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# Development of Contextual-Based Digital Comic Media to Improve Numeracy Skills of Grade II Elementary School Students

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**Article**

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**Abstract**

*Numeracy skills are fundamental competencies that constitute a primary demand in 21st-century education, particularly for elementary school students. The low level of students' ability to solve mathematical word problems remains an urgent issue that needs to be addressed through more contextual and engaging learning media innovations. This study aims to develop contextual-based digital comic media to improve the numeracy skills of Grade II elementary school students. The research employed a Research and Development (R&D) method using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The participants consisted of 28 Grade II students from SDN Makassar 1. Research instruments included expert validation sheets, student response questionnaires, observation sheets, and pretest-posttest instruments. The validation results showed scores of 87.5% from the material expert, 84.2% from the media expert, and 89.0% from the language expert, all categorized as highly valid. The practicality level of the media reached 88.3%. The effectiveness of the media was demonstrated by an increase in the average score from 58.6 in the pretest to 82.4 in the posttest, with an N-Gain score of 0.57 (moderate category). Therefore, the developed contextual-based digital comic media is considered valid, practical, and effective in improving the numeracy skills of Grade II elementary school students.*



## INTRODUCTION

Numeracy skills are fundamental competencies that have become a top priority within the Indonesian education system, particularly at the elementary school level. Numeracy is not merely related to basic arithmetic skills but also encompasses students' ability to understand, use, and interpret mathematical concepts and procedures to solve various real-life problems encountered in everyday situations (Dini et al., 2021). In other words, numeracy represents

functional and contextual mathematical literacy, where students are not only capable of performing numerical operations but are also able to reason through problem situations and select appropriate solution strategies.

Within the framework of the Merdeka Curriculum, mathematics learning in Grade II elementary school is directed toward developing a deep understanding of whole number concepts and enhancing students' ability to apply them in contextual situations closely related to their daily experiences. This curriculum emphasizes meaningful, student-centered learning approaches and focuses on strengthening foundational literacy and numeracy competencies as the basis for lifelong learning (Ministry of Education, Culture, Research, and Technology, 2023). Therefore, innovation in learning strategies and instructional media has become an essential necessity.

Data from both national and international assessments consistently indicate that Indonesian students' numeracy skills remain at a level requiring serious attention. The PISA 2022 report placed Indonesia's average mathematics literacy score at 366, significantly below the OECD average of 472 (OECD, 2023). This result ranked Indonesia 68th out of 81 participating countries, indicating a substantial gap in mathematical competence between Indonesian students and global standards. Although there has been some improvement compared to previous reports, the rate of progress has not been sufficient to close the existing gap.

At the national level, the 2023 Computer-Based National Assessment (ANBK) revealed that a large proportion of lower-grade elementary school students still fall into the "need intervention" category in numeracy competence, particularly in solving word problems that require contextual reasoning (Ministry of Education, Culture, Research, and Technology, 2023). These findings are reinforced by repeated results from the Programme for International Student Assessment (PISA), which consistently highlight Indonesian students' weaknesses in applying mathematical concepts to authentic situations. Data from the Educational Research and Development Agency (Balitbangdikbud, 2022) further emphasize that the mathematical reasoning abilities of lower-grade elementary school students need to be systematically improved through structured and innovative instructional interventions.

The low numeracy skills of elementary school students are often rooted in learning approaches that remain mechanistic and procedural. Teachers tend to train students to memorize calculation algorithms without providing adequate understanding of the meaning and relevance of mathematical concepts in real-life contexts (Wardhani & Rumiati, 2022). Consequently, when students encounter word problems that require contextual and analytical thinking, they experience

significant difficulties. Research by Nurhidayah et al. (2022) confirmed that approximately 65% of lower-grade elementary school students face challenges in transforming information from word problems into appropriate mathematical models. This condition is further exacerbated by the limited availability of innovative and interactive learning media capable of motivating students to actively engage in the learning process.

Grade II elementary school students are generally between 7–8 years old, which according to Piaget's cognitive development theory places them in the concrete operational stage. At this stage, students require rich visual representations and familiar real-life contexts to understand abstract mathematical concepts (Prihandoko, 2020). Learning media that utilize visual narratives and storytelling elements are considered effective in bridging students' understanding from the concrete domain to mathematical abstraction. Asri and Kurniawan (2022) emphasized that the use of illustrated story-based media for lower-grade elementary school students can simultaneously enhance students' cognitive and affective engagement, which ultimately has a positive impact on their mathematics learning outcomes.

Comics as instructional media have been empirically proven to increase students' motivation, engagement, and understanding across various fields of study (Hidayah & Ulya, 2020). The comic format, which combines verbal narratives with visual illustrations, activates the dual-coding process that enhances information retention and comprehension (Mayer, 2021). Digital comics, as an evolution of printed comics, offer additional advantages, including broader accessibility, ease of reproduction, and the potential integration of interactive elements. Research conducted by Pratiwi and Santoso (2022) demonstrated that digital mathematics comics significantly improved the learning outcomes of Grade II elementary school students. Similarly, Rahmawati et al. (2023) found that contextual-based learning media strengthen lower-grade students' understanding of numeracy concepts because they present learning situations that are familiar and meaningful.

The Contextual Teaching and Learning (CTL) approach serves as the primary theoretical framework underlying the development of digital comics in this study. CTL emphasizes that effective learning occurs when students are able to connect new knowledge with real-life contexts that are relevant to them (Johnson, 2019). Fadilah and Suherman (2021) showed that the consistent implementation of CTL significantly improves elementary school students' mathematical problem-solving skills. Integrating CTL principles into a digital comic format enables learning

experiences that are not only enjoyable but also conceptually and contextually meaningful.

Furthermore, the Realistic Mathematics Education (RME) framework developed by Freudenthal also forms the theoretical foundation of this study. RME views mathematics as a human activity that should be learned within realistic and meaningful contexts (Dini et al., 2021). This approach encourages students not merely to receive mathematical knowledge passively but to actively construct their understanding through the mathematization of real-life situations. The integration of RME and CTL within the digital comic design provides a strong pedagogical foundation for this development research.

Previous studies have made important contributions but still leave several research gaps that need to be addressed. Most comic-based media development for mathematics learning has focused on upper-grade elementary school or junior high school students, whereas studies specifically targeting Grade II elementary school students that integrate digital comics with the CTL approach remain very limited. In addition, the integration of local narrative elements closely related to students' daily lives into mathematics comic media has not been systematically explored in Indonesian development research (Susanto et al., 2023).

Based on the background and research gap analysis described above, this study was conducted with three primary objectives: (1) to develop contextual-based digital comic media that are valid, practical, and effective in improving the numeracy skills of Grade II elementary school students; (2) to comprehensively describe the validity, practicality, and effectiveness of the developed media; and (3) to analyze the extent of improvement in students' numeracy skills through the use of contextual-based digital comic media. This study is expected to make a meaningful contribution to the development of innovative and meaningful mathematics learning media that align with the demands of the Merdeka Curriculum.

## METHOD

This study employed a Research and Development (R&D) approach using the ADDIE model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected because of its structured framework and its ability to facilitate formative evaluation at each stage, ensuring that the resulting product meets the standards of validity, practicality, and effectiveness simultaneously (Branch, 2009). The research participants consisted of 28 Grade II students of SDN Makassar 1 in the 2024/2025 academic year.

### 1. Analysis Stage

The analysis stage was conducted to comprehensively identify the learning needs related to numeracy in Grade II elementary school. Activities at this stage included: (a) problem analysis through comprehensive classroom observations and in-depth interviews with classroom teachers; (b) analysis of student characteristics related to dominant learning styles and cognitive development levels; (c) analysis of Merdeka Curriculum documents concerning learning outcomes and learning objectives for Grade II numeracy; and (d) an extensive literature review on the theories of Contextual Teaching and Learning (Johnson, 2019), multimedia learning principles (Mayer, 2021), and Realistic Mathematics Education (Dini et al., 2021). The analysis results revealed that 68% of students experienced difficulties in solving mathematical word problems, and teachers required more innovative, engaging, and contextually relevant learning media.

**2. Design Stage**

The design stage involved a series of systematic activities, including: (a) formulating learning objectives based on the revised Bloom's Taxonomy for The design stage included a series of systematic activities consisting of: (a) formulating learning objectives based on the revised Bloom's Taxonomy to ensure comprehensive coverage of cognitive aspects; (b) determining product success criteria based on the established standards of validity, practicality, and effectiveness; (c) developing storyboards featuring three daily-life themed scenarios, namely *"Shopping at Mrs. Sari's Canteen"* (addition and subtraction), *"Our Soccer Team"* (comparison and ordering of numbers), and *"Rara's Birthday Cake"* (simple division); and (d) designing pretest and posttest evaluation instruments based on numeracy skill indicators, including conceptual understanding, procedural application, and mathematical reasoning (Wardhani & Rumiati, 2022).

**3. Development Stage**

At this stage, **Prototype 1** of the digital comic was produced. The comic was developed using Canva Pro by incorporating all multimedia learning design principles proposed by Mayer (2021), including the principles of spatial contiguity, coherence, personalization, and segmentation. Prototype 1 was subsequently validated by three expert validators: (1) an elementary mathematics education expert; (2) an instructional media expert; and (3) an Indonesian language expert. Validation was conducted using a four-point Likert-scale validation instrument. The validation results and expert feedback served as the basis for revising Prototype 1 into Prototype 2, which was then ready for field testing.

**4. Implementation Stage**

Prototype 2 was implemented in a Grade II classroom at SDN Makassar 1 over three learning sessions, each lasting 2 × 35 minutes, using a one-group pretest-posttest design. Effectiveness data were collected through pretest and posttest instruments consisting of numeracy word problems, as well as observation sheets documenting students' active engagement during the learning process. Practicality data were collected through student response questionnaires administered after all learning sessions had been completed (Nieveen & Folmer, 2020).

**5. Evaluation Stage**

Evaluation was conducted comprehensively through quantitative and qualitative data analyses. Effectiveness was analyzed using the N-Gain formula developed by Hake (1998):

**N-Gain = (Spost – Spre) / (Smax – Spre)**

with the following classifications: low if N-Gain < 0.3; moderate if 0.3 ≤ N-Gain ≤ 0.7; and high if N-Gain > 0.7.

Validity and practicality were calculated based on percentage scores according to the criteria proposed by Akbar (2013): ≥ 85% (very valid/practical), 70–84% (valid/practical), 55–69% (fairly valid/practical), and < 55% (invalid/impractical). All evaluation results were used as the basis for developing the revised operational product (**Prototype 3**) before wider dissemination.

## RESULTS AND DISCUSSION

### 1. Description of the Digital Comic Media Product

The contextual-based digital comic media developed through this study consists of three story episodes, each containing 3–4 progressively structured numeracy problems that are appropriate to the cognitive development level of Grade II elementary school students.

The first episode, entitled "Shopping at Mrs. Sari's Canteen," integrates concepts of addition and subtraction of whole numbers within the authentic context of buying and selling transactions at school. The second episode, "Our Soccer Team," presents concepts of comparing and ordering numbers through sports-related activities that are familiar to students. The third episode, "Rara's Birthday Cake," incorporates simple division concepts within the warm and familiar context of family life.

Each episode was designed using simple and communicative Indonesian-language dialogues, brightly colored illustrations that attract students' visual attention, and fictional characters that reflect the daily lives of Grade II elementary school students. Numeracy problems were naturally embedded into the storyline so that students were motivated to solve them as an organic part of the reading

experience rather than merely completing isolated exercises detached from context.

This approach is consistent with the CTL principle proposed by Johnson (2019), which states that effective learning occurs when new knowledge is constructed within meaningful real-life contexts. Furthermore, the development of this media also considered the principles of Universal Design for Learning (UDL) to accommodate the diversity of students' learning styles and abilities (Andini et al., 2023).

**2. Expert Validation Results**

The validation process involved three validators with relevant and comprehensive expertise. The material expert validator was an elementary mathematics education lecturer specializing in numeracy instruction; the media expert validator was an educational technology lecturer with experience in e-learning development; and the language expert validator was a lecturer in applied linguistics and Indonesian language education. All three validators independently assessed the product using a four-point Likert-scale validation instrument covering various aspects of product quality.

**Table 1. Summary of Validation and Media Practicality Results**

| Validation Aspect | Score (%) | Category |
|---|---|---|
| Material Expert | 87.5% | Very Valid |
| Media Expert | 84.2% | Very Valid |
| Language Expert | 89.0% | Very Valid |
| Practicality (Student Responses) | 88.3% | Very Practical |

The material expert validation results showed a score of 87.5% (very valid category). The validators appreciated the alignment between the story contexts used and the learning in the Merdeka Curriculum numeracy learning, as well as the appropriateness of the difficulty level of the questions, which was adjusted to the cognitive development of Grade II students. The media expert validation obtained a score of 84.2% (very valid category), with revisions suggested regarding the font size in several comic panels, which was considered too small for comfortable reading by students. The language expert validation achieved the highest score, namely 89.0% (very valid category), reflecting the appropriateness of language use in relation to the characteristics and linguistic abilities of Grade II elementary school students.

Based on constructive feedback from the validators, revisions were made in four main aspects: (1) adjustment of the minimum font size to 14 pt for all dialogue texts and problem statements; (2) improvement of the resolution of all illustrations to a minimum of 300 dpi to ensure optimal visual clarity; (3) addition of a user guide for teachers, including strategies for facilitating classroom discussion; and (4) simplification of several dialogue sentences considered too complex for Grade II students' level of comprehension. These revisions resulted in Prototype 2, which was ready for field testing with the research subjects. These findings are consistent with the study by Hidayah and Ulya (2020), which emphasized that readability and visual clarity are critical factors in the development of effective comic-based learning media for elementary school students. Similarly, Susanto et al. (2023) recommended multi-expert validation as an essential requirement in the development of digital media for mathematics learning.

**3. Media Practicality**

Media practicality was measured through response questionnaires administered to 28 students, covering five evaluative aspects: ease of use, clarity of material presentation, visual attractiveness, relevance of story context to daily life, and the usefulness of the media in understanding numeracy content. The analysis results showed an average practicality score of 88.3%, which falls into the very practical category.

Analysis by aspect revealed an interesting pattern. The visual attractiveness aspect obtained the highest score (91.2%), followed by story context relevance (90.5%). These two aspects indicate that students responded positively to the presentation approach that used characters and situations closely related to their daily lives. Clarity of material presentation scored 89.1%, while usefulness in understanding the material scored 86.4%. The ease of use aspect received the lowest score (84.6%), mainly due to limited access to digital devices in some students' homes. To overcome this limitation, the teacher provided a printed version as an alternative that could be used both at school and at home.

These practicality findings are in line with the study by Rahmawati et al. (2023), which showed that contextual-based learning media consistently receive positive responses from lower-grade elementary school students because they present learning situations that are familiar, relevant, and personally meaningful. Classroom teachers also provided positive evaluations regarding the ease of integrating the media into lesson plans, confirming that the digital comic meets practicality criteria from a professional user perspective as stated by Nieveen and Folmer (2020). Nurhidayah et al. (2022) further emphasized that the successful implementation of digital media in elementary classrooms largely depends on the ease of adaptation by teachers, which was clearly fulfilled in this study.

**4. Effectiveness of the Media on Numeracy Skills**

The effectiveness of the digital comic media was measured through a comparative analysis of pretest and posttest scores as well as N-Gain calculations for each numeracy skill indicator. The average pretest score of all participants was 58.6 (SD = 9.3), reflecting initial numeracy abilities that were still below the minimum mastery criteria. After the implementation of the digital comic media over three learning sessions, the average posttest score increased to 82.4 (SD = 7.1), indicating a substantial and relatively consistent improvement across all participants.

**Table 2. N-Gain Analysis Results per Numeracy Indicator**

| Numeracy Indicator | N-Gain | Category |
|---|---|---|
| Conceptual Understanding of Numbers | 0.54 | Moderate |
| Application of Concepts in New Contexts | 0.65 | Moderate |
| Computational Procedures | 0.58 | Moderate |
| Mathematical Reasoning and Proof | 0.48 | Moderate |
| Overall Average | 0.57 | Moderate |

The overall N-Gain value of 0.57 indicates an improvement in numeracy skills in the moderate category, according to Hake's classification (1998). Analysis of each indicator shows informative variation. The highest improvement occurred in the indicator "application of concepts in new contexts" (N-Gain = 0.65), which directly reflects the effectiveness of the CTL approach integrated into the comic narrative. Students were able to apply concepts of addition, subtraction, and division in story situations different from previously learned examples.

Improvements in "conceptual understanding of numbers" (N-Gain = 0.54) and "computational procedures" (N-Gain = 0.58) were also in the moderate category, indicating adequate reinforcement of conceptual understanding.

The lowest improvement occurred in the "mathematical reasoning and proof" indicator (N-Gain = 0.48). This can be understood considering that mathematical reasoning is a higher-order thinking skill that requires a longer development period and more intensive practice compared to conceptual understanding or procedural skills. This finding provides valuable information for the further development of instructional media, which needs to allocate greater emphasis to the development of mathematical reasoning skills.

These results are consistent with the findings of Fadilah and Suherman (2021), who demonstrated that the CTL approach significantly improves elementary school students' mathematical problem-solving skills, particularly in applying concepts in authentic contexts. This finding also supports Mayer's (2021) multimedia learning principle, which states that the combination of textual narration and visual illustrations in a coherent format significantly enhances understanding and information retention compared to presenting material through a single modality.

Observational data from the learning process provide additional insights that complement the quantitative data. Students' active engagement in learning activities showed a consistent increase from 62% in the first session to 78% in the second session, and reached 89% in the third session. This increasing trend indicates that the digital comic media is not only effective in improving cognitive learning outcomes but also successfully promotes active participation and intrinsic motivation among students in learning mathematics.

## 5. Integrative Discussion

Overall, this development research successfully produced a contextual-based digital comic media that meets the three criteria of instructional product quality: validity, practicality, and effectiveness. This success cannot be separated from the systematic and comprehensive implementation of the ADDIE model, which enables the identification and refinement of issues at each development stage before proceeding to the next. The integration of CTL principles into the comic design proved to be the main strength of the product, as it effectively bridges the gap between abstract formal mathematics and students' concrete everyday experiences.

The findings of this study strengthen the theoretical framework of Realistic Mathematics Education (RME), which emphasizes that mathematics should be learned as a meaningful human activity within realistic contexts (Dini et al., 2021). The use of familiar local contexts—such as school canteens, sports activities, and birthday celebrations—proved effective in increasing learning relevance and promoting both cognitive and affective engagement in numeracy learning. This is also in line with the principles of the Merdeka Curriculum, which positions meaningful and student-centered learning as its main orientation (Ministry of Education, Culture, Research, and Technology, 2023).

Asri and Kurniawan (2022) reinforced that the use of story-based visual media for lower-grade elementary students significantly increases motivation and conceptual understanding in mathematics. Susanto et al. (2023) added an important dimension, stating that the development of digital mathematics learning media that incorporates local and culturally relevant contexts has a greater impact on students' conceptual understanding and application of mathematics compared to media using generic or abstract contexts. These findings collectively support the approach adopted in this study.

The limitation of this study lies in the relatively small number of participants (28 students from one school) and the short implementation period (three sessions). These limitations restrict the generalizability of the findings to broader and more diverse populations. Further research involving larger samples across different geographical and socio-economic contexts is highly recommended to confirm and extend these findings. In addition, the development of more advanced interactive features—such as responsive animations, AI-based automatic feedback, and gamification elements—should be further explored to enhance students' digital engagement potential (Andini et al., 2023).

## CONCLUSION

Based on the results and discussion presented, several comprehensive

conclusions can be drawn. First, the contextual-based digital comic media developed through the ADDIE model is classified as highly valid based on expert assessments: material expert (87.5%), media expert (84.2%), and language expert (89.0%), meeting all established validity standards. Second, the media is considered highly practical, with a student response score of 88.3%, particularly in terms of visual attractiveness and contextual relevance that reflect the closeness of the media to students' everyday experiences. Third, the media is proven effective in improving Grade II elementary students' numeracy skills, as shown by an increase in the average score from 58.6 to 82.4 with an N-Gain value of 0.57 (moderate category), accompanied by an increase in active student engagement from 62% to 89%.

Based on these findings, it is recommended that elementary school teachers actively utilize contextual-based digital comic media as an innovative alternative in mathematics learning, particularly for numeracy word problem topics. Further development should be conducted to expand content coverage, enhance digital interactivity through animation elements and automated feedback, and test the effectiveness of the media on more diverse populations.

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