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Enhancing Elementary Students' Computational Thinking through 'Code4Kids' Coding-Based Worksheets

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Abstract

This study investigates the early-stage development and feasibility of the *Code4Kids* worksheet, an unplugged coding-based instructional resource designed to enhance computational thinking (CT) and digital literacy among fourth-grade elementary students. An exploratory Research and Development (R&D) approach was employed, focusing on needs analysis, prototype development, and expert validation. Data were collected through classroom observations, teacher interviews, and structured expert evaluations to examine contextual readiness, instructional design alignment, and pedagogical suitability. The needs analysis revealed limited student digital literacy, insufficient structured CT materials, and low teacher confidence in implementing coding-related instruction. Based on these findings, a theory-informed worksheet prototype integrating decomposition, pattern recognition, abstraction, and algorithmic thinking was developed. Expert validation results (mean score = 4.6/5) and positive teacher feedback indicate that the prototype is developmentally appropriate, pedagogically coherent, and feasible for classroom implementation in low-resource settings. The study concludes that unplugged, worksheet-based coding materials can serve as an accessible entry point for integrating CT in elementary education. These findings provide an empirical foundation for future classroom trials and broader implementation of the *Code4Kids* model.

1. Introduction

Technology is one of the most significant advances in human civilization, and its impact is still being felt today [1]. Rapid advancements in digital technologies have reshaped how individuals interact with information, communicate, and solve problems in daily life. As a result, digital literacy and computational thinking (CT) have become essential competencies for students beginning in the earliest grades of schooling. Digital literacy encompasses not only the ability to operate digital tools but also the capacity to access, evaluate, interpret, and create information in digital formats [2, 3]. Likewise, CT represents a broader set of cognitive processes, including decomposition, pattern recognition, abstraction, and algorithmic thinking, that enable learners to approach problems systematically and logically. These competencies are increasingly viewed as foundational skills for twenty-first-century learning, as they support higher-order thinking, creativity, and adaptability in technology-rich environments.

Recent international frameworks, such as the OECD Learning Compass 2030 and UNESCO digital competency standards, emphasize that CT and digital literacy are no longer optional skills but core competencies required for future workforce participation and civic engagement. Empirical studies in high-impact international journals further indicate that early exposure to CT enhances students' cognitive flexibility, problem-solving transferability, and long-term academic performance in STEM-related domains. Therefore, integrating these competencies at the primary level is not merely a curricular innovation but a strategic educational necessity.

Globally, many countries have recognized the importance of integrating CT and coding into primary education. Nations such as India, South Korea, and Australia have introduced mandatory coding curricula at the elementary school level, emphasizing early exposure to structured problem-solving tasks and technology-based reasoning [4]. Research in these countries demonstrates that introducing coding at a young age supports long-term development of logical reasoning, metacognitive skills, and digital creativity. Although prior international studies have demonstrated the effectiveness of both digital and unplugged coding interventions, most have been conducted in technologically advanced contexts with strong institutional support. Limited research has examined how to systematically design computational-thinking instruction for low-resource educational environments. Moreover, few studies integrate cognitive-development theory explicitly into the design of unplugged instructional materials for primary learners. Furthermore, studies show that unplugged coding activities that teach computing principles without computers can be equally effective as digital coding, particularly for younger learners who benefit from physical, visual, and hands-on experiences.

In Indonesia, however, the integration of CT into elementary education remains limited and inconsistent. Although recent policy directions highlight the importance of digital literacy, many schools lack adequate infrastructure, teacher readiness, or structured learning materials that align with the characteristics of primary-aged learners. Students in the concrete operational stage (typically ages 9–10) require contextual, visually rich, and step-by-step materials to grasp abstract concepts [5]. Unfortunately, existing learning resources are often fragmented, overly theoretical, or not tailored to students' developmental needs. Moreover, many coding programs rely on computer-based platforms, which are difficult to implement in schools with limited technological facilities [6]. These challenges create a significant gap between national expectations for digital literacy and the actual realities faced in classrooms. Despite increasing policy attention, empirical research that translates these policy aspirations into structured, classroom-ready instructional tools remains scarce. There is a lack of validated, context-sensitive worksheets that align computational-thinking principles with the developmental characteristics of Indonesian elementary students.

Empirical studies in Indonesia have also highlighted ongoing challenges in integrating digital literacy into elementary classrooms. Students often struggle to understand technology-related instructions, while teachers report limited confidence in introducing coding or computational tasks due to a lack of appropriate training and materials [7]. Previous research consistently indicates that effective instruction in computational thinking requires well-designed, age-appropriate learning tools that provide structured guidance, meaningful contexts, and clear scaffolding [4]. Unplugged coding has been identified as a promising approach in low-resource settings, yet few studies have developed or validated contextual worksheets tailored specifically for Indonesian elementary schools.

The absence of structured, developmentally appropriate, and contextually relevant worksheets represents a clear research gap. Most existing studies focus on technology-based interventions, while little attention has been given to designing unplugged learning resources that do not depend on digital devices. Furthermore, local research on CT rarely targets fourth-grade students, despite this age being optimal for introducing foundational CT skills according to cognitive-development theory [8]. As such, there is a critical need for accessible, teacher-friendly materials that support both digital literacy and CT in environments with limited technological infrastructure.

This study seeks to address this gap by developing the "*Code4Kids*" worksheet, a coding-based instructional tool designed specifically for fourth-grade elementary students. The development process integrates findings from needs analysis, cognitive development theory, and computational thinking frameworks to produce structured, engaging, and developmentally aligned learning activities. The study also includes expert validation to ensure the accuracy of content, linguistic clarity, and pedagogical suitability. By focusing on unplugged coding activities, the worksheet provides an equitable solution for schools with limited access to digital technologies [9-12].

In response to these identified gaps, this study proposes a structured, developmentally grounded instructional solution to bridge theory, policy expectations, and classroom realities. Accordingly, the primary objective of this study is to develop and preliminarily validate the *Code4Kids* unplugged coding worksheet for fourth-grade elementary students in Indonesia. Specifically, this research aims to analyze the digital literacy and computational-thinking readiness of students and teachers, design and develop a theory-informed instructional prototype, and evaluate its content validity and pedagogical suitability through expert review. By addressing these objectives, the study seeks to provide an empirically grounded instructional model that supports the equitable integration of computational thinking in primary education contexts with limited technological infrastructure.

2. Materials and Methods

This study specifically employed the preliminary three phases of the Borg and Gall development cycle: 1. needs assessment, 2. initial product development, and 3. expert validation. No experimental classroom intervention or effectiveness testing was conducted at this stage, as the objective was limited to prototype feasibility and developmental refinement. The study design therefore aligns with early-stage educational design research (EDR), emphasizing iterative development rather than hypothesis testing.

The research was carried out in two public elementary schools located in Banda Aceh, Indonesia, both of which served as representative sites for understanding classroom readiness and contextual limitations in implementing CT and digital literacy instruction. The two schools were selected using purposive sampling based on three criteria: (1) availability of Grade 4 classes, (2) limited access to digital infrastructure, and (3) willingness of school administrators to participate in research activities. The study was conducted from April to September 2025.

Participants in this study were fourth-grade teachers directly responsible for instructional delivery in their classrooms, thereby enabling the collection of grounded insights into teaching needs and existing pedagogical challenges [13]. Specifically, two Grade 4 homeroom teachers participated as primary informants in the needs analysis stage. In addition, classroom observations involved approximately 128 fourth-grade students across the two schools. Students were not treated as experimental subjects; rather, they were observed to document authentic instructional practices and classroom dynamics. In addition, expert validators, including specialists in educational technology and scholars in elementary education, were involved to ensure that the developed materials met professional standards for content, pedagogy, and cognitive appropriateness for young learners. Three expert validators were involved: one CT specialist, one expert in elementary pedagogy, and one educational technology practitioner. Each expert independently reviewed the worksheet prototype using a structured validation instrument. The overall research process was conducted from April to September 2025, allowing for systematic data collection across different phases of the academic calendar and ensuring that the findings accurately reflected authentic school conditions.

The primary instructional material produced in this study was the *Code4Kids* worksheet, a structured coding-based learning resource designed specifically for fourth-grade students who are at a developmental stage suitable for the introduction of foundational CT concepts. Several research instruments were developed to support the Research and Development process, including an observation checklist to document existing teaching materials, classroom practices, and available infrastructure; a semi structured interview guide aimed at eliciting detailed information from teachers regarding their instructional challenges, existing digital literacy practices, and expectations for learning tools; and expert validation sheets that examined multiple aspects of the worksheet such as accuracy of content, clarity of language, suitability for the cognitive development of nine to ten year old learners, and the alignment of instructional design with pedagogical best practices [14, 15].

The observation checklist consisted of 18 indicators grouped into four domains: instructional practices, student engagement, availability of learning materials, and technological infrastructure. Each classroom observation lasted approximately 90 minutes and was documented using structured field notes. The semi-structured interview guide contained 12 open-ended questions organized into three themes: teacher understanding of digital literacy and CT, instructional challenges in implementing coding-related tasks, and expectations for worksheet-based learning tools. Each interview lasted between 30 and 45 minutes and was audio-recorded with participants' consent, then transcribed verbatim. The expert validation sheet included 20 evaluative items rated on a five-point Likert scale (1 = very inappropriate to 5 = very appropriate). The instrument assessed four dimensions: conceptual accuracy, clarity of instructions, alignment with computational-thinking components, and developmental suitability. All instruments underwent internal review to ensure coherence, relevance, and alignment with the theoretical foundations of child development and CT education [16, 17].

The Research and Development process followed the preliminary steps of the Borg and Gall model, which include needs analysis, initial product design, and expert evaluation [18]. The research procedure was implemented in six sequential stages: (1) obtaining institutional permission from school authorities, (2) conducting classroom observations, (3) carrying out teacher interviews, (4) analyzing qualitative data to define design specifications, (5) developing the initial worksheet prototype, and (6) conducting expert validation followed by systematic revision. In the needs analysis stage, classroom observations were conducted to examine the realities of current instructional practices, particularly the extent to which digital literacy and CT were incorporated into daily lessons [19]. Teacher interviews were then conducted to gather more nuanced perspectives on difficulties in implementing coding-related tasks, limitations in available learning tools, and expectations for resources to facilitate more effective instruction [20]. The data generated during this phase served as a critical foundation for designing the initial prototype, ensuring that the characteristics and structure of the *Code4Kids* worksheet responded directly to the gaps and instructional needs identified in the field.

During the prototype development phase, the worksheet was designed to include a series of unplugged coding activities that emphasize key CT components, such as decomposition, pattern recognition, abstraction, and algorithmic reasoning. These activities were intentionally adapted to suit fourth-grade students' cognitive level, incorporating relatable contexts, visual cues, and step-by-step tasks to support comprehension and engagement. Following the initial design, the prototype underwent expert evaluation carried out by professionals in elementary education and educational technology [20]. These experts reviewed the worksheet for conceptual accuracy, developmental suitability, and overall pedagogical coherence. Quantitative validation scores were calculated by averaging ratings across all items and experts. Qualitative feedback provided in open-ended sections was coded and categorized to identify recurring suggestions for revision. Their feedback, which encompassed both strengths and areas requiring improvement, was analyzed qualitatively and used to refine the structure, instructions, and content of the worksheet to enhance its usability and instructional value.

Qualitative data obtained from observations, teacher interviews, and expert review comments were analyzed using thematic analysis to identify recurring themes related to content suitability, pedagogical feasibility, clarity of instructional flow, and the extent to which the worksheet supported CT development [21]. The thematic analysis followed four steps: data familiarization, initial coding, theme generation, and theme refinement. Coding was conducted manually by the research team, and discrepancies were resolved through peer discussion to enhance analytical rigor. This analytical process allowed the researchers to interpret how well the prototype aligned with classroom realities and learner characteristics. It provided a basis for making systematic revisions to improve the overall quality of the *Code4Kids* worksheet. The themes that emerged from the analysis, such as the need for clearer scaffolding, more contextualized examples, and more explicit alignment with targeted CT skills, guided the final refinement of the prototype [22]. The results of this process provided early evidence regarding the feasibility, relevance, and potential effectiveness of the *Code4Kids* worksheet for supporting digital literacy and CT instruction in Indonesian elementary schools.

3. Results and Discussion

This study produced an early-stage prototype of the *Code4Kids* worksheet. It generated a comprehensive set of data derived from the stages of needs analysis, expert validation, and initial dissemination within partner schools. The findings provide an overview of the readiness of learning environments, the suitability of the developed prototype, and the potential for further refinement before classroom implementation [23]. This section explicitly addresses Research Question 1 regarding the readiness of students, teachers, and school environments to integrate CT and digital literacy. The main discoveries are presented systematically and supported by observational and interview data.

3.1. Need Analysis

The needs analysis phase revealed several important issues that directly shaped the development of the *Code4Kids* worksheet. Both participating schools demonstrated relatively low levels of digital literacy among students, particularly in their ability to operate basic digital tools, interpret visual prompts, and understand instructions for technology-based activities. Classroom observations across multiple sessions showed that many students required repeated explanations when engaging with tasks involving simple sequencing, directional instructions, or identifying digital symbols. These findings answer Research Question 1 by demonstrating that students' readiness for CT integration remains at a foundational level, particularly in structured reasoning and sequential thinking. The observed difficulties indicate that learners lack sufficient cognitive scaffolding necessary for higher-order CT processes such

Figure 1. Classroom observation sessions during the needs analysis phase.

as abstraction and algorithmic reasoning. These classroom patterns indicate that existing learning experiences do not yet provide sufficient exposure to foundational digital skills that support the development of CT [24].

Interviews with teachers further reinforced these findings. Teachers reported limited preparation and confidence in teaching coding-related content because they rarely received professional development opportunities in digital literacy or CT. Many teachers reported relying primarily on general textbooks or teacher-made materials that lacked systematic guidance for introducing concepts such as stepwise problem-solving or simple algorithmic reasoning. Teachers also reported challenges related to time allocation, limited access to digital devices, and the lack of structured resources aligned with the cognitive development of fourth-grade students. These results support prior research emphasizing teacher readiness as a critical factor in CT integration. However, an important and somewhat conflicting finding emerged: teachers indicated that their primary concern was not the lack of digital infrastructure, but rather the absence of ready-to-use, structured instructional materials. This finding contrasts with the dominant literature, which frames hardware limitations as the primary barrier to CT implementation. These conditions illustrate a clear gap between curriculum expectations and the instructional supports currently available in the school environment [25].

The combined results from observations and interviews confirm the urgent need for instructional materials that do not depend on digital devices yet still support the development of CT. This study's findings, therefore, shift the focus from technological availability to pedagogical scaffolding as the central determinant of CT readiness in low-resource contexts. The findings highlight the importance of learning resources that are accessible, easy for teachers to implement, and appropriate for learners aged nine to ten years. Based on these insights, the study identified unplugged coding activities as a promising approach that can address the constraints faced by schools while still enabling students to build foundational skills such as sequencing, pattern recognition, and logical reasoning [20]. This interpretation aligns with earlier studies demonstrating that unplugged approaches can effectively foster CT skills in low-resource settings; however, the present study extends this literature by providing empirical classroom-based evidence from Indonesian primary schools. This conclusion provided a strong evidence base for the design priorities used in developing the *Code4Kids* worksheet.

The images in Figure 1 were captured directly during the research process and document authentic classroom conditions in the partner schools. Taken by the research team as original visual documentation of the observational stage, the figure illustrates that students' learning challenges were not merely technical but also cognitive, reflecting limited exposure to structured problem-solving tasks. This finding supports previous research indicating that early CT development requires explicit scaffolding and guided reasoning rather than unguided exploration [26, 27]. Unlike studies that assume digital tools are prerequisites for CT learning, the present findings suggest that conceptual difficulties may emerge even before technology is introduced, thereby highlighting the importance of cognitive preparation before digital integration.

Teacher interviews further reinforced these patterns. Most teachers reported limited confidence in teaching coding-related or CT-based content, mainly because they had not received sufficient professional development in these areas. Teachers explained that they relied primarily on general textbooks or self-developed materials that lacked systematic instruction in decomposition, sequencing, or logical reasoning. This resulted in fragmented instructional practices that were not aligned with the goals of CT integration.

Figure 2. Teacher interview and discussion sessions.

Table 1. Summary of needs analysis findings.

No.	Aspect	Findings	Interpretation for Worksheet Design
1	Student digital literacy	Students had difficulty following step-by-step instructions, interpreting symbols, and completing sequencing tasks.	Learning tasks must be simplified and supported with clear visual guidance.
2	Problem-solving ability	Students struggled with logical ordering and identifying patterns.	Activities should focus on basic CT components.
3	Teacher readiness	Teachers reported low confidence in teaching coding and CT-related content.	Materials must be teacher-friendly and easy to use independently.
4	Teaching resources	No structured worksheets or CT-specific materials were available.	A structured worksheet is urgently needed.
5	School infrastructure	Limited access to digital devices and computer facilities.	An unplugged approach is more feasible.
6	Curriculum alignment	CT concepts were not explicitly integrated into daily lessons.	The worksheet must explicitly integrate CT components.

The visual documentation in Figure 2 was produced by the research team during field data collection and serves as empirical evidence of the interview and consultation process. Interestingly, an unexpected finding emerged from the interviews. Teachers emphasized that their main concern was not the absence of digital devices, but rather the lack of ready-to-use instructional materials that could guide both teachers and students step by step. This unexpected finding contradicts several prior studies that prioritize technological infrastructure as the primary barrier to CT implementation. The present study instead identifies instructional design as a more critical limiting factor in this specific educational context. The main issues identified during the needs analysis include students' low digital literacy, teachers' limited readiness, and the absence of computational thinking–oriented learning resources.

As shown in Table 1, these interconnected challenges collectively justify the need for a new instructional solution. While these findings are consistent with previous studies in Indonesian primary schools, the present research contributes new empirical evidence by systematically linking readiness data to concrete instructional design decisions. These tables align with previous findings in Indonesian primary schools, which reported similar challenges related to infrastructure limitations, teacher preparedness, and the lack of age-appropriate digital learning materials [28].

Based on these findings, the study concludes that there is an urgent need for instructional materials that are accessible, scaffolded, and developmentally appropriate for learners aged nine to ten years. Unplugged coding activities were identified as a promising approach because they allow students to engage in CT processes without relying on digital devices. The importance of this finding lies in its potential to reframe CT integration strategies in low-resource settings, suggesting that structured worksheet-based approaches can serve as an equitable entry point before digital expansion. This conclusion is consistent with earlier studies demonstrating that unplugged approaches can effectively foster CT skills in low-resource settings [29–31].

Overall, the needs analysis provides strong empirical justification for the Code4Kids worksheet's design priorities. However, this phase is limited by its focus on two schools and reliance on observational and interview data without standardized digital literacy testing instruments. Future research should include broader

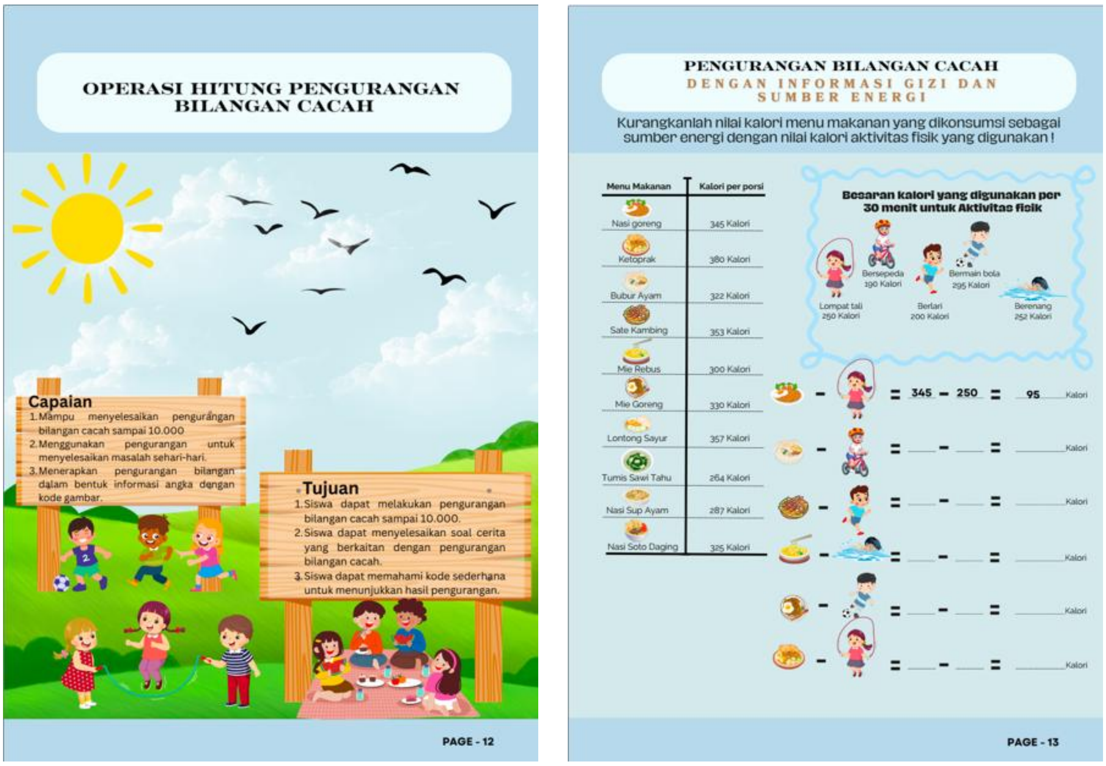

Figure 3. Sample pages of the Code4Kids worksheet prototype.

samples and quantitative readiness assessments to strengthen generalizability. By focusing on step-by-step reasoning, contextualized problem scenarios, and visually supported tasks, the worksheet directly responds to the gaps identified in the learning environment. These findings establish the study's novelty by demonstrating that classroom-based readiness analysis can systematically inform the development of an unplugged CT model tailored to Indonesian elementary education. This phase establishes a solid foundation for the prototype development stage, ensuring that the product is not only theoretically grounded but also empirically informed.

3.2. Prototype Development

This phase addressed Research Question 2, which focused on how the *Code4Kids* worksheet was developed based on the results of the needs analysis. The main outcome of this stage was a prototype of a structured, unplugged worksheet designed to introduce the core components of CT in a format accessible to fourth-grade students.

The prototype was developed by translating the main problems identified in the needs analysis into concrete design features. Students' difficulties in following instructions and understanding symbolic representations were addressed by simplifying task formats and using clear visual guidance. Similarly, teachers' need for practical and easy-to-use materials was reflected in the use of short instructions, consistent layouts, and examples that demonstrate the expected thinking process. Overall, the first draft of the *Code4Kids* worksheet was designed not only as a tool to introduce CT skills but also as an engaging learning resource that supports classroom instruction in environments where digital devices are limited [32–34].

Figure 3 presents sample pages of the Code4Kids worksheet prototype. Each worksheet unit was designed to guide students from simple recognition tasks to more complex reasoning activities. The prototype consists of four main learning units, each targeting a key CT component: decomposition, pattern recognition, abstraction, and algorithmic thinking. These components were selected because they are widely recognized as foundational elements of CT for young learners [35].

To support student understanding, the instructional flow was intentionally arranged in a gradual progression. Activities begin with highly concrete examples, such as matching, sorting, and identifying patterns, before moving toward tasks that require students to organize steps, predict outcomes, and construct simple procedures. This design reflects the cognitive characteristics of fourth-grade learners, who benefit from learning experiences that move from concrete to abstract thinking.

The alignment between CT components and worksheet activities is summarized in Table 2. Each computational

Table 2. Mapping of computational thinking components in the *Code4Kids* worksheet.

CT Component	Implementation in the Code4Kids Worksheet
Decomposition	Dividing daily calorie intake into smaller units (per meal and per portion)
Algorithmic Thinking	Following a step-by-step procedure to calculate total daily calories
Pattern Recognition	Using the same calculation pattern for all characters
Abstraction	Selecting relevant numerical information and ignoring decorative elements

Table 3. Expert validation scores across evaluation aspects.

No	Aspect	CT Expert	Elementary Education Expert	Coding Expert	Mean	Category
1	Content relevance	5	4	5	4.6	Very feasible
2	Language clarity	4	5	4	4.5	Very feasible
3	Instructional Logic	5	5	4	4.7	Very feasible
			Overall Mean		4.6	Very feasible

thinking component was explicitly embedded into the worksheet tasks. Decomposition was implemented by guiding students to divide daily calorie intake into smaller units (morning, afternoon, and evening meals). Algorithmic thinking was reflected in the requirement to follow a clear, step-by-step procedure to calculate total daily calories. Pattern recognition was developed by encouraging students to apply the same calculation pattern across different characters. Abstraction was supported by prompting students to focus on relevant numerical information while ignoring decorative elements.

The worksheet was therefore designed to support step-by-step computational thinking processes. Students were guided to decompose daily calorie intake into manageable parts, follow a structured sequence of steps, recognize repeated patterns, and distinguish essential information from irrelevant details. This structured approach is consistent with previous studies emphasizing the importance of guided and well-organized CT instruction for young learners [28,30]. However, the present study differs from most existing research by embedding these principles into a worksheet-based format rather than digital platforms. This represents an important contribution, as many schools in low-resource contexts cannot rely on continuous access to computers or tablets.

An unexpected finding during the development process was that teachers viewed the prototype not only as a student learning tool but also as a form of instructional support. They reported that the clear sequencing of tasks and the presence of worked examples helped them understand how CT concepts could be taught step by step. This suggests that the worksheet functions both as a learning resource and as a form of professional guidance for teachers.

Overall, the prototype development stage demonstrates that CT concepts can be effectively translated into unplugged, worksheet-based activities without losing their conceptual depth. This finding challenges the common assumption that CT must be taught through digital programming environments. Instead, it highlights the role of instructional design in shaping meaningful CT learning experiences, especially in contexts with limited technological infrastructure.

3.3. Expert Validation

This phase addressed Research Question 3, which examined the feasibility of the *Code4Kids* worksheet for classroom use. The main outcome of this stage was a systematic evaluation of the prototype by three expert validators specializing in coding education, CT, and elementary content learning. Overall, the experts rated the worksheet as highly feasible, indicating that the design was conceptually sound, developmentally appropriate, and pedagogically relevant for fourth-grade learners. The quantitative results of the expert evaluation are summarized in Table 3.

The validation involved three experts from different domains, namely a CT specialist, an elementary education pedagogy expert, and a coding practitioner. This multidisciplinary evaluation ensured that the worksheet was assessed from theoretical, pedagogical, and technical perspectives. The worksheet obtained consistently high scores across all evaluated dimensions, including content relevance, clarity of language, instructional logic, and visual presentation. The overall mean score of 4.6 (out of 5) indicates that the prototype is categorized as "very feasible" for early-stage classroom implementation. This finding suggests that the worksheet already meets the minimum quality standards required for instructional materials in primary education.

Beyond numerical ratings, the experts' qualitative feedback provided deeper insights into the prototype's strengths and limitations. Experts agreed that the worksheet effectively captures the core components of CT, particularly through its step-by-step task structure

Figure 4. Expert validation and feedback session.

and contextualized problem scenarios. They emphasized that such explicit structuring is essential for young learners who are still developing basic reasoning and digital literacy skills.

Figure 4 provides empirical evidence of the iterative development process and illustrates how expert input directly informed the refinement of the worksheet. It highlights the dynamic interaction between theoretical principles of computational thinking and practical pedagogical considerations, thereby making the instructional design process transparent. This transparency represents a novel contribution, as many computational thinking studies tend to report only the final products without explicitly visualizing how expert feedback shapes the development process.

An important and somewhat unexpected finding was that the experts perceived the worksheet not only as a learning tool for students but also as a form of pedagogical support for teachers. They emphasized that clear task sequencing, worked examples, and a consistent layout could assist teachers with limited prior experience in teaching CT-related concepts. This dual function of the worksheet as both a student resource and a teacher support tool were not an initial design objective. Still, it emerged as a significant added value of the prototype.

Several constructive suggestions were also provided. Experts recommended simplifying certain instructions to accommodate students with lower reading proficiency, increasing the use of familiar and contextually relevant scenarios to enhance engagement, and refining the visual layout to make the pages more appealing and less text-heavy. They further suggested adding a brief teacher guide to clarify learning objectives, anticipated student responses, and possible classroom implementation strategies.

These findings are consistent with previous studies emphasizing that instructional materials for young learners should integrate conceptual clarity, visual simplicity, and contextual relevance [28]. However, this study extends existing work by demonstrating that these principles can be effectively embedded in an unplugged, worksheet-based format, an approach that remains relatively underexplored in CT research.

Overall, the expert validation stage confirms that the *Code4Kids* prototype is suitable for limited classroom trials. At the same time, it underscores the importance of iterative refinement in educational product development. Rather than treating validation as a final step, this study positions expert feedback as a central mechanism for enhancing instructional quality and strengthening the connection between theory and classroom practice in CT education.

3.4. Dissemination to School Partners

This phase focused on introducing the *Code4Kids* worksheet prototype to partner schools and examining teachers' initial responses to its design, usability, and classroom relevance. The dissemination was conducted through structured briefing sessions, guided walkthroughs of the worksheet, and open discussions with fourth-grade teachers and curriculum coordinators from SDN 1 Banda Aceh and SDN 13 Banda Aceh.

Figure 5 provides empirical evidence of the prototype's real-world feasibility and illustrates how the worksheet was introduced, interpreted, and discussed by its intended users. It strengthens the ecological validity of the research by demonstrating that the Code4Kids worksheet is not only theoretically grounded but also contextually acceptable and practically usable in authentic classroom settings. Such visual documentation of early-stage adoption is rarely emphasized in computational thinking studies, which often focus solely on post-intervention outcomes.

The main finding of this phase was that teachers responded positively to the worksheet's structure and clarity. They reported that the step-by-step organization of tasks helped reduce students' cognitive load and made abstract CT concepts easier to understand. Teachers also noted that the use of familiar everyday contexts helped

Figure 5. Dissemination and classroom introduction of the Code4Kids worksheet.

Table 4. Summary of research questions, findings, and interpretations.

Research Question	Key Findings	Interpretation
RQ1: What is the profile of digital literacy and CT readiness?	Students demonstrate low digital literacy; teachers lack computational thinking (CT) resources; technological infrastructure is limited.	There is a clear need for unplugged CT instructional materials.
RQ2: How was Code4Kids developed?	The prototype was guided by needs analysis, computational thinking theory, and expert validation.	The instructional prototype is pedagogically grounded and aligned with learner characteristics.
RQ3: What is the feasibility of Code4Kids?	Expert validation score = 4.6 (very feasible); teacher feedback was positive.	The model is ready for limited trials (TRL Level 2).

students relate the activities to their own experiences, thereby increasing engagement and motivation.

An important and unexpected finding was that teachers perceived the worksheet not only as a resource for student learning but also as a form of instructional support. Several teachers explained that the explicit sequencing of tasks, worked examples, and consistent formatting helped them understand how CT concepts could be gradually introduced in the classroom. This indicates that the worksheet functions simultaneously as a student-centered learning tool and as an implicit form of professional guidance, an added value that was not initially anticipated.

Another key finding relates to contextual feasibility. Given the limited access to digital devices in both schools, teachers emphasized that the worksheet's unplugged format made it more realistic to implement. This reinforces the argument that meaningful CT learning does not necessarily depend on digital platforms but can be supported through carefully designed printed materials.

These findings are consistent with previous research highlighting that teacher acceptance, perceived usefulness, and contextual compatibility are critical for the successful integration of CT in primary education [28]. However, this study extends existing work by showing that worksheet-based CT materials can simultaneously support student learning and build teachers' capacity. This aspect remains underreported in the CT literature.

Overall, the dissemination phase provides early evidence that the *Code4Kids* worksheet is pedagogically meaningful, contextually appropriate, and practical to implement. Rather than serving as a final evaluation, this phase represents a transitional step toward classroom trials. The feedback collected during dissemination informed minor revisions of the prototype and confirmed its readiness for limited implementation in real learning environments.

3.5. Interpretation of Results

The findings collectively answer the research questions shown in Table 4. The consolidated findings of this study provide a clear picture of the current readiness for integrating digital literacy and CT in the partner schools, as well as the feasibility of the *Code4Kids* worksheet as an instructional tool [36]. First, the results addressing Research Question 1 indicate that both students and teachers demonstrate limited readiness. Students showed low levels of digital literacy, particularly in understanding technology-related instructions, and teachers reported insufficient access to structured resources for teaching CT. These conditions highlight the need for unplugged, developmentally appropriate learning materials for use in low-resource school environments [37].

About Research Question 2, the development of the *Code4Kids* worksheet was guided by the needs identified during the preliminary study, supported by CT theory, and refined through expert validation. This process ensured that the worksheet aligns with the cognitive characteristics of fourth-grade learners and incorporates pedagogical elements necessary for building foundational CT skills, such as decomposition, pattern recognition, and algorithmic thinking [38]. The iterative development stages contributed to producing a prototype that is coherent, structured, and responsive to the learning challenges observed in the classroom.

Finally, findings related to Research Question 3 demonstrate strong feasibility for early implementation. Expert evaluation produced an average score of 4.6, indicating that the worksheet is categorized as "very feasible" for instructional use. This was further supported by positive teacher feedback during dissemination sessions, where educators expressed confidence in using the worksheet and noted its practicality, contextual relevance, and compatibility with existing teaching routines. Based on these results, the *Code4Kids* prototype meets the Technology Readiness Level (TRL) 2 criteria, indicating it is ready for limited classroom trials to further refine its effectiveness. Collectively, these findings reinforce the hypothesis that unplugged worksheets can provide an effective entry point for introducing CT in elementary schools with minimal technological infrastructure [38].

3.6. Limitations

This study has several limitations that should be considered when interpreting the findings. First, the research did not include direct measurements of student learning outcomes, as the main focus was on the early stages of product development and feasibility testing. The evaluation of students' learning impact is planned for the next phase of the project. Second, the data were collected from only two elementary schools, which limits the generalizability of the results to other educational contexts. Third, teachers' confidence in teaching coding and CT varied considerably, which may have influenced their perceptions of the worksheet's usability and relevance. Finally, this study did not use a quantitative comparison group, making it impossible to draw causal conclusions about the effectiveness of the Code4Kids worksheet relative to other instructional approaches.

4. Conclusions

This study explored the early-stage development and feasibility of the LKPD *Code4Kids* as an unplugged, coding-based instructional resource designed to strengthen CT and digital literacy among fourth-grade elementary students. In direct response to the research questions outlined in the introduction, the findings provide three central conclusions. First (RQ1), the needs analysis revealed that both students and teachers demonstrated limited readiness for systematic CT integration, characterized by low foundational digital literacy, insufficient structured instructional materials, and minimal exposure to step-by-step computational reasoning. Second (RQ2), the development process showed that a theory-informed and needs-based design approach could successfully translate core CT components into structured, worksheet-based learning activities aligned with the cognitive characteristics of fourth-grade learners. Third (RQ3), expert validation and teacher dissemination results confirmed the feasibility and pedagogical appropriateness of the *Code4Kids* prototype for classroom implementation.

The findings from the needs analysis, prototype development, and expert and teacher evaluations collectively demonstrate that the worksheet holds strong potential as a practical, pedagogically sound tool for introducing foundational CT concepts in low-resource classroom environments. Although this research did not yet measure learning outcomes through experimental testing, the evidence gathered indicates that *Code4Kids* effectively addresses existing gaps in instructional materials by offering structured, developmentally appropriate, and contextually relevant learning activities.

An important and somewhat unexpected finding of this study was that teachers identified instructional scaffolding rather than technological infrastructure as the primary barrier to CT implementation. This observation contrasts with the dominant literature that frequently emphasizes hardware limitations as the central constraint in digital education reform. The present findings, therefore, suggest a contextual discrepancy: in low-resource primary schools, pedagogical design may play a more decisive role than device availability in enabling early CT development.

The study further confirms the importance of providing accessible learning tools that align with students' cognitive characteristics and teachers' instructional needs. Teacher feedback highlighted that the worksheet's visual structure, step-by-step task progression, and contextual problem scenarios can support the development of early CT skills such as decomposition, pattern recognition, abstraction, and algorithmic thinking. The strong expert validation results also reinforce the feasibility of the worksheet for classroom implementation, suggesting that *Code4Kids* has met essential quality criteria for content accuracy, instruction clarity, and instructional flow.

In terms of novelty, this study contributes a transparent and empirically grounded model for integrating CT through an unplugged, worksheet-based format in Indonesian elementary education. While many previous studies focus primarily on digital platforms or programming environments, this research demonstrates that CT principles can be systematically operationalized in printed instructional materials without diminishing conceptual depth. The explicit linkage between needs analysis data and instructional design decisions further distinguishes this study from intervention-based research that does not document the developmental process in detail.

These conclusions underscore the broader implication that thoughtfully designed unplugged materials can serve as an equitable entry point for integrating CT in elementary schools, especially where technological infrastructure remains limited. The prototype's readiness level indicates that it is suitable for limited classroom trials, which will provide opportunities to evaluate its instructional effectiveness, usability, and long-term impact on student learning [39].

In practice, the findings imply that policymakers and school leaders should prioritize developing structured, developmentally aligned instructional resources alongside investments in digital infrastructure. Pedagogical capacity-building and instructional design innovation appear to be equally, if not more, critical for sustainable CT integration at the primary level.

Future research should include pilot testing with larger student groups, assessment of learning gains, refinement based on classroom implementation outcomes, and examination of scalability across diverse school contexts. Longitudinal studies are also recommended to examine the sustained impact of unplugged worksheet-based interventions on students' higher-order thinking skills. Additionally, comparative studies between unplugged and digital coding approaches may help clarify optimal strategies for different educational settings. Overall, this study contributes to the growing body of knowledge on digital literacy and CT integration in primary education by offering an empirically informed, teacher-friendly, and contextually grounded early intervention model through the *Code4Kids* worksheet. By reframing CT integration as a matter of instructional design rather than solely technological access, this research provides a meaningful and context-sensitive contribution to the discourse on equitable digital education reform.

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Data Availability Statement: Data supporting the results of this study are not publicly available due to ethical restrictions and the protection of participant confidentiality. However, anonymized datasets may be obtained from the corresponding author upon a reasonable request, subject to institutional approval.

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