelia et al. (2019) that narrative is an innate human cognitive structure that can facilitate the comprehension of abstract ideas. Third, CT integration makes learning more smooth by giving students a foundation for data analysis. Together, these elements contribute to the media's high efficacy.

Benefits-wise, this research has been successful in producing media that is easily accessible, fits the traits of students in the digital generation, and can increase learning interest and numeracy comprehension. This medium is very flexible and can be utilised for both in-person and online learning. However, this study has certain shortcomings. It's crucial to be cautious when extrapolating results because there aren't enough samples. The examined material's primary objective remains data presentation. Additionally, the long-term effects of E-Comic use on children's development of computational thinking skills have not been evaluated. The findings of this investigation are in line with a number of earlier research. Fitriani & Leton (2024) proving that digital comics improve the understanding of mathematical concepts through attractive visual flows. Khotimah & Hidayat (2022) additionally, it was discovered that interactive e-comics could boost students' enthusiasm and interest in their studies. This research is also in line with the findings Batul et al. (2022) which claims that CT is highly successful in enhancing pupils' mathematical analytical and problem-solving skills. Findings Purba et al. (2025) the fact that E-Comic enhances numeracy literacy adds to the validity of the study's findings. As a result, this study adds credence to the idea that using CT in conjunction with visual media improves numeracy skills. This study can help advance the creation of CT-based learning materials at the junior high school level because no notable inconsistencies with earlier research were discovered.

This study has significant ramifications for educators, educational institutions, and media producers. CT-based E-Comics can be a creative media substitute for educators to promote more enjoyable, contextual, and 21st-century learning. This media can help schools implement the Independent Curriculum by enhancing numeracy literacy. In theory, this study advances the CT integration model as a method of teaching mathematics in digital visual media. Opportunities for the creation of additional digital learning resources that support a range of student learning styles are also made possible by this research.

CONCLUSION

According to the findings of the conducted research, E-Comic has been shown to be a legitimate and appropriate learning tool to help pupils improve their numeracy abilities. Students responded favourably to E-Comic's practicality, with a participation rate of 89.38% in the limited trial and 86.42% in the field test. Students' engagement with E-Comic media also fosters critical thinking, problem-solving, and the development of computational thinking abilities. Students' favourable reaction to the E-Comic learning experience and their capacity to finish assignments with computational thinking components both demonstrate this. The positive response of the students and their involvement in completing tasks containing CT elements showed that this media was

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effective in improving numeracy skills. Thus, it can be concluded that *CT-based E-Comic* is an innovative learning medium that is able to improve students' numeracy skills.

Teachers are advised to employ CT-based E-Comics as a substitute medium for teaching mathematics in order to boost students' motivation and numeracy abilities. Schools must encourage the usage of modern digital media by offering sufficient resources and teacher training. By including interactive elements and expanding the content to cover additional maths subjects, media producers can carry on the innovation of E-Comics. In order to test the long-term consistency of the efficacy of CT-based E-Comic, researchers are further encouraged to carry out studies with a larger sample size and various situations.

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