



DEVELOPING COMPUTER SCIENCE UNPLUGGED WORKSHEETS TO ENHANCE SECOND-GRADE NUMBER CONCEPT UNDERSTANDING

Titik Purnamasari^(1*), Raden Sulaiman⁽¹⁾, Ali Shodikin⁽¹⁾

¹Department of Mathematics Education, Universitas Negeri Surabaya, Indonesia

*Corresponding Author. E-mail: 24030785001@mhs.unesa.ac.id

ARTICLE INFO

Article History:

Received: 16-Feb. 2026

Revised: 18-Mar. 2026

Accepted: 19-Mar. 2026

Keywords:

Computer Science
Unplugged, Elementary
Mathematics
Education,
Mathematics
Worksheets, Number
Concepts, Second-
Grade Students

ABSTRACT

This study aimed to develop and evaluate Computer Science Unplugged (CS Unplugged)-based student worksheets to enhance second-grade students' understanding of number concepts. This study employed a Research and Development approach using the ADDIE model and involved 26 second-grade students in a limited practical trial. The developed worksheets were evaluated through expert validation, practicality testing based on teacher and student responses, and effectiveness testing using a one-group pretest-posttest design. The results indicated that the worksheets achieved a very high level of validity (media: 92.67%; content: 91.67%) and practicality (students: 91.38%; teacher: 90%). The effectiveness test showed a substantial improvement in students' learning outcomes, with the mean score increasing from 67 in the pretest to 90.38 in the posttest, and an N-gain score of 0.73, categorized as high. These findings demonstrate that CS Unplugged-based worksheets are valid, practical, and effective for improving students' understanding of number concepts while supporting the integration of computational thinking in elementary mathematics education.

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How to Cite:

Purnamasari, T., Sulaiman, R., & Shodikin, A. (2026). Developing Computer Science Unplugged Worksheets to Enhance Second-Grade Number Concept Understanding. *Journal of Mathematics Education and Science*, 9(1), 20-33. <https://doi.org/10.32665/james.v9i1.6341>

INTRODUCTION

Mathematics education plays a critical role in developing students' logical reasoning, problem-solving abilities, and higher-order thinking skills required in the 21st century. However, improving students' mathematical understanding remains a persistent challenge, particularly at the elementary level, where foundational concepts are first established. Large-scale international assessments continue to report that students' performance in mathematics, especially in number-related domains, remains moderate in many countries, including Indonesia (OECD, 2019). These results indicate that many students struggle to develop a solid conceptual understanding of basic numeracy, which serves as a prerequisite for more advanced mathematical learning (Jordan et al., 2009).

One major factor contributing to this issue is the dominance of instructional practices that emphasize procedural fluency rather than conceptual understanding, which often limits students' opportunities to explore mathematical ideas through meaningful learning experiences. From a developmental perspective, elementary students generally operate within the concrete operational stage, where learning becomes more effective when supported by hands-on activities,

concrete representations, and contextual interactions. In this regard, contextual and interactive learning approaches have been shown to significantly enhance students' mathematical understanding (Pantin & Khoirotunnisa, 2025). Previous studies also indicate that conceptual understanding develops more effectively when students actively construct knowledge through exploration and interaction with meaningful representations (Clements & Sarama, 2020; Fyfe et al., 2014). Furthermore, well-designed instructional materials can play a crucial role in improving students' conceptual mastery and overall learning outcomes (Kul et al., 2018; Lefevre et al., 2009; Zhou et al., 2022). These findings highlight the importance of developing instructional resources that can bridge abstract mathematical concepts with students' concrete learning experiences.

In recent years, scholars have increasingly emphasized the integration of computational thinking into mathematics education as a means of strengthening students' problem-solving and analytical abilities. Computational thinking has been recognized as a fundamental skill for the digital age (Wing, 2006). One promising approach for introducing computational thinking in early education is Computer Science Unplugged (CS Unplugged), which teaches computational concepts through physical, collaborative, and game-based activities without relying on digital technology (Bell et al., 2009). Prior studies have shown that CS Unplugged can effectively increase student engagement and promote conceptual understanding through experiential learning (Smith & Caldwell, 2016). Furthermore, unplugged activities provide meaningful entry points for introducing computational ideas to elementary students while simultaneously supporting mathematical reasoning (Munasinghe et al., 2023). These activities also contribute to the development of critical thinking, collaboration, and problem-solving skills (CAKIROGLU et al., 2022).

Empirical studies further demonstrate that unplugged learning activities can significantly improve students' computational thinking abilities, motivation, and engagement (Busuttill & Formosa, 2020; Chen et al., 2023; del Olmo-Muñoz et al., 2020). Additionally, integrating computational thinking into mathematics learning has been found to positively influence students' mathematical achievement (Chan et al., 2021). While these studies provide important insights into the benefits of computational thinking integration, most of them focus primarily on developing computational thinking skills or addressing specific mathematical topics, such as number patterns or arithmetic operations.

Despite these contributions, limited attention has been given to the systematic development of CS Unplugged-based instructional materials specifically aimed at improving students' conceptual understanding of number concepts in early elementary education. Existing studies rarely design structured learning materials that explicitly align unplugged activities with early numeracy concepts (Bell et al., 2009; Brackmann et al., 2017). Moreover, many studies focus primarily on the implementation of learning activities rather than on the development and comprehensive evaluation of instructional products. Consequently, aspects such as instructional validity, classroom practicality, and learning effectiveness are often not simultaneously examined in a systematic instructional design framework (Branch & Varank, 2009; Reeves & Hedberg, 2003). This limitation reveals an important research gap in the design of structured, activity-based teaching materials that integrate CS Unplugged with early mathematics learning. Particularly, there is a lack of empirically validated instructional materials designed to support second-grade students in developing a deep conceptual understanding of number concepts through unplugged computational activities.

This limitation reveals an important research gap in the design of structured, activity-based teaching materials that integrate CS Unplugged with early mathematics learning. Although unplugged approaches have been shown to support computational thinking and problem-solving skills among young learners (Brackmann et al., 2017; Rodríguez-Martínez et al., 2020), there is still a lack of empirically validated instructional materials specifically designed to support second-grade students in developing deep conceptual understanding of number concepts through unplugged computational activities.

Addressing this gap, the present study develops CS Unplugged-based teaching materials in the form of student worksheets (Lembar Kerja Murid/LKM) focusing on number concepts. These worksheets are designed to provide kinesthetic, collaborative, and conceptually oriented learning experiences that align with the cognitive characteristics of early elementary learners, while simultaneously fostering computational thinking and mathematical reasoning (Bell et al., 2009; Brackmann et al., 2017).

The novelty of this study lies in three main aspects. First, it systematically integrates CS Unplugged activities into structured mathematics instructional materials specifically aimed at strengthening conceptual understanding of number concepts, rather than solely focusing on computational thinking skills. Second, the instructional materials are developed using the ADDIE instructional design model (Branch & Varank, 2009), ensuring a systematic development process grounded in instructional design principles. Third, the developed materials are comprehensively evaluated in terms of validity, practicality, and effectiveness through empirical classroom implementation.

Therefore, this study aims to develop CS Unplugged-based student worksheets that are valid, practical, and effective in improving second-grade students' conceptual understanding of number concepts in elementary mathematics learning.

METHOD

This study employed a Research and Development (R&D) approach to develop Computer Science Unplugged (CS Unplugged)-based mathematics teaching materials in the form of student worksheets (Lembar Kerja Murid/LKM) for second-grade elementary school students. The research was conducted during the odd semester of the 2025/2026 academic year at SDN Sumberrejo I, Bojonegoro, East Java, Indonesia. The school was selected purposively because preliminary observations indicated the need for innovative instructional materials that support students' conceptual understanding of number concepts through concrete and activity-based learning.

The study adopted the ADDIE instructional design model, which consists of five stages: analysis, design, development, implementation, and evaluation ('Aniqoh et al., 2025). This model was selected because it provides a systematic, iterative framework for designing, developing, and evaluating instructional products to ensure their quality, usability, and effectiveness.



Figure 1. ADDIE Development Model

The CS Unplugged-based worksheets were developed and validated by six experts (three material experts and three media experts), and instrument validity and reliability were examined using expert judgment and Cronbach's alpha. The developed materials were then implemented in a limited classroom trial involving 26 second-grade students and three elementary school teachers to evaluate their practicality and usability.

Table 1. Structure of Research Instruments and Measurement Constructs

Instrument	Construct/Indicator	Description / Example Item	Item Numbers	Number of Items
Media Expert Validation	Visual Design Quality	Clarity and organization of layout, visual balance, and readability	1-5	5
	Instructional Attractiveness	Visual appeal and attractiveness of instructional materials	6-9	4
	Learner Appropriateness	Suitability of media with students' characteristics and learning needs	10-14	5
	Usability	Practicality, durability, and flexibility of media use in classroom activities	15-17	3
	Media Quality	Overall quality and effectiveness of the instructional media	18	1
	Size Suitability	Appropriateness of media size for students' use	19-20	2
Material Expert Validation	Language Clarity	Clarity and readability of language used in the teaching materials	1-2	2
	Curriculum Alignment	Alignment of materials with Learning Outcomes (CP) and Learning Objectives (TP)	3-4	2
	Content Accuracy	Accuracy and correctness of mathematical concepts	5-8	4
	Content Currency	Relevance and up-to-date nature of the content	9-12	4
	Learner Development Appropriateness	Suitability of materials to students' cognitive development level	13-17	5
	Material Components	Completeness and organization of instructional components	18-19	2
	Assessment Alignment	Alignment of assessment with learning materials and objectives	20	1
Teacher Response Questionnaire	Perceived Ease of Use	The worksheets are easy to implement and use in classroom instruction	T1-T3	3
	Instructional Efficiency	The worksheets help teachers deliver mathematics lessons efficiently	T4-T6	3
	Instructional Attractiveness	The worksheets increase students' interest and participation	T7-T8	2
	Perceived Usefulness	The worksheets improve students' computational thinking and number understanding	T9-T10	2
Student Response Questionnaire	Learning Motivation	I actively participate in learning activities using the worksheets	S1-S2	2
	Instructional Attractiveness	The worksheets are visually interesting and enjoyable	S3-S4	2
	Perceived Ease of Use	The instructions and tasks in the worksheets are easy to understand	S5-S7	3
	Perceived Usefulness	The worksheets help me understand number concepts better	S8-S10	3

The study employed four instruments: media expert validation, material expert validation, teacher response questionnaire, and student response questionnaire. These constructs were adapted from learning motivation theory and the Technology Acceptance Model (TAM). Each item was measured using a five-point Likert scale ranging from strongly disagree (1) to strongly agree

(5). The internal consistency of the instrument was assessed using Cronbach's alpha, Composite Reliability (CR), and Average Variance Extracted (AVE).

The participants included three expert validators (three materials experts and three media experts) for validity assessment, three second-grade teachers for practicality evaluation, and 26 second-grade students for effectiveness testing; the inclusion of multiple teachers aimed to enhance the reliability and objectivity of the practicality evaluation. Data were collected through expert validation questionnaires, teacher and student response questionnaires, and a number concept understanding test administered using a one-group pretest-posttest design. To calculate the percentage of the validity results using the formula:

$$V = \frac{TS}{S_{max}} \times 100\% \quad (1)$$

V = Validation

TS = Total score obtained

S_{max} = Maximum score

The level of validity of CS Unplugged-based mathematics teaching materials, as indicated by the validity scores, is shown in Table 2 (Saragi & Hasanah, 2025).

Table 2. Validity Percentage Criteria

Interval (%)	Category
0 % - 25%	Highly Invalid
25 % - 50%	Invalid
50% - 75%	Valid
75% - 100%	Highly Valid

The Practicality Test was carried out to teachers and students by providing a response questionnaire that had been provided. The calculation of the percentage of practicality is carried out using the formula:

$$P = \frac{TS}{S_{max}} \times 100\% \quad (2)$$

P = Practical

TS = Total score obtained

S_{max} = Maximum score

The level of practicality of CS Unplugged-based mathematics teaching materials, as reflected in the practicality scores, is shown in Table 3 (Saragi & Hasanah, 2025).

Table 3. Practicality Percentage Criteria

Interval (%)	Category
0 % - 25%	Very Impractical
25 % - 50%	Impractical
50% - 75%	Practical
75% - 100%	Very Practical

Statistical analysis was conducted using IBM SPSS to ensure the robustness of the findings, including normality and homogeneity tests to examine data distribution and variance consistency. Students' learning improvement was calculated using the normalized gain (N-gain) based on Hake's (1999) criteria. In addition, a Wilcoxon signed-rank test was applied to determine whether the difference between pretest and posttest scores was statistically significant, and effect size analysis was conducted to estimate the magnitude of the learning impact.

$$N - Gain = \frac{\text{Score posttest} - \text{Score Pretest}}{\text{Score ideal} - \text{Score Pretest}} \times 100\% \quad (3)$$

The value and interpretation of the N-Gain score can be seen in Table 4:

Interval (%)	Category
$(g \geq 0.70)$	High
$(0.30 \leq g < 0.70)$	Moderate
$(g < 0.30)$	Low

RESULTS

Analysis

The analysis phase aimed to identify the needs and problems in mathematics learning on number concepts for second-grade students. This stage involved the analysis of learning outcomes, student characteristics, textbooks, existing student worksheets (LKM), and relevant literature, as well as classroom observations. The findings revealed that existing teaching materials were still limited in facilitating students' conceptual understanding. Learning activities tended to be procedural and lacked meaningful, concrete experiences. Additionally, students at the concrete operational stage require activity-based learning supported by manipulatives and real-life contexts. These findings highlight the need for innovative instructional materials that integrate active learning approaches, such as CS Unplugged.

Design

Based on the analysis results, the design phase focused on formulating learning objectives and structuring the teaching materials. Learning outcome indicators for number concepts were developed in alignment with the Independent Curriculum. The structure of the CS Unplugged-based LKM was systematically designed, including content organization, activity sequences, and visual layout. The design emphasized progressive learning, moving from concrete to abstract representations, and incorporated CS Unplugged principles such as problem-solving, collaboration, and hands-on activities. The layout and visual elements were designed using Canva to ensure clarity, attractiveness, and readability for elementary students.

Development

During the development phase, the teaching materials were designed by systematically integrating the principles of Computer Science Unplugged (CS Unplugged) to address the identified instructional challenges. CS Unplugged emphasizes learning without computers, learning by doing, enjoyable learning experiences, the use of simple everyday materials, and accessible learning opportunities that support both collaborative and independent learning (Jun, 2019). Guided by these principles, the materials were organized into activity-based tasks focusing on key number concepts, including number symbols, place value, comparing and ordering numbers, composing and decomposing numbers, and basic arithmetic operations. Each activity was designed to support students' conceptual understanding through concrete, interactive, and developmentally appropriate learning experiences.



Figure 2. Reading and writing number symbols

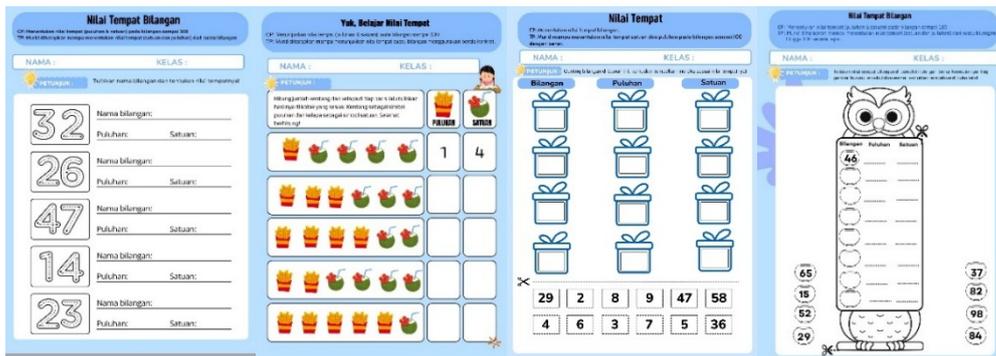


Figure 3. Place value

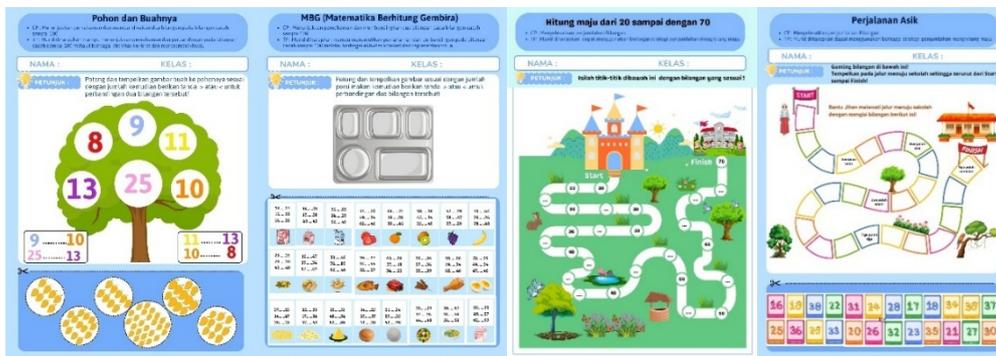


Figure 4. Comparing and Arranging Numbers

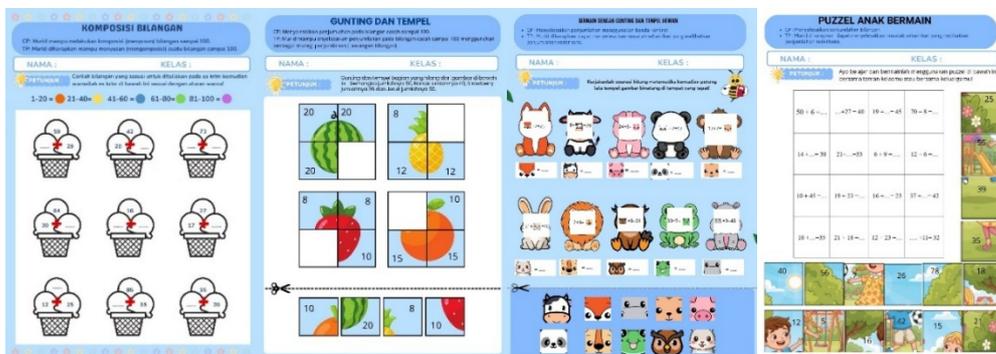


Figure 5. Composing and Decomposing numbers

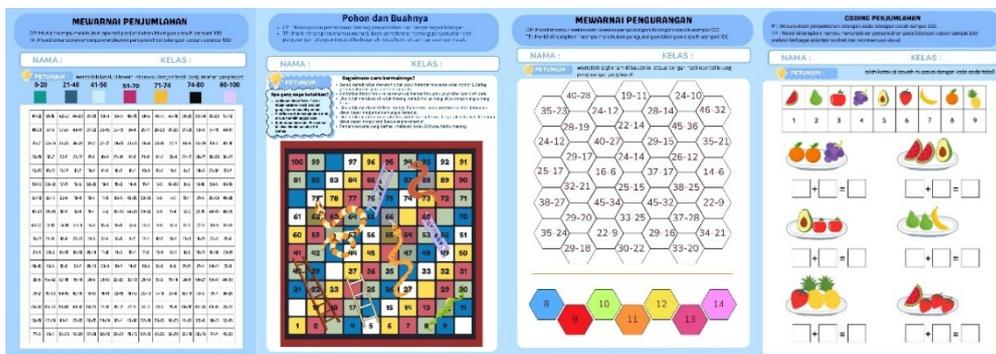


Figure 6. Addition and Subtraction of Numbers

Implementation

The developed CS Unplugged-based LKM was implemented in a second-grade elementary classroom involving 26 students. The implementation process involved guided learning activities using the developed worksheets, where students actively engaged in manipulative, game-based,

and collaborative tasks. During implementation, students demonstrated high engagement and participation. The activities encouraged interaction, problem-solving, and active exploration of number concepts. Teachers also reported that the materials were easy to use and supported effective classroom management.

Evaluation

The evaluation phase aimed to determine the feasibility of the developed teaching materials by examining three key aspects: validity, practicality, and effectiveness. Instrument validity and reliability were first evaluated to ensure that the measurement tools accurately and consistently assessed the quality of the developed materials.

Instrument Validity and Reliability

Before evaluating the feasibility of the developed teaching materials, the validity and reliability of the research instruments were examined to ensure measurement accuracy. Construct validity was assessed through factor loadings, while internal consistency reliability was evaluated using Cronbach's alpha (α), Composite Reliability (CR), and Average Variance Extracted (AVE). The results indicate that all constructs met the recommended thresholds for convergent validity and reliability (Hair et al., 2019). Factor loadings ranged from 0.70 to 0.87, exceeding the minimum threshold of 0.70. Cronbach's alpha values ranged from 0.83 to 0.91, indicating high internal consistency. Composite Reliability values were above 0.88, and all AVE values exceeded 0.50, confirming adequate convergent validity. These results demonstrate that the instruments used in this study possess satisfactory psychometric properties and are suitable for evaluating the validity, practicality, and effectiveness of the developed teaching materials.

Table 5. Measurement Model Evaluation of Research Instruments

Construct	Items	Factor Loading	Cronbach's α	CR	AVE
Visual Design Quality	M1-M5	0.71-0.85	0.89	0.91	0.67
Instructional Attractiveness	M6-M9	0.70-0.83	0.87	0.90	0.65
Learner Appropriateness	M10-M14	0.72-0.86	0.90	0.92	0.69
Usability	M15-M17	0.71-0.84	0.85	0.89	0.63
Language Clarity	C1-C2	0.74-0.82	0.83	0.88	0.66
Curriculum Alignment	C3-C4	0.72-0.84	0.84	0.88	0.65
Content Accuracy	C5-C8	0.73-0.86	0.88	0.91	0.67
Content Currency	C9-C12	0.71-0.85	0.87	0.90	0.66
Learner Appropriateness	C13-C17	0.72-0.87	0.91	0.93	0.70
Perceived Ease of Use (Teacher)	T1-T3	0.72-0.84	0.86	0.90	0.66
Instructional Efficiency	T4-T6	0.73-0.85	0.87	0.90	0.67
Instructional Attractiveness	T7-T8	0.74-0.86	0.85	0.89	0.68
Perceived Usefulness	T9-T10	0.75-0.87	0.86	0.90	0.69
Learning Motivation (Student)	S1-S2	0.74-0.85	0.84	0.88	0.67
Instructional Attractiveness	S3-S4	0.73-0.86	0.85	0.89	0.68
Perceived Ease of Use	S5-S7	0.72-0.84	0.87	0.90	0.66
Perceived Usefulness	S8-S10	0.74-0.86	0.88	0.91	0.68

Validity Evaluation

The validation results from media experts (Figure 7) indicate that the CS Unplugged-based worksheets achieved a very high level of validity, with an average feasibility score of 92.67%, categorized as *very valid*. The evaluation covered aspects such as visual design, readability, attractiveness, usability, flexibility, and suitability for students' characteristics. The materials received consistently high scores, particularly in the clarity of writing, quality of images, color composition, and layout consistency. These aspects contributed to the overall visual attractiveness and readability of the materials for elementary school students. Minor improvements were

suggested regarding the durability and reusability of the media; however, these aspects remained within acceptable feasibility standards. Overall, the results confirm that the developed teaching materials meet the criteria of high-quality instructional media and are suitable for classroom implementation.

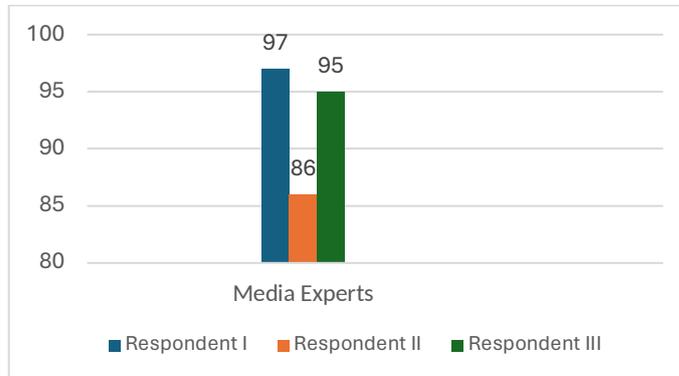


Figure 7. Results of the Teaching Materials Validity Assessment by Media Experts

The validation results from three material experts (Figure 8) also demonstrate a high level of validity, with an average score of 91.67%, categorized as *very valid*. The evaluation included indicators related to language clarity, curriculum alignment, conceptual accuracy, content relevance, and instructional structure. The results indicate that the developed materials demonstrate strong conceptual coherence and alignment with curriculum objectives. In particular, the integration of CS Unplugged activities effectively supports concrete, meaningful, and problem-based learning experiences. Although several minor revisions were recommended to further refine the instructional explanations, these suggestions did not significantly affect the overall feasibility of the materials.

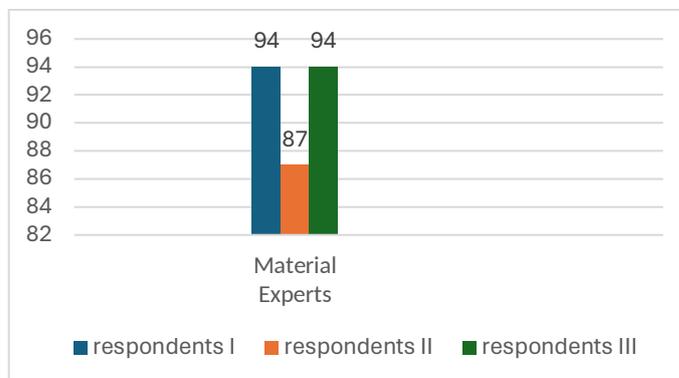


Figure 8. Results of the Teaching Materials Validity Assessment by Material Experts

Thus, the developed worksheets are considered highly appropriate for supporting elementary mathematics learning on number concepts.

Practicality Evaluation

Student responses (Figure 9) toward the developed worksheets yielded a practicality score of 91.38%, categorized as *very practical*. The evaluation involved ten indicators related to student engagement, visual attractiveness, clarity of instructions, readability, task clarity, and perceived usefulness. The predominance of high ratings (scores 4 and 5) indicates that students perceived the worksheets as engaging, easy to understand, and supportive of active participation during learning. The activity-based structure and the use of visual elements contributed to increased learning motivation and improved comprehension of number concepts.

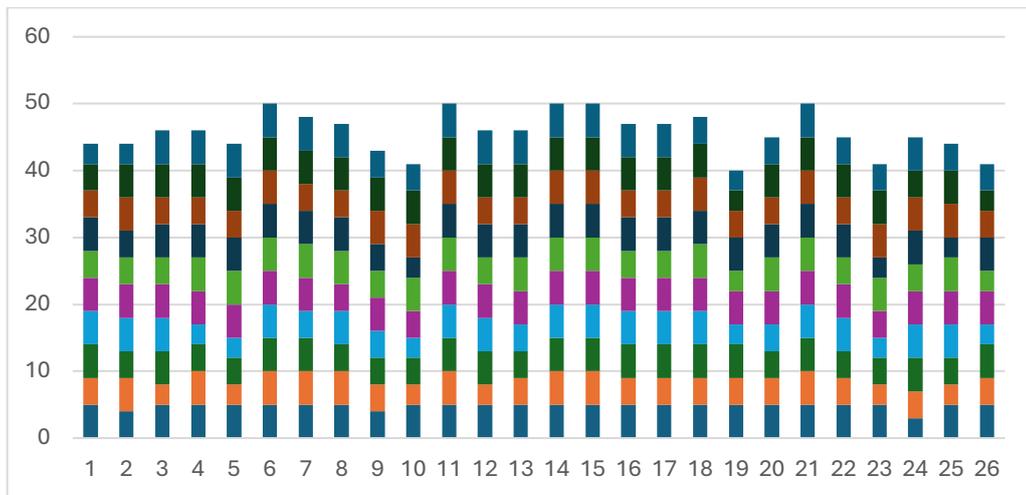


Figure 9. Practicality Evaluation Results of the Teaching Materials by Students

Teacher responses (Figure 10) also indicated a high level of practicality, with an average score of 90, categorized as *very practical*. The evaluation involved aspects of ease of use, instructional efficiency, and suitability for students' characteristics. The three participating teachers assigned scores of 90, 86, and 94, indicating that the worksheets were easy to implement and supported effective classroom instruction. Teachers reported that the activities facilitated student interaction and improved classroom engagement while maintaining manageable instructional time.

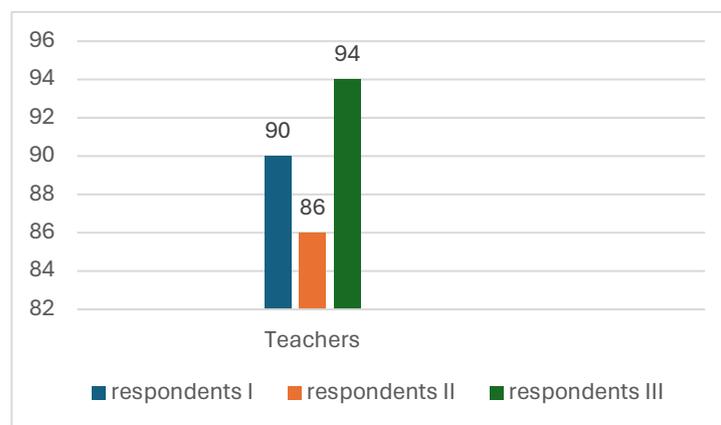


Figure 10. Practicality Evaluation Results of the Teaching Materials by Teachers

Overall, these findings confirm that the developed CS Unplugged-based worksheets demonstrate high practicality for elementary mathematics instruction.

Effectiveness Evaluation

The effectiveness of the developed worksheets was evaluated using a pretest-posttest design involving 26 students. Descriptive statistical analysis revealed a substantial improvement in students' learning outcomes. The mean pretest score was 67, which increased to 90.38 in the posttest, indicating a gain of 23.46 points.

N-Gain Analysis

To measure the magnitude of learning improvement, an N-gain analysis was conducted based on Hake's (1999) criteria. The results showed an average N-gain score of 0.7284 (72.84%), categorized as high. The distribution of students' N-gain scores is presented in Table 6.

Table 6. Distribution of Students' N-Gain Scores

No	Pretest	Posttest	N-gain	Category
1	73	93	0,74	High
2	77	97	0,87	High
3	67	97	0,91	High
4	80	97	0,85	High
5	73	97	0,89	High
6	73	93	0,74	High
7	67	93	0,79	High
8	63	80	0,46	Moderate
9	57	87	0,70	Moderate
10	67	87	0,61	Moderate
11	67	93	0,79	High
12	77	93	0,70	Moderate
13	67	93	0,79	High
14	63	90	0,73	High
15	77	93	0,70	Moderate
16	47	77	0,57	Moderate
17	80	100	1,00	High
18	77	97	0,87	High
19	63	90	0,73	High
20	67	83	0,48	Moderate
21	50	77	0,54	Moderate
22	57	87	0,70	High
23	63	93	0,81	High
24	73	93	0,74	High
25	63	87	0,65	Moderate
26	57	83	0,60	Moderate

Of the 26 students, 20 students (76.92%) achieved high improvement, while 6 students (23.08%) achieved moderate improvement, and no students fell into the low improvement category. These findings indicate that the intervention produced substantial learning gains across students with varying initial ability levels. The overall N-gain calculation results are illustrated in Figure 11.

	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Score	26	,46	1,00	,7284	,13249
Ngain_Persen	26	45,95	100,00	72,8446	13,24924
Valid N (listwise)	26				

Figure 11. N-gain Calculation Results

Normality Test

Before to inferential analysis, a Shapiro-Wilk normality test (Figure 12) was conducted. The results indicated that the pretest scores were normally distributed ($p = 0.161 > 0.05$), whereas the posttest scores were not normally distributed ($p = 0.021 < 0.05$). Consequently, a nonparametric statistical test was employed for further analysis.

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	,132	26	,200 [*]	,943	26	,161
Posttest	,238	26	<,001	,906	26	,021

*. This is a lower bound of the true significance.
 a. Lilliefors Significance Correction

Figure 12. Shapiro-Wilk normality test Results

Wilcoxon Signed-Rank Test

The Wilcoxon Signed-Rank Test (Figure 13) revealed a statistically significant difference between pretest and posttest scores ($p < 0.001$), indicating that the instructional intervention significantly improved students' mathematics learning outcomes.

Test Statistics ^a	
	Posttest - Pretest
Z	-4.475 ^b
Asymp. Sig. (2-tailed)	<.001

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

Figure 13. Results of the Wilcoxon Signed-Rank Test

To estimate the magnitude of the intervention effect, the effect size (r) was calculated using the formula $r = Z/Nr$. With a Z value of -4.475 and a sample size of 26 students, the effect size was $r = 0.88$, which is categorized as a very large effect according to Cohen's (2013) criteria. This result indicates that the CS Unplugged-based instructional materials produced not only statistically significant improvements but also a strong educational impact on students' conceptual understanding of number concepts.

DISCUSSION

The findings of this study indicate that the CS Unplugged-based student worksheets (LKM) are valid, practical, and effective in improving second-grade students' conceptual understanding of number concepts. These results address the research objective of developing instructional materials that support meaningful mathematics learning at the elementary level. The positive evaluations from experts, teachers, and students demonstrate that the materials meet essential instructional quality standards and are feasible for classroom implementation. The improvement in students' learning outcomes suggests that integrating CS Unplugged activities helps students connect abstract mathematical ideas with concrete learning experiences through manipulatives, collaborative activities, and problem-solving tasks. Such activity-based learning environments encourage students to actively explore and construct their understanding of number concepts, which explains the improvement in their conceptual learning.

These findings are consistent with previous studies emphasizing the role of activity-based learning and well-designed instructional materials in enhancing students' conceptual understanding in mathematics (Kul et al., 2018; Lefevre et al., 2009; Zhou et al., 2022). In addition, integrating computational thinking activities has been widely recognized as an effective strategy for developing logical reasoning and structured problem-solving skills (Chen et al., 2023; Wing, 2006). Therefore, this study contributes to mathematics education by demonstrating that CS Unplugged activities can be systematically integrated into elementary mathematics instruction to strengthen early numeracy and conceptual understanding through constructivist learning principles. Practically, the developed worksheets provide teachers with an accessible instructional resource that enhances student engagement without requiring digital technology. However, this study was limited by the relatively small sample size and the use of a one-group pretest-posttest design. Future research should involve larger and more diverse samples, employ experimental or quasi-experimental designs, and examine the long-term impact of CS Unplugged-based learning across different mathematical topics and grade levels.

CONCLUSION

This study developed and systematically evaluated CS Unplugged-based student worksheets aimed at enhancing second-grade students' understanding of number concepts, demonstrating high levels of validity and practicality based on expert evaluation and user responses, along with a positive improvement trend in learning outcomes reflected in medium to high N-gain scores,

indicating their potential effectiveness in supporting conceptual understanding. This study contributes by extending the application of CS Unplugged beyond computational thinking into structured early mathematics learning through the integration of activity-based, manipulative, and collaborative experiences within an ADDIE framework aligned with students' concrete operational stage. However, the findings should be interpreted cautiously due to the one-group pretest-posttest design, which limits causal inference; therefore, further research using more rigorous designs, broader samples, and extended variables such as computational thinking and affective aspects is recommended to strengthen the generalizability and explanatory power of these results.

ACKNOWLEDGMENT

The author would like to thank the lecturers at Universitas Negeri Surabaya (UNESA) for their invaluable guidance, direction, and input throughout the research process. He also thanks the principal, teachers, and all members of SDN Sumberrejo I for their permission, support, and cooperation, enabling the smooth implementation of this research.

AI ACKNOWLEDGMENT

The authors declare that generative AI or AI-assisted technologies were not used in any way to prepare, write, or complete this manuscript. The authors confirm that they are the sole authors of this article and take full responsibility for the content therein, as outlined in COPE recommendations.

INFORMED CONSENT

The authors have obtained informed consent from all participants.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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