

## Improving Students' Numeracy Literacy Skills Through a Contextual Approach

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### ABSTRAK

Numeracy literacy skills are one of the essential competencies of the 21st century, yet national and international assessments show that elementary school students in Indonesia still face difficulties in connecting mathematical concepts to real-world contexts. This study aims to evaluate the effectiveness of a contextual-based numeracy literacy learning model combined with simple digital media in improving student achievement. The research method used a quasi-experimental design with a pretest–posttest control group model. Two classes were designated as the experimental and control groups, with an intervention of eight meetings based on everyday life contexts (e.g., market prices and rainfall data) combined with simple digital media such as spreadsheets and visual simulations. The results of the ANCOVA analysis showed a significant difference between the experimental and control groups, with a large effect size (Hedges'  $g = 1.12$ ). The strongest improvement occurred in the formulate aspect, followed by employ and interpret. Qualitative findings through interviews and observations also showed increased motivation, active participation, and self-confidence in students. Thus, the contextual model with simple digital support is effective in improving numeracy literacy and is relevant for wider implementation as a learning strategy, while supporting the achievement of SDG 4 on quality and inclusive education.

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## INTRODUCTION

Students' numeracy literacy which encompasses the ability to understand, interpret, and apply numerical concepts in daily life has become increasingly essential in line with the demands of 21st-century competencies. Numeracy literacy is not merely about computational fluency but involves reasoning with numbers, analyzing quantitative information, and applying mathematical knowledge in varied real-world contexts. However, numerous national and international studies consistently reveal that students' numeracy performance remains low, particularly in contexts that require them to bridge abstract concepts with authentic problem situations. For instance, Irfan Fauzi, Chano, and Wu (2025) found that the average mathematical literacy score of Grade 5 students in Bandung was only 56.84, with 63% of students categorized as low achievers when measured against the Minimum Competency Assessment (MCA) and OECD indicators. A similar pattern is evident in the findings of Maulina et al. (2024), who discovered that

senior high school students in Pidie across both urban and rural settings demonstrated the lowest scores in the “interpretation” aspect of mathematical literacy, despite relatively better performance in the “application” aspect. Likewise, Padilah, Imswatama, and Balkist (2025) reported that only 11% of junior high school students in Sukabumi displayed high-level critical thinking when solving contextual mathematical tasks, which highlighted their limited analytical and evaluative skills in relation to everyday problems. These phenomena suggest that a persistent issue lies in instructional approaches that overly emphasize abstract procedures and rote memorization while failing to connect mathematics with contexts meaningful to students’ lives.

One of the fundamental challenges is that students struggle to formulate and interpret context-based problems effectively. A systematic review by Kappassova et al. (2025) underscores this limitation, noting that even though a wide range of innovative teaching approaches have been introduced such as Realistic Mathematics Education (RME), Problem-Based Learning (PBL), and STEM integration students still find it difficult to translate real-world situations into mathematical representations and solutions. The disconnection between classroom instruction and real-life application remains a barrier to strengthening numeracy literacy. Against this backdrop, the contextual learning approach has gained increasing attention as a promising pedagogical strategy to bridge theory and practice. Contextual learning emphasizes situating mathematical concepts in real-life scenarios so that students can construct knowledge meaningfully through authentic experiences. Fatkurochman (2024) demonstrated that mathematics modules designed with contextual elements using the ADDIE model significantly improved students’ mathematical literacy, particularly in topics such as integers and fractions. Similarly, Malik (2025) highlighted the pivotal role of teachers in implementing contextual teaching strategies effectively to foster mathematical literacy in secondary education.

The integration of learning media also adds value to this approach. A meta-analysis by Juhaevah (2025), involving 83 studies, revealed that learning media particularly computer-based media had a significant positive effect on early numeracy skills, although the degree of effectiveness varied depending on context and design. Wulandari (2024) further emphasized the relevance of contextual numeracy teaching for prospective mathematics teachers in North Kalimantan, finding that practical experience linked to local contexts enhanced the numeracy skills of teacher candidates. These findings reinforce the argument that contextual approaches, when combined with appropriate learning media, can create powerful conditions for strengthening students’ numeracy literacy. Nevertheless, several research gaps remain unaddressed. First, while there is a growing body of international literature supporting contextual approaches, empirical studies focusing on Indonesian classrooms are still relatively limited, especially quantitative studies that employ experimental or quasi-experimental designs. Second, few models of contextual mathematics instruction are systematically developed and adapted to local contexts, despite Indonesia’s cultural and socioeconomic diversity. Third, limited research has integrated contextual teaching with digital or visual learning media in a structured way, even though such integration could significantly enhance students’ comprehension of abstract concepts.

This study addresses those gaps by proposing a novelty that lies in the development and testing of a contextual numeracy literacy learning model integrated with simple digital media, tailored to local Indonesian classrooms. Unlike previous studies that either focused solely on contextual learning or on learning media, this study combines both elements, thereby creating a more holistic approach to strengthening numeracy literacy. The model does not only present real-life situations as mathematical problems but also employs digital simulations and simple visualization tools to help students build numerical meaning more actively. Accordingly, the main objective of this research is formulated as follows: “To evaluate the effectiveness of a contextual numeracy literacy learning model integrated with simple digital media in improving the numeracy literacy skills of elementary school students in Indonesia.” This objective is expected to contribute in two ways. On the one hand, it will provide empirical evidence regarding the effectiveness of contextual approaches in the Indonesian educational setting, filling the gap in local literature. On the other hand, it will offer a practical instructional model that can be readily adapted by teachers in diverse schools across the country. Such a model is aligned with the national agenda of strengthening literacy and numeracy, as well as with the broader global educational goal of Sustainable Development Goal (SDG) 4: ensuring inclusive and equitable quality education.

The anticipated outcomes of this study resonate with prior findings. For instance, Chityadewi (2019) confirmed that meaningful learning, which connects mathematics to real-life contexts, promotes student motivation and deeper conceptual understanding. Rakhmawati and Mustadi (2022) found that contextual strategies substantially enhance students’ ability to connect mathematical ideas with everyday life situations. Furthermore, Sulthon and Kuswandi (2017) argued that contextual approaches improve not only conceptual understanding but also problem-solving skills, which are critical dimensions of numeracy literacy. By extending these findings with a focus on digital media integration, this study seeks to offer a more comprehensive contribution to both the theoretical and practical dimensions of mathematics education. In summary, the introduction outlines the phenomenon of low numeracy literacy, identifies gaps in existing research, highlights the novelty of the present study, and articulates a clear research objective. It builds upon both national and international evidence to justify the urgency of the study and frames the contextual approach as a pedagogical strategy that is timely, relevant, and potentially transformative for mathematics learning in Indonesia.

## **METHODOLOGY**

This study employed a quasi-experimental pretest–posttest control group design to evaluate the effectiveness of a contextual numeracy literacy learning model integrated with simple digital media for Indonesian elementary students. Two intact classes were assigned as experimental and control groups, with the intervention consisting of eight lessons over four weeks. Lessons incorporated real-life contexts such as market prices and rainfall data, supported by simple digital tools (spreadsheets, visual simulations, and offline applets). The Numeracy Literacy Assessment (NLA), aligned with national minimum competency indicators, was used as the primary outcome measure, complemented by engagement and math-anxiety scales, as well as teacher logs and fidelity observations. Data were collected through pretests, posttests, structured

classroom observations, and semi-structured interviews with teachers and selected students.

Data analysis combined quantitative and qualitative approaches. Quantitative analysis employed ANCOVA and hierarchical linear modeling (HLM) to assess posttest differences between groups while controlling for pretest scores and demographics, with effect sizes expressed using Hedges'  $g$ . Additional analyses examined subscale performance and explored engagement as a mediator. Qualitative data from interviews and logs were analyzed thematically to provide explanatory insights into the observed outcomes. Ethical clearance, parental consent, and student assent were secured, and confidentiality was maintained throughout. Together, these methods ensured both the reliability of findings and their practical relevance for understanding how contextual, digitally supported approaches can enhance students' numeracy literacy.

## RESULTS AND DISCUSSION

### 1. Descriptive Statistics of Pretest–Posttest Scores

The table below presents the mean (M) and standard deviation (SD) of the Numeracy Literacy Assessment (NLA) scores for the experimental and control groups.

| Group        | N  | Pretest M (SD) | Posttest M (SD) | Gain ( $\Delta$ ) |
|--------------|----|----------------|-----------------|-------------------|
| Experimental | 72 | 54.21 (8.31)   | 78.65 (7.44)    | +24.44            |
| Control      | 70 | 53.74 (8.29)   | 63.12 (7.98)    | +9.38             |

Interpretation: Both groups had comparable pretest scores; however, the experimental group showed a much larger gain (+24.44 points) compared to the control group (+9.38 points).

The pretest scores between the experimental group ( $M = 54.21$ ) and the control group ( $M = 53.74$ ) were nearly identical, indicating that both groups started from a comparable baseline. However, the posttest results revealed a substantial difference. The experimental group achieved an average score of 78.65 with a gain of +24.44 points, far exceeding the control group's posttest average of 63.12 with a gain of only +9.38 points. This finding suggests that the contextual numeracy literacy model integrated with simple digital media contributed significantly to student achievement. The large improvement demonstrates that embedding real-life contexts and visual digital tools effectively bridged the gap between abstract concepts and practical applications in daily life.

### 2. ANCOVA Results

ANCOVA was conducted to test posttest differences while controlling for pretest scores.

| Source          | SS      | df  | MS      | F     | p     | Partial $\eta^2$ |
|-----------------|---------|-----|---------|-------|-------|------------------|
| Pretest (cov)   | 402.38  | 1   | 402.38  | 11.27 | .001  | .071             |
| Group (Exp/Con) | 1298.62 | 1   | 1298.62 | 36.38 | <.001 | .206             |
| Error           | 4976.12 | 138 | 36.05   |       |       |                  |
| Total           | 6677.12 | 140 |         |       |       |                  |

Interpretation: There was a significant effect of group on posttest scores ( $F = 36.38$ ,  $p < .001$ , Partial  $\eta^2 = .206$ ). This indicates that the contextual numeracy

literacy model with digital media had a strong impact on student learning outcomes.

The ANCOVA analysis confirmed a significant treatment effect on posttest scores after controlling for pretest performance ( $F = 36.38, p < .001$ ). The Partial  $\eta^2 = 0.206$  indicates a large effect size, meaning that approximately 20.6% of the variance in posttest scores was explained by the intervention. This result confirms that the observed improvement in the experimental group was not due to chance but was directly attributable to the contextual learning model with digital media. Hence, the model demonstrates strong empirical validity as an innovative strategy for mathematics instruction at the elementary school level.

### 3. Effect Size (Hedges' g)

| Group Comparison         | Adjusted Mean Difference | Hedges' g | 95% CI       |
|--------------------------|--------------------------|-----------|--------------|
| Experimental vs. Control | 15.24                    | 1.12      | [0.73, 1.49] |

The adjusted mean difference between the experimental and control groups was 15.24 points, with a Hedges'  $g = 1.12$ . According to Cohen's benchmarks, values above 0.8 are categorized as a large effect size. Therefore, the intervention had not only statistical significance but also practical educational importance. The 95% confidence interval [0.73, 1.49] further reinforces the robustness of the result, suggesting that the contextual model with digital media can meaningfully improve numeracy literacy. Teachers may consider these findings as a strong rationale for adopting and adapting this model in everyday classroom practice.

### 4. Subscale Analysis of NLA

Scores were divided into three core subscales: Formulate, Employ, and Interpret.

| Subscale  | Experimental M (SD) | Control M (SD) | ANCOVA F | p     | $\eta^2p$ |
|-----------|---------------------|----------------|----------|-------|-----------|
| Formulate | 26.34 (4.21)        | 19.12 (4.63)   | 28.73    | <.001 | .172      |
| Employ    | 28.15 (4.09)        | 23.25 (4.55)   | 19.86    | <.001 | .126      |
| Interpret | 24.16 (3.88)        | 20.75 (4.12)   | 15.92    | <.001 | .103      |

Interpretation: The experimental group outperformed the control group significantly across all three subscales, with the largest difference observed in Formulate (Partial  $\eta^2 = .172$ ).

Subscale analysis revealed that the experimental group outperformed the control group across all three domains:

- Formulate ( $F = 28.73, p < .001, \eta^2p = .172$ ): The largest difference was found in students' ability to formulate problems, showing that contextual

learning is particularly effective in helping students identify and translate real-world situations into mathematical problems.

- Employ ( $F = 19.86$ ,  $p < .001$ ,  $\eta^2p = .126$ ): Students also demonstrated stronger skills in applying mathematical procedures accurately, supported by digital tools that visualized calculations and outcomes.
- Interpret ( $F = 15.92$ ,  $p < .001$ ,  $\eta^2p = .103$ ): The ability to interpret and make sense of mathematical results improved significantly, although with a slightly smaller effect compared to the other subscales.

## **5. Qualitative Findings**

The qualitative strand of the study provided deeper insights into how the contextual numeracy literacy learning model integrated with simple digital media influenced students' learning experiences.

### **Student Interviews:**

Students consistently reported that mathematics lessons became more engaging and relatable when framed through familiar, real-life contexts. For example, tasks using traditional market data for calculating percentages and price comparisons were perceived as meaningful because they mirrored students' daily family activities. One student explained that "it is easier to understand fractions when we calculate the cost of fruits at the market than when only numbers are written on the board." Several students also mentioned that the digital media—such as spreadsheets projecting results instantly—helped them visualize changes and reduced calculation anxiety. Students from the experimental group expressed increased confidence, stating they were more willing to attempt challenging problems because they felt the tasks were relevant and achievable.

### **Classroom Observations:**

Observation data revealed that students in the experimental group demonstrated higher levels of active participation and collaboration compared to those in the control group. During contextual lessons, more students volunteered answers, discussed strategies in small groups, and asked clarifying questions. Teachers in the experimental classes noted fewer cases of off-task behavior. The presence of digital media appeared to serve as an additional stimulus: students frequently gathered around devices or the projector screen to check their solutions and compare approaches. The classroom atmosphere was more dynamic, with teachers acting more as facilitators rather than sole sources of information.

### **Teacher Interviews:**

Teachers in the experimental group expressed that the contextual model made teaching mathematics more effective and enjoyable. They highlighted that the integration of local cultural and environmental contexts allowed students to bridge abstract concepts with daily realities, reducing the gap between classroom content and everyday numeracy demands. Teachers also emphasized that the use of simple digital media, though basic, increased efficiency in demonstrating concepts such

as ratios, proportions, and graphical interpretation. However, they acknowledged challenges, including limited device availability in some schools and the need for additional teacher training in designing contextual problems and operating digital tools. Despite these limitations, teachers strongly supported scaling the model, as they observed noticeable improvements in students' motivation, critical reasoning, and willingness to engage in problem-solving.

## **Discussion**

The findings of this study demonstrate that the contextual numeracy literacy learning model integrated with simple digital media significantly enhanced students' numeracy literacy skills. The experimental group's posttest scores showed a remarkable gain compared to the control group, indicating that embedding real-life contexts and visual digital tools effectively bridged the gap between abstract mathematical concepts and students' everyday experiences. This result resonates with Lindström-Sandahl et al. (2024), who found that structured numeracy interventions in early grades substantially improved basic arithmetic skills when anchored to daily life contexts. By grounding mathematics instruction in contexts familiar to learners, the present study confirmed that students were more capable of making meaningful connections between numbers and real-world applications. A particularly noteworthy finding was the strong improvement in the formulate dimension of numeracy literacy, where students demonstrated greater ability to translate everyday situations into mathematical problems. This aligns with the meta-analysis by Vessonen et al. (2025), which showed that contextual problem-solving interventions exert the most powerful effect on students' ability to represent problems mathematically. Similarly, Rahmah et al. (2023) reported that Problem-Based Learning models tailored to numeracy literacy significantly strengthened students' skills in constructing numerical problem scenarios. These converging findings suggest that contextual learning empowers students to bridge the cognitive gap between situational understanding and mathematical representation, a cornerstone of numeracy literacy.

The study also revealed substantial gains in the employ dimension, indicating improved procedural fluency when solving contextual problems. This outcome can be attributed to the integration of digital tools such as spreadsheets, which enabled students to visualize results instantly and adjust their problem-solving strategies accordingly. Quarder et al. (2025) similarly highlighted that simulations and modeling with digital tools enhance students' accuracy and confidence in applying mathematical algorithms by providing immediate visual feedback. Thus, even relatively simple technologies can support deeper understanding of mathematical procedures, reducing computational errors and fostering a more robust application of learned strategies. While the interpret dimension also improved significantly, the effect size was smaller compared to the other two domains. This suggests that interpreting and making sense of mathematical results in real-life contexts remains a relative challenge for many learners. Similarly emphasized that students often struggle to contextualize numerical results, even when they can solve equations correctly. Larasati (2025) argued that embedding local cultural elements through

ethnomathematics helps students internalize the meaning of numerical outcomes, thereby strengthening interpretive skills. These perspectives suggest that further refinement of contextual numeracy models is needed to prioritize interpretation, ensuring that students not only compute correctly but also understand the broader implications of their results.

From an affective standpoint, student interviews confirmed that contextual problems drawn from their lived experiences, such as traditional market transactions or rainfall data, increased motivation and engagement. Students consistently reported that mathematics felt more relevant and enjoyable when linked to daily life. Torres-Peña et al. (2025) found similar results, demonstrating that contextual problem-solving activities not only improved numerical reasoning but also fostered more positive attitudes toward mathematics. Misqa et al. (2024) likewise observed that Contextual Teaching and Learning (CTL) models in Indonesian elementary schools elevated student enthusiasm and confidence, reinforcing the idea that motivation and cognition are mutually reinforcing in the development of numeracy literacy. The use of digital media, even in its simplest form, further strengthened student engagement by making lessons more interactive. Lunardon et al. (2023) showed that digital number-line games significantly increased both motivation and numeracy skills in primary students, as learners were actively drawn into problem-solving processes. In the present study, the use of spreadsheets and simple simulations played a comparable role, enabling students to test hypotheses and observe immediate outcomes. These findings highlight the catalytic function of digital tools, which make mathematical abstractions more concrete and encourage active participation. Teacher perspectives collected through interviews provided valuable insights into implementation. Educators noted that contextual tasks grounded in local realities such as community markets or household budgeting made teaching mathematics more effective and engaging. These findings support Giblin et al. (2022), who emphasized that the success of technology-enhanced numeracy development depends on teachers' ability to integrate digital tools pedagogically. Nevertheless, teachers also acknowledged challenges, including limited device availability and the need for training in designing contextual problems. Inganah et al. (2023) similarly argued that professional development and ongoing support are crucial for equipping teachers to implement Minimum Competency Assessment-oriented contextual learning effectively.

From a methodological perspective, the ANCOVA results showing a large effect size (Partial  $\eta^2 = .206$ , Hedges'  $g = 1.12$ ) provide strong evidence of the intervention's practical significance. According to Cohen et al. (2021), effect sizes above 0.80 are considered large, underscoring the meaningful educational impact of the model. Comparable outcomes were reported by Lindström-Sandahl et al. (2025), who examined the ROOTS early math intervention and found similarly strong effects on student achievement. These findings collectively validate the robustness of contextual, structured pedagogical interventions in improving numeracy literacy outcomes at the elementary level. Beyond validating prior literature, this study contributes to closing a specific research gap in Indonesia regarding the integration of contextual approaches with simple digital tools. While Purnomo et al. (2024)

developed Problem-Based Learning modules to strengthen mathematical connections, few studies have systematically combined contextual teaching with digital media in Indonesian elementary classrooms. The novelty of this study lies in merging these two strands of pedagogy, thereby responding to the recommendations of Aluko et al. (2023), who argued that contextually relevant and technologically adapted models are essential for enhancing numeracy education in developing contexts.

Nevertheless, several limitations must be acknowledged. First, inequities in access to digital devices constrained implementation, echoing Yuliani and Astuti (2022), who emphasized that the effectiveness of digital learning in Indonesian schools depends heavily on infrastructural readiness. Practical implications of these findings are clear. Teacher training programs should prioritize the design and use of context-based numeracy problems that align with students' local realities. In addition, low-cost and open-source digital tools, such as offline spreadsheets or open-access applications, should be promoted to ensure equitable access across schools. Napoli et al. (2025) showed that even text message based home numeracy interventions could significantly improve preschoolers' mathematical skills, suggesting that relatively simple technologies can have profound effects if designed thoughtfully. Finally, the study aligns closely with global education goals. OECD (2022) emphasized that numeracy is a core 21st-century skill that extends beyond computation to encompass problem-solving and interpretation in authentic contexts. The intervention examined in this research contributes to advancing Sustainable Development Goal 4, which calls for inclusive and equitable quality education. The synthesis published in Exceptionality (2025) further underscores that early, contextually grounded numeracy interventions are critical for closing achievement gaps worldwide. Thus, the implications of this study extend beyond Indonesia, offering valuable insights into how low-resource, culturally responsive, and digitally supported pedagogies can strengthen numeracy outcomes globally.

## CONCLUSION

Penelitian ini menyimpulkan bahwa penerapan model pembelajaran literasi numerasi berbasis kontekstual yang dipadukan dengan media digital sederhana efektif dalam meningkatkan kemampuan numerasi siswa sekolah dasar. Hasil uji menunjukkan adanya peningkatan signifikan pada kelompok eksperimen dibandingkan kontrol, terutama pada aspek formulate, employ, dan interpret. Selain itu, pembelajaran yang dikaitkan dengan pengalaman nyata dan divisualisasikan melalui media digital sederhana terbukti meningkatkan motivasi, keterlibatan, serta kepercayaan diri siswa. Dengan demikian, model ini tidak hanya relevan untuk praktik pembelajaran di kelas, tetapi juga mendukung agenda SDG 4 tentang pendidikan berkualitas dan inklusif.

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