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Development of a Culture-Based Coding E-Book from North Sumatera to Enhance Computational Thinking

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ABSTRACT

This study aimed to develop a North Sumatra culture-based coding activity e-book to enhance CT skills in early childhood education. The ADDIE development model consisting of the analysis, design, development, implementation, and evaluation phases, was employed and involved 160 children from nine kindergartens in Medan City. Expert validation indicated that the e-book was feasible for instructional use, with scores exceeding 80%, while the CT measurement instrument demonstrated high reliability with a Cronbach's Alpha of 0.744. Small- and large-scale trials consistently showed significant improvement in children's CT abilities, confirmed by the Wilcoxon test ($Z = -8.901$; $p < 0.05$). These results highlight that integrating local culture into coding activities supports CT development and simultaneously strengthens cultural values from an early age. The findings reinforce the importance of contextualized digital learning media that align with the goals of 21st-century education and foster cultural identity. The study further suggests that culture-based coding media can serve as an innovative learning resource to enrich PAUD (early childhood) instruction. Future research is encouraged to apply this concept in other cultural settings and include additional interactive features—such as animation, audio, gamification, or augmented reality—to enhance children's engagement and learning outcomes. Long-term investigations are also needed to examine CT development over extended periods, along with broader collaboration with teachers and early childhood institutions to support continuous refinement of the media based on classroom needs.

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1. INTRODUCTION

Indonesian One of the primary challenges of the Society 5.0 era lies in the field of education, where rapid and significant advancements require the sector to adapt to the digitalization of educational systems (Izzah, Suwaibatulilla, Khasfiyatin, Rina, & Supeno, 2023). This condition is equally relevant to early childhood education (ECE). ECE is designed to foster the potential of every child, as early childhood represents a critical period of rapid growth and development (Budiyanto, Shahbodin, Ulin, Umam, & Isnaini, 2021). At this stage, children are expected not only to acquire literacy skills such as reading, writing, and numeracy, but also to develop problem-solving abilities related to computational thinking (CT), including logical reasoning, sequencing, abstraction, and algorithms (Mulyati, 2023). In its simplest form, CT encompasses logical thinking, problem-solving, the application of algorithms, and coding/programming (Safitri, Hermawan, Haryadi, Rahmatia, & Supriyanto, 2024). In various countries, the implementation of CT skills in schools has been carried out since 2014. The integration of CT into the curriculum helps children develop programming and technology skills, as well as enhance their critical thinking and problem-solving abilities (Zafrullah, Gunawan, Haidir, & Ramadhani, 2025). The integration of CT concepts into the curriculum aligns with changes in educational policy. Policymakers must provide support for teachers and take into account cultural, socioeconomic, and geographical factors (García-Valcárcel Muñoz & Caballero-González, 2019). Culture in education bridges children's familiar experiences and skills with school content, requiring teachers to recognize and understand children's CT practices before introducing formal CT concepts (Fajriyah, Rizqiyani, & Fitria, 2024).

According to the World Economic Forum (2023), problem-solving skills and digital literacy are among the five most essential competencies in the era of technological transformation. However, computational thinking (CT) literacy at the early childhood education (ECE) level in Indonesia remains relatively low. A report by the Ministry of Education, Culture, Research, and Technology (2024) indicates that only around 18% of ECE institutions have integrated coding-based activities or basic technology into their learning practices. Furthermore, the availability of coding learning media that align with young children's developmental characteristics is still very limited (Budiyanto et al., 2025 ; (Abidin, 2023). Most coding media adopted in Indonesia originate from foreign contexts, making them less compatible with local cultural values and less supportive of meaningful learning experiences for children.

The integration of local culture in education holds significant urgency, as it helps children build stronger connections between learning experiences and their daily lives while fostering cultural identity from an early age (E. Firminia & Suryaningsih, 2025). North Sumatra is culturally diverse—home to various ethnic groups such as Batak, Malay, and Nias—yet the immense cultural potential of this region has not been optimally utilized in digital learning media, particularly in the context of CT development in ECE settings. Therefore, innovative learning media are needed to not only strengthen children's computational abilities but also incorporate local cultural values as part of efforts to enhance character education and digital literacy in the next generation (Anggreni & Fachrurrazi, 2025).

Research on computational thinking in early childhood education has shown a significant increase over the past decade. Recent systematic reviews confirm that computational thinking interventions implemented through plugged activities, unplugged activities, robotics, and digital media are effective in enhancing young children's logical reasoning, problem solving, and algorithmic thinking skills (Misirli & Komis, 2023). Nevertheless, these studies continue to exhibit a high degree of heterogeneity in research design, measurement instruments, and outcome indicators, which limits the generalizability and comparability of the findings (Michalakopoulos, Zygouris, & Bagos, 2025)

Several large scale experimental studies have demonstrated that programming activities involving tangible objects or robotics significantly stimulate key components of computational thinking, such as decomposition, abstraction, and debugging, among children aged four to six years (Hufad, Fathurrohman, & Rusdiyani, 2021). Despite their effectiveness, these approaches face practical

constraints related to cost, infrastructure availability, and accessibility, particularly in early childhood education settings in developing countries.

Other studies indicate that digital storytelling and design based learning approaches can enhance preschool children's coding skills and computational thinking through digital story creation activities that emphasize narrative and visual elements as entry points to computational thinking learning (Metin, Kalyenci, Başaran, Relkin, & Bilir, 2024). However, such studies generally do not integrate local cultural elements systematically into instructional design.

In the Indonesian context, several research and development studies have focused on developing digital e modules or e books for basic literacy and coding instruction in early childhood education, reporting high levels of validity and practicality. Nonetheless, most of these studies remain limited to product feasibility evaluations and do not consistently examine computational thinking effectiveness using robust and measurable pretest and posttest experimental designs (M. E. Firminia & Arianti, 2025 (Fitriani, Komalasari, Adzhani, & Nelisma, 2022)

Therefore, a clear research gap remains regarding the development and experimental evaluation of local culture based coding activity e books aimed at improving computational thinking in early childhood. Integrating local cultural values not only has the potential to enhance children's engagement and meaningful learning experiences but also contributes to the early formation of cultural identity, an aspect that has yet to be systematically and quantitatively examined within the computational thinking early childhood education literature.

CT is one of the essential skills that supports 21st-century learning, aiming to understand and solve complex problems. In simple terms, CT is defined as a structured method for identifying and solving problems (Kemendikbud, 2020). CT can be developed through coding learning. The advantage of coding is that it helps children address everyday life problems while fostering computational thinking skills (Anggraeni, Qonita, & Mulyana, 2024). Early childhood is highly receptive to new learning and capable of absorbing new concepts. Introducing basic skills at an early age helps children develop problem-solving, logical reasoning, and critical thinking abilities that are valuable in today's digital era (Zafrullah et al., 2025). In the context of education, the significance of this skill lies in its potential to enhance analytical and creative abilities, preparing children for future professions that demand technological competence (Romandoni et al., 2023 ; Kumala et al., 2021) CT is applied in formulating problems and finding solutions effectively in computational terms (Budiyanto et al., 2021).

Although Computational Thinking (CT) is widely recognized today as a core competency for 21st-century learning supporting children in understanding and solving complex problems in a structured, logical, and systematic manner (e.g., abstraction, decomposition, algorithms)—research indicates that CT literacy among young children remains highly fluctuating and often low when CT stimulation is not provided intensively (Hardiyanti, Christianti, & Rambe, 2025). For example, a study profiling CT abilities among 5–6-year-old children in early childhood education centers in Surakarta reported that CT skills develop "variably according to the intensity of stimulation," meaning that without concrete exposure—such as coding activities or pattern-based tasks children's CT abilities tend to stagnate. Conversely, intervention-based studies demonstrate that coding-focused learning (both "plugged" and "unplugged") can significantly improve preschoolers' CT skills, problem-solving abilities, and mathematical performance (Abdullah & Istiqamah, 2025).

A solution to enhance computational thinking in early childhood is through innovative coding learning designed using an activity book packaged in digital form as an e-book. An e-book is a product resulting from the utilization of technology in education, including early childhood education (Mulyati, 2023). E-books offer several advantages that can improve the efficiency and effectiveness of the learning process, such as being more practical and portable, environmentally friendly, longer-lasting, easy to reproduce for students, and simple to distribute (Ragili Yanti & Fariha Sari, 2024). Furthermore, the coding activity e-book is integrated with elements of North Sumatran culture, such as ethnic groups, traditional houses, traditional foods, traditional games, traditional musical instruments, and traditional

clothing. This combination allows children to preserve local culture while simultaneously keeping pace with current developments in information technology.

The initial observations conducted in 9 kindergartens in Medan City revealed that early childhood education still predominantly applies a teacher-centered approach and focuses mainly on reading, writing, and arithmetic skills. Activities aimed at stimulating CT abilities are still rarely implemented, with limited digitalization of media and teaching materials, and the concept of CT remains relatively new for teachers (Palts & Pedaste, 2020; Basu, Biswas, & Kinnebrew, 2017). Therefore, it is necessary to integrate CT concepts with coding learning in early childhood education to address challenges and harness opportunities in the 21st century. Accordingly, this study aims to develop teaching materials in the form of an e-book coding activity to enhance computational thinking in early childhood, thereby enabling children to solve education-related problems (M. E. Firminia & Arianti, 2025). This initiative is also aligned with *Asta Cita* as the Presidential Mission, which is outlined as a national priority in the RPJMN 2025–2029, specifically in *Asta Cita* number 4, which emphasizes strengthening the development of human resources (HR), science, technology, education, health, sports achievements, gender equality, as well as the empowerment of women, youth (millennial and Gen Z), and persons with disabilities. Based on these challenges and opportunities, this study was conducted with the intention of developing innovative and culturally relevant digital learning media to support early childhood computational skills (Denning & Tedre, 2021 ;(Eisenberg, 2010). Specifically, the research aims to produce a prototype of a coding activity e-book that integrates North Sumatran cultural content, ensuring its feasibility both in terms of material appropriateness and media quality for use in early childhood education settings. The study also seeks to determine the practicality of the e-book when applied by teachers and used by children aged 5–6 years during classroom learning activities in kindergartens. Furthermore, the research intends to evaluate the effectiveness of the developed e-book in enhancing children's Computational Thinking skills through systematic pretest and posttest assessments. Through these objectives, the study is expected to contribute meaningful advancements to early childhood digital learning innovation while simultaneously preserving cultural identity and aligning with 21st-century competence needs.

2. METHODS

The research This study employed a Research and Development (R&D) design using the Dick and Carey ADDIE model, aiming to develop a coding activity e-book integrated with North Sumatran culture to enhance the computational thinking skills of early childhood learners aged 5–6 years. The stages included analysis, design, development, implementation, and evaluation. The research design is presented in Diagram 1.

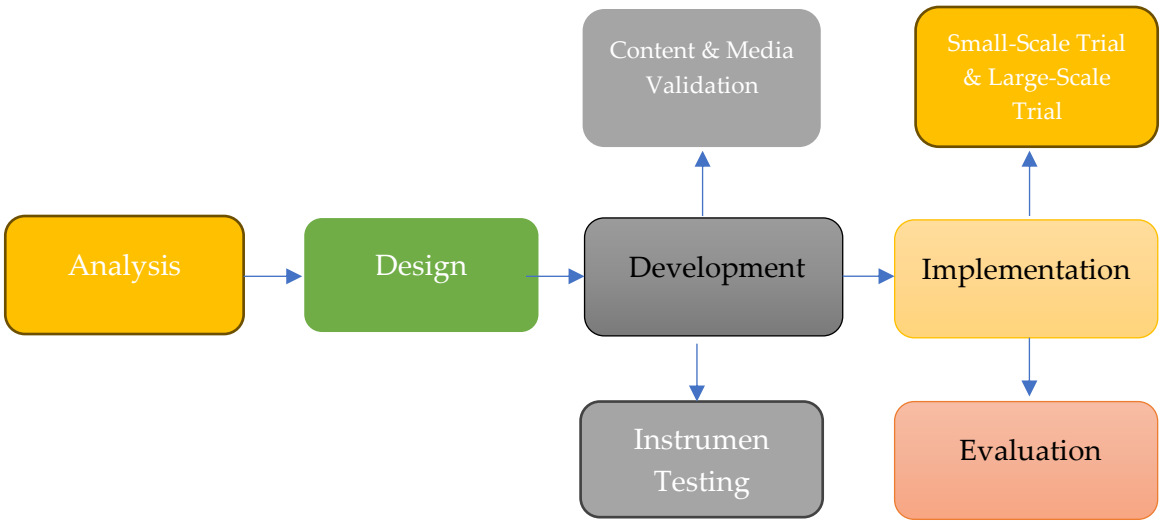

Figure 1. Stages of Development Research

This study employed the ADDIE development model, consisting of five stages, Analysis, Design, Development, Implementation, and Evaluation. The model was selected because it provides a systematic workflow for developing learning media that align with the needs and characteristics of early childhood education.

The Analysis stage involved identifying instructional needs through field observations and interviews with teachers to understand children's prior knowledge, availability of learning resources, and the potential integration of local cultural content into coding instruction. The findings from this stage served as the foundation for determining learning objectives, materials, and indicators of computational thinking (CT) skills to be developed.

In the Design stage, the researcher formulated the structure of the media by preparing the storyboard for the cultural-based coding e-book, including narrative content, visual illustrations, and problem-solving activities tailored to children's developmental levels. During this stage, learning flow, instructional scenarios, CT assessment indicators, expert validation sheets, and practicality and effectiveness instruments were also developed.

The Development stage focused on producing the e-book prototype using digital media development tools. Once the prototype was completed, expert validation was conducted to assess the quality of material, media, and instructional design. Additionally, instrument validation was performed to ensure the validity and reliability of the assessment tools used to measure children's CT skills. Revisions were made based on expert feedback until the product met the eligibility criteria.

The Implementation stage included product testing in two phases a small-scale trial to examine usability and a large-scale trial to determine the effectiveness of the e-book in enhancing CT skills in early childhood education settings. During this phase, children's CT performance was assessed through observations and the administration of pretest and posttest instruments. The final stage, Evaluation, involved a comprehensive analysis of product feasibility, practicality, and effectiveness based on expert validation results, trial implementation, and statistical testing. The findings were used to refine the e-book to ensure it is valid, practical, and effective for classroom implementation, particularly in promoting CT skills through culturally relevant learning experiences.

2.1 Data Collection Procedures

The research was conducted from May to August 2025 in nine kindergartens located in Medan City, North Sumatra. A saturated sampling technique was applied, wherein the entire population was included as research subjects due to the relatively small population size. Thus, the population and sample consisted of 160 children enrolled across the selected kindergartens. In addition to the children, classroom teachers were involved as informants responsible for providing practicality responses and assisting in observing children's learning behavior during the intervention.

The product development procedures began with expert validation involving four expert validators specializing in learning materials, instructional media, and early childhood pedagogy. Data were collected using validation questionnaires and analyzed using the expert validation formula to determine the feasibility level of the developed media.

The effectiveness assessment was conducted using a one-group pretest–posttest design. Children's computational thinking skills were observed using a validated CT observation instrument, administered before (pretest) and after (posttest) the learning intervention using the culture-based coding activity e-book. The differences in scores were analyzed statistically to determine the significance of improvement in children's CT skills following the implementation. The validation data were then calculated using the following validation formula:

$$\boxed{P = \frac{\sum R}{\mathrm{N}} x\ 100\%}$$

% = Percentage score
$\sum$ = Total
N = Maximum score

The data collection technique was carried out through direct observation using observation sheets that had been tested for validity and reliability with the assistance of SPSS at an alpha value of 0.05. This approach facilitated the gathering of information and evidence through systematic observation and recording of various phenomena that served as the objects of observation, as well as indicators of the research variables (Sugiyono, 2021)

2.2. Data Analysis Procedures Research Instrument

The development of the coding activity e-book involved four validators to assess the content suitability of the material in the developed product and to evaluate the design of the e-book coding activity. The validation framework, addressed to two material experts and two media experts, is presented in Table 1.

Table 1. Validation Framework for Material and Media

Validation	Indicator	Items	Item Numbers
Material	Relevance to children's needs	3 items	1,2,3
	Content feasibility	3 items	4,5,6
	Ease of use	2 items	7,8
	Outcomes	2 items	9,10
Media	Language quality	7 items	1,2,3,4,5,6,7
	E-book design	3 items	8,9,10
	E-book structure	2 items	11,12
	Illustration	3 items	13,14,15

The data analysis technique in this study was conducted quantitatively to measure the feasibility, practicality, and effectiveness of the North Sumatra culture-based coding activity e-book in enhancing computational thinking (CT) skills in early childhood. The analysis procedures were aligned with the research objectives and the developmental stages of the media, which were based on the ADDIE model, ensuring that the collected data accurately represented the quality and impact of the media implementation.

The feasibility analysis was carried out through expert validation covering three key components: content, media, and instructional design. The collected data were analyzed using a percentage formula to determine the level of feasibility. The media was categorized as "feasible" when the validation results reached ≥ 60%. This evaluation ensured that the local cultural content and coding activities developed were pedagogically and technically appropriate for young children before being implemented in field trials.

Furthermore, practicality analysis was conducted during the trial phase through observations of implementation and responses from teachers and children while using the media (Sunaryati et al., 2024). The data were analyzed in percentage form to assess the usability, clarity, and supportiveness of the media within the classroom context. A high level of practicality indicated that the e-book aligned with the characteristics of early childhood development and could be easily utilized in kindergarten settings.

To determine the effectiveness of the media, pretest and posttest scores of CT skills were compared in both small-scale and large-scale trials. In the small-scale trial, the Wilcoxon test was employed as a non-parametric statistical technique due to the non-normal distribution of the data. In the large-scale trial, a Paired Sample t-Test was used as a parametric analysis technique to examine differences in mean scores from the same sample measured before and after the intervention. Effectiveness was indicated by a significance value of $p < 0.05$, demonstrating a statistically significant improvement in children's CT skills following the implementation of the e-book (Sauter, 2022).

All data analyses were conducted using statistical software to ensure the accuracy, objectivity, and reliability of the research findings. Thus, the analytical approach applied in this study provides strong and valid evidence regarding the contribution of the culturally contextualized e-book in enhancing computational thinking skills in early childhood education.

3. FINDINGS AND DISCUSSION

3.1. Findings (Result of the Development of Coding Activity E-Book)

3.1.1. Need Analysis

The needs analysis represents a foundational stage in this development research, aimed at identifying gaps between existing instructional practices and the ideal conditions required to support Computational Thinking (CT) learning in early childhood education. Based on observations conducted in six kindergartens in Medan City, learning activities were predominantly teacher centered and focused mainly on early literacy and numeracy skills. Structured learning experiences designed to stimulate CT components such as logical reasoning, sequencing, pattern recognition, and problem solving were rarely integrated into daily classroom practices. This condition contrasts with theoretical perspectives that emphasize CT as a fundamental cognitive skill that should be introduced from an early age through concrete, experiential, and developmentally appropriate activities.

Interviews with early childhood teachers revealed limited conceptual understanding of CT and its pedagogical application in early childhood classrooms. Many teachers perceived CT as closely associated with computer usage or advanced digital technologies, which led to uncertainty in implementing CT oriented activities for children aged five to six years. In addition, teachers reported constraints related to the availability of appropriate coding learning media that align with children's developmental characteristics. Most existing resources were limited to simple worksheets or digital applications developed in foreign contexts, which often lack cultural relevance and fail to connect learning content with children's everyday experiences.

The literature review further indicated that while numerous studies have demonstrated the effectiveness of coding based learning in enhancing young children's CT skills, only a limited number have systematically integrated local cultural elements into instructional media. North Sumatra possesses rich cultural resources, including traditional houses, games, and ethnic traditions, which have not been optimally utilized as contextual learning tools for CT development. Drawing on sociocultural learning theory, meaningful learning occurs when cognitive development is mediated by cultural and social contexts familiar to children. Therefore, these findings highlight the need to develop a culture based coding activity e book that supports CT learning while embedding local cultural values, thereby enhancing engagement, conceptual understanding, and cultural identity formation in early childhood education.

3.1.2. Design

Following the needs analysis, the design stage was conducted as a strategic response to the instructional gaps identified in early childhood coding and computational thinking learning. This stage focused on translating empirical findings and theoretical frameworks into a structured learning product. The design process began with the formulation of learning objectives aligned with core components of Computational Thinking, including sequencing, logical reasoning, pattern recognition, decomposition, and algorithmic thinking. These objectives were adjusted to the developmental characteristics of children aged five to six years, ensuring that learning activities remained concrete, play based, and developmentally appropriate, as recommended in early childhood pedagogy.

Subsequently, coding lessons and learning activities were systematically planned and organized into thematic units. Each unit was designed to introduce basic coding concepts through progressive levels of difficulty, starting from simple directional commands and patterns to more complex problem solving tasks. Worksheets and interactive activities were then developed as part of a digital activity book format, allowing children to engage in hands on problem solving while being guided by visual cues and storytelling elements. The design emphasized child friendly layouts, minimal text, rich illustrations, and repetitive structures to support early learners' cognitive processing and attention span.

A distinctive feature of the design stage was the integration of North Sumatran cultural elements as contextual learning anchors. Cultural content such as ethnic groups, traditional houses, traditional foods, local games, and cultural practices was deliberately embedded within coding tasks and story scenarios. For example, children were asked to sequence routes to traditional houses, identify patterns in traditional motifs, or solve simple algorithmic problems based on local games (Alnashr & Nuraini, 2022; Denning & Tedre, 2021). This culturally responsive design aligns with sociocultural learning theory, which emphasizes that learning becomes more meaningful when new concepts are connected to learners' cultural backgrounds and lived experiences. In addition, the instructional design was aligned with national policy directions, particularly Module 3 on the implementation of coding education issued by the Directorate of Early Childhood Education, which emphasizes strengthening foundational literacy and problem solving competencies from an early age (Hasbi et al., 2020).

3.1.3. Development

The next stage was the realization of the coding activity e-book integrated with North Sumatran culture to enhance computational thinking skills. For product feasibility testing, the coding activity e-book was evaluated by expert judgments in both material and media. The content development of the e-book was organized into five chapters, consisting of theories and practices of coding learning, as well as North Sumatran cultural elements interwoven with coding activities as a means of stimulating computational thinking in early childhood. The worksheets included in the e-book were designed to help children practice problem-solving skills in the form of computation and algorithms; in simple terms, they trained children to reason through spatial abilities, think critically, and practice finding solutions to the problems they encountered (Maharani, Nusantara, Rahman, & Qohar, 2021). The

validation process of the coding activity e-book integrated with North Sumatran culture to develop computational thinking skills was carried out by four expert judges specializing in early childhood education. The validation results are presented in Table 2.

Table 2. Expert Validation Results of the Coding Activity E-Book

Validator	Mean	Percentage	Category
Material Expert 1	2,6	65%	Feasible with Revision
Material Expert 1	3,9	97,5	Feasible without Revision
Media Expert 1	3,8	95,3%	Feasible without Revision
Media Expert 2	3,3	84,3%	Feasible without Revision

Table 2 presents the validation results from material and media experts, showing percentages above the average feasibility threshold. However, Material Expert 1 suggested revisions to the coding activity e-book, specifically by adding coding learning activities relevant to the Nias and Karo ethnic groups. After incorporating these revisions, the product was deemed feasible for use and implementation in early childhood education. Furthermore, the researcher conducted instrument testing to evaluate both the effectiveness of the developed product and its impact on enhancing computational thinking skills in early childhood. The validity and reliability results are presented in Table 3.

Tabel 3. Validity and Reliability Test Results

Item	r product moment	r-table (n=15)	Validity Status	Cronbach's Alpha	Reliability Status
Item001	0,562	0,514	Valid	0,744	Reliable Fairly
Item002	0,533	0,514	Valid		Reliable Fairly
Item003	0,426	0,514	Rejected	Rejected	Rejected
Item004	0,588	0,514	Valid	0,744	Reliable Fairly
Item005	0,678	0,514	Valid		Reliable Fairly

Based on Table 3, the results of the validity and reliability tests show that four items are valid and reliable to be used as research instruments and are ready to assess *computational thinking* abilities. Item 003 was excluded because its validity score was lower than 0.514, which is below the established *r-table* value; therefore, it was omitted from the field research. The calculated Cronbach's Alpha value of the four valid items was 0.744, indicating that the instrument is sufficiently reliable. Furthermore, the realized design of the e-book cover is presented in Figure 2 below.

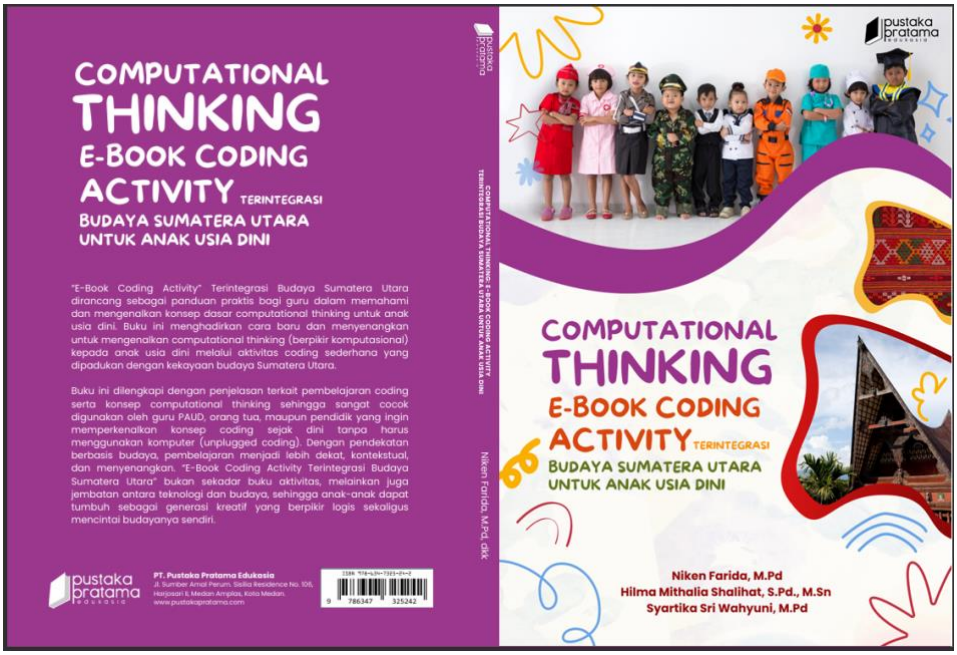

Figure 1. Cover Design of the Coding Activity E-Book

Figure 2. draft of Chapter 4 (Results and Discussion) along with examples of culture-based coding

3.1.4. Implementation

After the product had passed the validation stage, the next step was the implementation of coding learning integrated with North Sumatran culture through the developed e-book. This stage was divided into two phases. The small-scale trial was conducted in three kindergartens, namely Santo Thomas II Kindergarten, Najmah Rugayah Kindergarten, and Pondok DAUD Kindergarten, with a total of 49 children. Prior to the trial, teachers, as both users and observers, received training and orientation regarding Computational Thinking (CT) and the developed Coding Activity E-Book. The purpose of the small-scale trial was to obtain data on the feasibility of the developed product based on validation results from material and media experts. In practice, the specific aim of the small-scale trial was to implement coding learning activities contained in the e-book and to review and analyze whether

the e-book required revision or refinement before being applied on a larger scale.

Coding learning integrated with North Sumatran culture to enhance Computational Thinking (CT) skills was tested in a small-scale trial with early childhood learners (Figure 2). The achievement of CT indicators was observed both at the individual level and as averages across each kindergarten. The implementation of this field trial involved teachers, who carried out the learning process using the Coding Activity E-Book as a guide, after receiving prior training from the researcher. The analysis of the small-scale trial results is presented in Table 4.

Table 4. Small-Scale Trial Results

Achievement	TK Santo Thomas II		TK Najmah Rugayah		TK Pondok DAUD	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Nilai Min	8	10	4	8	6	8
Nilai Max	12	13	9	14	9	13
Rata-rata	2,41	2,91	1,51	2,66	1,67	2,54
Number of children	15		19		16	

The results of the small-scale trial presented in Table 4 indicate an overall increase in the Computational Thinking (CT) abilities of early childhood learners after the implementation of the Coding Activity E-Book integrated with North Sumatran culture. At TK Santo Thomas II, the mean score improved from 2.41 in the pretest to 2.91 in the posttest, with scores ranging from 8 to 13. Similarly, TK Najmah Rugayah demonstrated significant improvement, with the mean increasing from 1.51 to 2.66, and scores rising from 4–9 in the pretest to 8–14 in the posttest. Meanwhile, TK Pondok DAUD also showed positive progress, with the mean increasing from 1.67 to 2.54 and scores ranging between 6–13. These results highlight that the use of the Coding Activity E-Book not only improved the minimum and maximum scores across all three schools but also raised the average achievements, indicating its effectiveness in stimulating CT development in young children.

Figure 3. Implementation of the Small-Scale Trial

The researcher also classified the development of computational thinking into four criteria: BB, MB, BSH, and BSB. These criteria served as benchmarks for comparing differences before and after the treatment was given. A comparison of the pretest and posttest results of computational thinking skills from the small-scale trial is presented in the following graph.

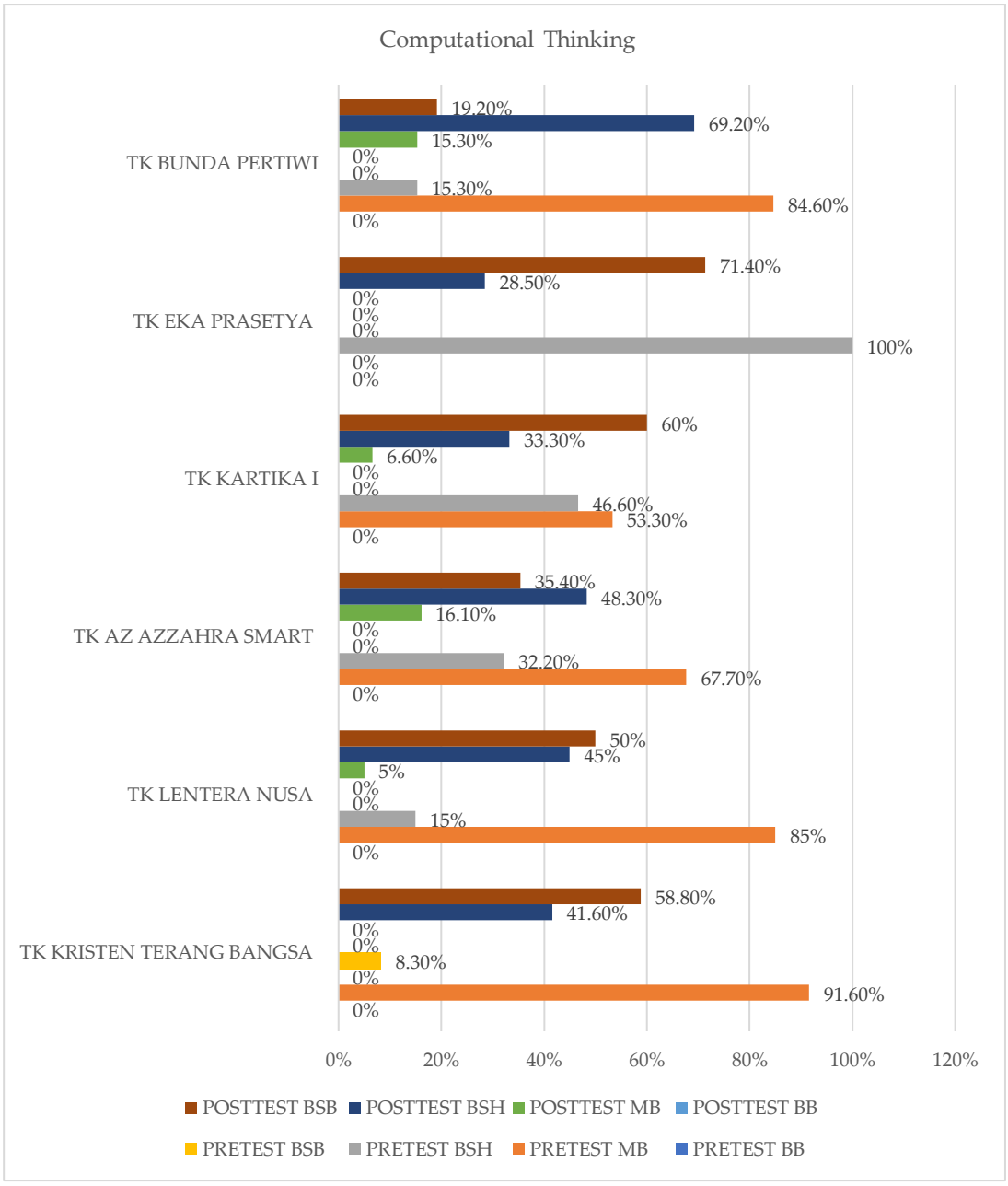

Figure 1. Computational Thinking Ability in the Small-Scale Trial

Based on Figure 1, the small-scale trial results indicate a clear improvement in children's Computational Thinking (CT) skills after participating in coding lessons using the E-book Coding Activity. The proportion of children in the Very Well Developed (BSB) category increased from 0% to 27%, while the Well Developed as Expected (BSH) category rose substantially from 12.5% to 80%. In contrast, the Beginning to Develop (MB) and Not Yet Developed (BB) categories declined to 0%, demonstrating a positive shift from lower to higher levels of CT achievement.

The findings from the small-scale trial served as the basis for revising the product prior to large-scale implementation. Revisions focused on strengthening the alignment between learning content and CT indicators, as well as increasing the level of challenge in the worksheets to better suit children aged 5–6 years. Overall, the culturally integrated coding materials were well understood and feasible for classroom use. Following these revisions, the large-scale trial was conducted in six kindergartens involving 111 children, using the same research design as the small-scale trial. The results of the large-scale implementation are presented in Table 5.

Table 5. Results of the Large-Scale Trial

School Name	Pretest			Posttest		
	Max	Min	Mean	Max	Min	Mean
TK Kristen Terang Bangsa	14	6	1,88	16	9	3,1
TK Lentera Nusa	14	6	1,85	16	7	3,15
TK Az-Zahra Smart	11	4	1,95	16	6	3,01
TK Kartika 1	12	4	1,97	16	8	3,23
TK Eka Prasetya	12	5	1,98	16	9	3,39
TK Bunda Pertiwi	9	5	1,75	16	7	2,78

Based on Table 5, the results of the large-scale trial across six schools indicate an improvement in children's computational thinking abilities after the implementation of coding instruction integrated with North Sumatran culture. In the pretest stage, the lowest mean score was obtained by TK Bunda Pertiwi at 1.75, while the highest mean score was achieved by TK Kartika 1 with 1.97. Overall, the average pretest scores across all schools were below 2, indicating that children's initial CT abilities were still relatively low.

After the intervention through coding instruction integrated with North Sumatran culture, the posttest results showed a significant improvement. The highest average score was achieved by TK Eka Prasetya with 3.39, followed by TK Kartika 1 with 3.23. Meanwhile, the lowest average score remained at TK Bunda Pertiwi with 2.78. This improvement was also reflected in the maximum and minimum scores, where almost all schools achieved the maximum posttest score of 16, and the minimum scores were higher compared to the pretest. These findings demonstrate that the activities in the coding activity e-book effectively enhanced children's CT skills across all schools involved in the large-scale trial.

Figure 4. Implementation of the Large-Scale Trial

Next, for the effectiveness test, the results of the large-scale trial must meet the requirements of the data normality test and hypothesis testing. The results are presented in Table 6.

Table 6. Data Normality Test

Tests of Normality

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Pretest CT	.190	111	.000
Posttest CT	.138	111	.000

a. Lilliefors Significance Correction

Table 7. Wilcoxon Test

Test Statistics[a]

	Posttest CT - Pretest CT
Z	-8.901[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Based on the Kolmogorov-Smirnov normality test, the significance values were 0.000 for both the pretest and posttest ($p < 0.05$). Thus, the data were not normally distributed, and hypothesis testing was carried out using the nonparametric Wilcoxon Signed Rank Test, as presented in Table 7. The results of the Wilcoxon Signed Rank Test showed a Z value of -8.901 with a significance value (Asymp. Sig. 2-tailed) of 0.000. Since the significance value was smaller than 0.05 ($p < 0.05$), it can be concluded that there was a significant difference between the pretest and posttest scores of children's computational thinking (CT) skills. These results indicate that the use of the coding activity e-book integrated with North Sumatran culture had a positive and effective impact on improving children's computational thinking abilities.

3.1.5. Evaluation

From a practicality perspective, the trial results indicate that the e-book is generally easy for teachers to use and engaging for children; however, further refinement is needed to optimize its implementation in early childhood education settings. Recommended improvements include simplifying activity instructions by using more concise and operational language, adding step-by-step visual examples, and providing a comprehensive teacher guide that clearly outlines learning objectives, implementation procedures, and the specific Computational Thinking indicators addressed in each activity. In addition, the inclusion of differentiated activity options is necessary to accommodate variations in the abilities of children aged 5–6 years, enabling flexible use of the e-book in both whole-class and small-group learning contexts. These aspects of practicality are essential, as instructional media for early childhood education must support ease of use for teachers while maintaining the playful, concrete, and contextual nature of learning (Leung et al., 2025)

From a content perspective, improvements should focus on deepening and expanding coding materials integrated with North Sumatran culture. Several initial activities were

considered overly simple and therefore need to be enhanced by introducing more varied patterns, more complex algorithmic routes, and open-ended problems that encourage logical and reflective thinking. Cultural integration should also be enriched through more diverse representations, such as traditional games, textile motifs, and authentic socio-cultural activities, allowing children to meaningfully connect coding concepts with their everyday experiences. This strengthening of content aligns with computational thinking theories that emphasize the development of problem solving, pattern recognition, and sequencing skills from an early age through culturally meaningful contexts(Quinn, Caudle, & Harper, 2025; Lee, Joswick, & Pole, 2023). Consequently, the e-book functions not only as a cognitive learning resource but also as a medium for fostering children's cultural identity.

3.2. Discussion

The findings of this study regarding the feasibility of the coding activity e-book integrated with North Sumatran culture indicate that the results of the material and media validation obtained scores above 60%, placing them in the "feasible" category and ready for use. The validation of the instrument for observing computational thinking skills also demonstrated validity and reliability. This aligns with the observed indicators: decomposition, abstraction, algorithm design, and pattern recognition.

The high level of material and media feasibility obtained in this study indicates that the integration of North Sumatran cultural narratives through visual elements and interactive activities successfully meets the pedagogical and technical criteria for early childhood education. This finding emphasizes that local culture does not merely serve as a decorative component, but rather functions as a meaningful instructional context that substantially supports the understanding of computational thinking (CT) concepts (E. Firminia & Suryaningsih, 2025). The strong validity and reliability of the observation instruments further reinforce the consistency of measurements across CT indicators, including decomposition, abstraction, algorithm design, and pattern recognition (Ria & Susilowati, 2023). Thus, it can be interpreted that the integration of local cultural content not only enhances the relevance and engagement of children in learning but also contributes to strengthening the conceptual foundation of CT in a more meaningful way (Qiyyamul, Arrafi, Ningsetyo, Zaidi, & Amiruddin, 2023).

The integration of North Sumatran local culture into the coding activity e-book can serve as an effective medium for fostering computational thinking skills in young children. By incorporating cultural elements such as folklore, Batak motifs, traditional customs, local languages, and environmental characteristics of North Sumatra into e-book–based coding activities, children not only learn technical skills such as decomposition (breaking down problems), pattern recognition, abstraction, and algorithmic thinking, but also develop emotional and cultural connectedness (Z.H Putra, et al., 2022). For example, when children write code to create interactions among characters in a Batak folktale, they must understand the structure of the storyline, break the narrative into smaller segments (decomposition), recognize recurring dialogue or conflict patterns (pattern recognition), determine which elements are essential to preserve for clarity (abstraction), and design an algorithm to simulate the sequence of story events (Silviani, Gandana, & Purwati, 2024). This approach not only makes coding relevant and meaningful but also deepens cultural understanding and strengthens local identity (Silviani et al., 2024).

Several international studies support the positive effects of integrating local culture into computational thinking education. For instance, the study *"Development of Computational Thinking Tasks Based on Riau Malay Culture: A Study of Fifth-Grade Public School Students in Pekanbaru, Indonesia"* demonstrated that computational thinking tasks contextualized with Riau Malay culture were proven to be valid, reliable, and effective in enhancing students' computational thinking abilities (Z.H Putra, et al., 2022). Similarly, the study *"Culturally Contextualized E-Book Based on West Papua's Culture to Support Elementary Students' Mathematical Connection Skills"* revealed that e-books embedded with local cultural contexts could strengthen critical thinking, abstraction, and conceptual understanding

in a more meaningful way(Muhiddin, Saleh, & Akib, 2025).

Research on integrating North Sumatran culture into coding activity e-books aimed at fostering computational thinking in early childhood can also be explained through child cognitive development theories. According to Piaget, early childhood (ages 2–7) corresponds to the preoperational stage, where children learn through symbols, imagination, and role-play. Coding activities contextualized with North Sumatran folktales or cultural symbols enable children to connect digital symbols (codes, icons, images) with concrete experiences from their environment (Quinn et al., 2025). This aligns with Vygotsky's perspective, which emphasizes the importance of the sociocultural context and the role of culture in cognitive development. Through locally contextualized e-books, children receive scaffolding from teachers and digital technology, allowing them to build computational thinking skills such as pattern recognition, decomposition, and algorithmic thinking (Perez Valdes, Boude Figueredo, & Vargas Sanchez, 2025).

Moreover, Bruner's theory of representation (enactive, iconic, symbolic) is also relevant. Children initially understand North Sumatran culture through direct experiences (enactive), followed by images and illustrations in the e-book (iconic), and eventually express their understanding through symbols or coding commands (symbolic) (Matthews, Nicholas, Kervin, Paatsch, & Wyeth, 2025). Thus, this study affirms that digital media–based learning integrating local culture not only develops 21st-century skills such as computational thinking but is also consistent with early childhood developmental theories, which emphasize learning through real-life contexts, symbols, and sociocultural interactions (Beyazhancer & Demir, 2024).

4. CONCLUSION

This study confirms that the North Sumatra culture–based coding activity e-book is a feasible, practical, and effective medium for enhancing computational thinking (CT) in early childhood. Expert evaluations yielded feasibility scores above 80% and the CT assessment instrument demonstrated high reliability (Cronbach's Alpha = 0.744). Field implementation with 160 kindergarten children showed a significant improvement in CT skills, supported by the Wilcoxon test results ($Z = –8.901$; $p < 0.05$). The integration of local culture provided meaningful pedagogical scaffolding that made abstract CT concepts more concrete and relevant to children's real-life experiences. These findings highlight that accelerating CT literacy in early childhood can be achieved not only through technology use but also through culturally responsive learning. The e-book model is therefore recommended for curriculum integration, and future studies are encouraged to explore its application in other cultural settings and with more advanced interactive features.

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