DIGITAL COMIC MEDIA FOR MATHEMATICAL LITERACY DEVELOPMENT IN EDUCATION: A CONTEXTUAL APPROACH

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Abstract

The purpose of this research is to produce a valid and practical contextual digital comic media for eighth-grade circle material. The research and development were conducted using the ADDIE R&D model. The research began with the stages of analysis, design, development, implementation, and evaluation. The developed digital comic was validated by expert validators: material experts, language experts, and media experts. The material experts scored 95.2%, with very valid criteria, the language experts scored 84%, with very valid criteria, and the media experts scored 84.6%, with very valid criteria. The validation results of the digital comic, validated by the expert validators, indicated that the digital comic was suitable for limited testing with students to determine its practicality. The digital comic, which had previously been revised based on the suggestions and input from the expert validators, was presented. The limited trial began with a small group trial with an average percentage of 85.5%, categorized as very practical, followed by a large group trial with an average percentage of 85.6%, categorized as very practical. The limited trial was conducted in class VIII D of SMPN 2 Menes. Posttest results showed that digital comics were able to support students' mathematical literacy skills, with high average scores in the small group trial of 18 and the large group of 18, with a stable standard deviation of 1.25 for the small group and 1.76 for the large group. Thus, digital comics, in addition to being practical, can also support students' mathematical literacy skills.

Keywords: Digital Comics, Contextual Approach, Mathematical Literacy

1. Introduction

The learning process in the era of the Industrial Revolution 4.0 must align with the rapid development of technology that merges the physical, biological, and digital dimensions, making the boundaries among them increasingly indistinct. This transformation is marked by massive digitalization and the use of artificial intelligence (AI) across various sectors, including education (Handayani, 2024). In line with this, the Association for Educational Communications and Technology (AECT, 2004) defines educational technology as the study and ethical practice of facilitating learning and improving performance through the creation, use, and management of appropriate technological processes and resources. This definition emphasizes that educational technology plays an essential role in addressing various challenges in the educational field, particularly in enhancing learning effectiveness (Febriyanti, 2023).

One of the fundamental problems in Indonesia's education system is the low level of students' mathematical literacy (Atiyah & Priatna, 2023). According to the Programme for International Student Assessment (PISA), Indonesia consistently ranks at the lower end—64th out of 65 countries in 2012, 62nd out of 70 in 2015, and 73rd out of 79 in

2018. These results indicate that Indonesian students still struggle to comprehend, reason, and apply mathematical concepts to real-life situations (Masfufah & Afriansyah, 2021). Kholifasari et al. (2020) further explained that such low mathematical literacy is caused by the rare use of literacy-based problems and students' lack of learning independence. The integration of technology should therefore not be limited to ICT subjects but also extended to other disciplines, including mathematics (Lutfianasafitri Elisa, 2024).

Mathematics is a continuously evolving discipline characterized by its abstract nature (Ariskasari & Pratiwi, 2019). Learning mathematics aims to develop logical, analytical, systematic, and critical thinking skills (Kusumawardani et al., 2018). Moreover, mathematics enables students to formulate, apply, and interpret concepts within various real-world contexts (Natsir & Munfarikhatin, 2021). This ability is known as mathematical literacy, which refers to the capacity to formulate, employ, and interpret mathematics in diverse situations (Manoy & Sari, 2020). Mathematical literacy is essential for students because it helps them efficiently solve problems, analyze situations, and draw conclusions logically (Genc & Erbas, 2019).

An initial observation at SMP Negeri 2 Menes revealed that students' mathematical literacy remains low. The average student score of 60.5 is below the Minimum Mastery Criteria (KKM) of 75, indicating that learning objectives have not been achieved. Interviews with mathematics teacher Mrs. Devi Mutyaningsih, S.Pd., indicated that most of the problems provided were still in the form of direct calculations, while contextual word problems were rarely used. As a result, students faced difficulties understanding and applying mathematical concepts to real-life situations. The teacher also noted that interactive learning media were seldom used, which limited students' engagement and contextual understanding of mathematics. This is in line with Alfian et al. (2024), who emphasized that learning media play a crucial role in creating effective and meaningful learning experiences. Therefore, innovation in developing interactive and contextual learning media is urgently needed.

Learning media can take the form of hardware or software used by teachers to deliver learning materials more effectively and efficiently (Magdalena et al., 2021). Teachers are required to select appropriate and effective media to help students overcome learning difficulties, enhance comprehension, and develop skills (Nurfadhillah et al., 2021). Appropriate media can motivate students and facilitate a better understanding of concepts (Rijal, 2021). One of the interactive media suitable for modern learning is digital comics. Digital comics are illustrated stories that combine concise text and dialogue, making them simple, clear, and enjoyable (Putra & Milenia, 2021; Aprilla et al., 2020). Their visual and narrative elements make mathematical concepts easier to grasp because they are presented through engaging and relatable stories (Zulfiah et al., 2020).

Digital comics have significant potential to support a more positive learning environment (Habiddin & Ashar, 2022). Previous studies have shown that comics can enhance students' motivation, conceptual understanding, and critical thinking skills in mathematics (Aprilla et al., 2020; Cahyono et al., 2023; Putro & Setyadi, 2022). In this study, digital comics are developed using a contextual approach to ensure that the story content relates closely to students' daily experiences. Contextual learning helps teachers connect lesson content with real-life situations and enables students to acquire knowledge through meaningful experiences (Suasaningdyah, 2017). The delivery of material is structured according to the steps of contextual learning and presented in the form of a comic narrative (Puspitorini, 2025), where real-world problems are used as the foundation of learning activities (Luh et al., 2019).

Based on the description above, this study aims to develop a contextual-based digital comic on the topic of circles for eighth-grade students. The goal is to produce a valid, practical, and effective learning medium that can enhance students' mathematical literacy. Through this development, mathematics learning is expected to become more engaging, meaningful, and relevant to students' real-life experiences.

2. Theoretical Background

The theoretical background of this study includes a review of mathematical literacy, digital comic learning media, the contextual approach in mathematics learning, and previous relevant research. This section serves as the foundation for developing contextual-based digital comic media aimed at improving students' mathematical literacy skills.

Mathematical literacy is one of the essential competencies required in the 21st century. It is defined as an individual's ability to formulate, apply, and interpret mathematics in various real-life contexts (OECD, 2019). A mathematically literate individual can efficiently and logically use mathematical knowledge and skills to solve real-world problems (Manoy & Sari, 2020; Genc & Erbas, 2019). In Indonesia, students' mathematical literacy remains relatively low, as evidenced by the PISA results that place the country at the lower ranks globally. Therefore, there is an urgent need for learning strategies and media that can help students understand mathematical concepts meaningfully and relate them to real-world situations.

Learning media serve as tools used by teachers to deliver learning materials more effectively and efficiently (Magdalena et al., 2021). The appropriate selection of learning media can help transform abstract concepts into concrete ones while increasing students' motivation and engagement (Nurfadhillah et al., 2021). One innovative medium that aligns with technological advancement is digital comics. Digital comics combine visual elements, text, and narrative, enabling messages to be conveyed in an appealing, simple, and understandable manner (Putra & Milenia, 2021; Aprilla et al., 2020). Through engaging presentation, digital comics can create a positive learning environment that enhances students' comprehension (Habiddin & Ashar, 2022).

Several studies have shown the effectiveness of digital comics in mathematics learning. Aprilla et al. (2020) found that comic-based learning media can improve students' motivation and learning outcomes. Cahyono et al. (2023) reported that digital comic media enhances students' critical mathematical thinking skills. Similarly, Putro & Setyadi (2022) concluded that digital comics are effective in helping students understand geometric concepts through visualization and contextualization. These findings demonstrate that digital comics have strong potential as innovative instructional media in mathematics education.

The development of digital comic media in this study is based on the Contextual Teaching and Learning (CTL) approach. CTL is a learning concept that helps teachers link lesson content with students' real-world experiences, encouraging them to construct knowledge through meaningful learning processes (Suasaningdyah, 2017). CTL emphasizes seven core components: constructivism, questioning, inquiry, learning community, modeling, reflection, and authentic assessment. By applying this approach, students are expected not only to memorize formulas but also to understand mathematical concepts through active engagement and real-life application.

Thus, integrating digital comic media with a contextual approach is expected to create a more engaging, interactive, and meaningful mathematics learning experience. This

medium not only serves as a visual aid but also as a tool to build mathematical literacy through enjoyable and relevant learning experiences connected to students' everyday lives.

3. Methods

This study employed a Research and Development (R&D) method using the ADDIE model, which consists of five stages: (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation. This model was chosen because it is systematic and suitable for producing instructional products that are valid, practical, and effective.

The subjects of this study were eighth-grade students of SMP Negeri 2 Menes, Pandeglang Regency, Banten Province. The population included all eighth-grade students, while the sample was selected purposively to represent students with diverse learning abilities. The object of this study was a contextual-based digital comic learning medium developed for the circle topic to enhance students' mathematical literacy skills.

Data collection techniques involved several instruments: (1) expert validation sheets for material, language, and media to assess the validity of the product; (2) student and teacher response questionnaires to measure the practicality of the media; and (3) mathematical literacy tests to evaluate the effectiveness of the developed digital comic. Quantitative data were obtained from validation results, questionnaires, and tests, while qualitative data were derived from expert feedback and participant comments during the trial phase.

The operational definitions in this study include: (1) Contextual-based digital comic learning media, referring to digital comic learning materials that present circle concepts by connecting them with real-life situations; (2) Mathematical literacy, defined as students' ability to formulate, apply, and interpret mathematical concepts in various real-world contexts; and (3) Validity, practicality, and effectiveness, representing the extent to which the media are appropriate, easy to use, and effective in improving students' learning outcomes.

Data analysis was conducted both quantitatively and qualitatively. The validation data were analyzed using percentage formulas to determine validity categories. Practicality data were analyzed based on student and teacher response percentages categorized as very practical, practical, fairly practical, less practical, or impractical. Effectiveness data were analyzed using posttest results of mathematical literacy through mean comparisons and benchmarked against the Minimum Mastery Criteria (KKM) to measure improvement in learning outcomes. The overall analysis results were used to conclude the feasibility and effectiveness of the developed contextual-based digital comic learning media.

4. Results and Discussion

This section presents the results of the research analysis, including the validation test, practicality test, and effectiveness test of the contextual-based digital comic learning media developed for the circle topic in eighth-grade mathematics. The results are described along with discussions that connect the findings with relevant theories and previous studies.

4.1 Validity Test Results

The validity of the developed digital comic was evaluated by three experts: material, language, and media. Each expert assessed the product based on relevance, accuracy, clarity, and appropriateness for classroom use. The results of the validation are presented in Table 1 below.

Table 1. Validation Results of Contextual-Based Digital Comic Media

Aspect Evaluated	Validator	Score (%)	Category
Content Accuracy	Material Expert	95.2	Very Valid
Language Use	Language Expert	84.0	Very Valid
Media Design	Media Expert	84.6	Very Valid

The data in Table 1 show that the contextual-based digital comic met the validity criteria with an average score above 84% across all aspects. The material expert provided the highest score, indicating that the content aligns with the mathematics curriculum and supports conceptual understanding. The language expert found that the dialogues and narration were clear and appropriate for the students' cognitive level, while the media expert confirmed that the visual layout and interactive elements were attractive and functional. Minor revisions were made according to expert feedback, such as adjusting font size and image balance to improve readability.

4.2 Practicality Test Results

The practicality of the digital comic was assessed through teacher and student questionnaires in both small-group and large-group trials. The responses evaluated ease of use, attractiveness, clarity, and usefulness in learning activities. The results are presented in Table 2 below.

Table 2. Practicality Test Results of Contextual-Based Digital Comic Media

Group	Aspect	Score (%)	Category
Small Group	Overall Practicality	85.5	Very Practical
Large Group	Overall Practicality	85.6	Very Practical

Based on Table 2, the digital comic achieved an average practicality score above 85%, categorized as "very practical." Teachers stated that the media was easy to integrate into classroom instruction and helped manage class engagement. Students reported that learning through digital comics made lessons more enjoyable and easier to understand, especially because the characters and settings reflected real-life situations. This finding is consistent with Nurfadhillah et al. (2021), who noted that interactive media can enhance student motivation and classroom participation.

4.3 Effectiveness Test Results

The effectiveness of the contextual-based digital comic was measured using a mathematical literacy posttest. The results are summarized in Table 3.

Table 3. Posttest Results of Students' Mathematical Literacy

Indicator	Average Score	Standard Deviation	Category
Mathematical Literacy	18.0	Stable	Improved

The posttest results indicate an average score of 18 with a stable standard deviation, suggesting improved mathematical literacy after using the digital comic. Students demonstrated better comprehension of circle concepts and were able to connect mathematical ideas with real-world applications, such as identifying circular objects and solving contextual problems. The use of storytelling and relatable visuals encouraged active learning and deeper conceptual understanding.

4.4 Discussion

The validation results demonstrate that the developed media meets the learning feasibility standards, as outlined by Arsyad (2018), who emphasizes that effective learning media should meet content, language, and visual design criteria. The practicality

results confirm that both teachers and students found the media user-friendly and engaging, supporting the findings of Alfian et al. (2024) that interactive learning tools enhance students' focus and participation.

Furthermore, the effectiveness results are consistent with previous studies by Aprilla et al. (2020) and Cahyono et al. (2023), which showed that digital comics can improve students' critical thinking and mathematical literacy through contextual and visualized learning. The integration of the Contextual Teaching and Learning (CTL) approach in the digital comic helped students relate mathematical concepts to daily life, making learning more meaningful. As Suasaningdyah (2017) explains, contextual learning enables students to construct knowledge actively based on real-world experiences.

In summary, the contextual-based digital comic developed in this study is valid, practical, and effective for use in mathematics learning. It provides a new alternative for teachers to integrate technology and context-based storytelling into instruction, fostering improved mathematical literacy and learner engagement in the 21st-century classroom

5. Conclusion

This study aimed to develop contextual-based digital comic learning media on the circle topic for eighth-grade students to enhance their mathematical literacy skills. Based on the research findings and data analysis, it can be concluded that the developed contextual-based digital comic meets the criteria of being valid, practical, and effective. The validation results indicated a "very valid" category from material, language, and media experts. The practicality test obtained an average score above 85%, categorized as "very practical." The effectiveness test results showed an improvement in students' mathematical literacy with an average posttest score of 18. These results demonstrate that contextual-based digital comics can help students understand mathematical concepts— especially on the circle topic—through real-life contexts. Therefore, this learning media is feasible to be used as an innovative alternative in mathematics learning within the digital era.

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