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Design, validation, and effectiveness of a Jambi local wisdom-based interactive worksheet for enhancing preschool children's numeracy skills

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Abstract

Background: Developing numeracy skills during early childhood is essential for establishing a strong foundation for later mathematical learning. However, limited availability of interactive learning materials that integrate local cultural contexts has reduced opportunities for meaningful and engaging numeracy experiences.
Aim: This study aimed to design, validate, and evaluate the effectiveness of a Jambi local wisdom-based interactive worksheet for enhancing the numeracy skills of preschool children aged 5–6 years.
Method: A Research and Development approach employing the ADDIE model was adopted. The study involved 27 preschool children, including 12 participants in a small-group trial and 15 in a large-group implementation. The developed worksheet was evaluated through expert validation, practicality assessment, and effectiveness testing using a one-group pretest–posttest design. Data were analyzed using descriptive statistics, the Wilcoxon Signed-Rank Test, and normalized gain (N-Gain).
Results: The worksheet achieved excellent validity, with expert validation scores of 91.6%, 100%, and 94.2% for media, content, and numeracy assessment, respectively. It was also rated highly practical (95%). Statistical analysis revealed a significant improvement in children's numeracy skills (p = 0.001), with a high average N-Gain score of 0.8545 (85.4%).
Conclusion: The Jambi local wisdom-based interactive worksheet is valid, practical, and highly effective in improving preschool children's numeracy skills while promoting contextual and culturally meaningful mathematics learning.

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INTRODUCTION

Early childhood represents a critical developmental period during which children experience rapid physical, cognitive, language, social-emotional, and moral growth that establishes the foundation for lifelong learning and development. During these formative years, children's brains develop at an accelerated pace, making them highly responsive to educational stimulation and meaningful learning experiences (Mualem et al., 2024; Rakesh et al., 2023; Subotnik et al., 2023; Tooley et al., 2021). Consequently, early childhood education plays a pivotal role in supporting children's holistic development by providing appropriate learning opportunities that correspond to their developmental characteristics (Darling-Hammond et al., 2020; Lunga et al., n.d.; Saracho, 2023).

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Rather than emphasizing academic achievement alone, early childhood education seeks to foster balanced development across multiple domains through engaging, child-centered, and developmentally appropriate practices. Cognitive development constitutes one of the essential domains because it enables children to acquire reasoning, problem-solving, and decision-making skills that are fundamental for future academic success (Clemente-Suárez et al., 2024; Darling-Hammond et al., 2020; Lemos et al., 2025; Yusumut et al., 2026). Among the various cognitive competencies, early mathematical understanding has received increasing attention due to its close relationship with children's logical thinking and analytical abilities. Developing mathematical competence from an early age allows children to recognize numbers, compare quantities, identify patterns, and solve simple problems encountered in everyday situations. These foundational competencies not only facilitate children's readiness for primary education but also contribute to their long-term academic performance and confidence in learning mathematics. Therefore, providing meaningful mathematical experiences during the preschool years has become a major priority in early childhood education systems worldwide. Establishing strong early numeracy competence through appropriate instructional support is consequently regarded as an essential investment in children's future educational development.

Early numeracy encompasses children's ability to recognize number symbols, understand numerical relationships, compare quantities, identify patterns, and apply simple mathematical reasoning in meaningful contexts. These competencies serve as the cornerstone of subsequent mathematical learning because they enable children to develop logical reasoning and conceptual understanding before engaging with more complex mathematical concepts. Despite its recognized importance, many preschool children continue to demonstrate limited numeracy performance due to insufficient opportunities for meaningful mathematical exploration. Classroom learning frequently relies on repetitive counting activities and memorization of number symbols without providing authentic experiences that encourage conceptual understanding (Kim, 2020). Such instructional practices often reduce children's engagement and fail to accommodate their natural curiosity and active learning characteristics. Furthermore, conventional learning materials generally present mathematical concepts in abstract forms that are disconnected from children's daily experiences and cultural environments (Clements et al., 2023; Quinn et al., 2025; Yang et al., 2023). As a result, children often experience difficulties in recognizing numerical symbols, comparing quantities, organizing sequences, and identifying simple patterns. These challenges indicate that improving numeracy development requires instructional approaches that actively involve children in meaningful learning activities rather than passive knowledge acquisition. Interactive learning resources have emerged as a promising solution because they promote active participation, immediate feedback, and experiential learning that align with the developmental needs of preschool children (Aslan et al., 2022; Sriarun et al., 2025; Zhang, 2023). Accordingly, developing innovative instructional materials capable of combining interactivity with contextual learning has become increasingly important for strengthening early numeracy development.

One promising approach for creating meaningful mathematics learning is the integration of local cultural knowledge into instructional media. Learning activities that reflect children's cultural backgrounds provide authentic contexts through which abstract mathematical concepts become more concrete, relevant, and understandable. Local wisdom also contributes to strengthening children's cultural identity while encouraging them to appreciate the traditions and values embedded within their communities (Ahmar & Azzajjad, 2025; Fathurrochman et al., 2026; Sakti et al., 2024; Wijayanti et al., 2025). However, the incorporation of local cultural contexts into digital instructional resources for early childhood mathematics education remains relatively limited. Existing instructional materials are generally designed using generic mathematical examples without

explicitly connecting learning activities to children's surrounding environments (Abrahamson et al., 2020; Bråting & Kilhamn, 2022; Clements et al., 2023; Kaminski & Sloutsky, 2020). This limitation reduces opportunities for children to experience mathematics as an integral part of their daily lives and cultural practices. In addition, interactive worksheets specifically designed to integrate local wisdom into preschool numeracy learning remain scarce despite the growing adoption of educational technology in early childhood classrooms. The development of culturally responsive interactive worksheets therefore represents an important strategy for simultaneously enhancing children's numeracy competence and promoting contextual learning experiences. By integrating interactive digital features with elements of Jambi local wisdom, instructional activities can become more engaging, meaningful, and relevant to children's lived experiences. Such an approach is expected not only to improve numeracy skills but also to enrich early childhood mathematics education through culturally responsive and technology-supported learning environments.

Previous studies have consistently established that early numeracy is a strong predictor of children's later mathematical achievement and cognitive development, while emphasizing the importance of providing meaningful mathematical experiences during the preschool years (Braeuning et al., 2020; Litkowski et al., 2020; Y. Liu et al., 2025; Seitz & Weinert, 2022). At the same time, advances in educational technology have demonstrated that interactive learning environments can enhance children's engagement and mathematics learning outcomes (Lavidas et al., 2022; Verbruggen et al., 2021). In parallel, culturally responsive mathematics education and ethnomathematics have been widely recognized as effective approaches for contextualizing mathematical concepts through learners' cultural experiences (Abdulrahim & Orosco, 2020; Kolovou, 2023a; Prahmana & D'Ambrosio, 2020). Nevertheless, these research streams have largely progressed independently. Existing studies predominantly investigate numeracy development, technology-enhanced learning, culturally responsive pedagogy, or ethnomathematics as separate domains, with limited attention to integrating these perspectives into a single instructional innovation for preschool mathematics education. Furthermore, empirical evidence regarding the development of interactive worksheets that incorporate local wisdom while simultaneously examining their validity, practicality, and effectiveness through a systematic Research and Development framework remains scarce. Therefore, this study addresses this gap by designing, validating, and evaluating a Jambi local wisdom-based interactive worksheet to enhance numeracy skills among preschool children aged 5–6 years.

Based on these considerations, this study aims to design, validate, and evaluate the effectiveness of a Jambi local wisdom-based interactive worksheet for enhancing the numeracy skills of preschool children aged 5–6 years. The study seeks to produce an instructional resource that is developmentally appropriate, culturally relevant, and capable of supporting meaningful mathematics learning in early childhood education. The development process emphasizes the integration of interactive digital features with authentic representations of local culture to increase children's engagement during learning activities. In addition, the study evaluates the quality of the developed worksheet through expert validation to ensure its instructional and content appropriateness. Practicality is also examined to determine whether the worksheet can be effectively implemented within preschool classroom settings. Furthermore, the effectiveness of the instructional resource is investigated by measuring improvements in children's numeracy performance following its implementation. The findings are expected to provide empirical evidence regarding the educational value of integrating local wisdom into interactive mathematics learning materials for preschool children. This study also contributes to expanding the application of culturally responsive pedagogy within early childhood mathematics education through technology-supported instructional design. Moreover, the developed worksheet is expected to serve as an

alternative learning resource for teachers seeking to deliver contextual and engaging numeracy instruction. Ultimately, this research contributes to the advancement of innovative mathematics education by integrating interactive technology, local cultural values, and evidence-based instructional development into a comprehensive learning resource for early childhood education.

LITERATURE REVIEW

Early numeracy is widely recognized as one of the most fundamental cognitive competencies developed during the preschool years. It encompasses children's understanding of number concepts, quantity relationships, counting principles, pattern recognition, measurement, spatial reasoning, and simple mathematical problem-solving. These competencies provide the foundation for children's future mathematical learning and influence their academic achievement throughout formal education. Research in developmental psychology has consistently demonstrated that numeracy skills acquired before entering primary school strongly predict later mathematics performance and general cognitive development (Amland et al., 2025; Davis-Kean et al., 2022; Y. Liu et al., 2025; ten Braak et al., 2022; Träff et al., 2020). Children who develop strong numeracy competencies at an early age tend to demonstrate better logical reasoning, analytical thinking, and problem-solving abilities than their peers (W. Chen, 2025; Y. Liu et al., 2025; Silver & Libertus, 2022; Torres-Peña et al., 2025). Early numeracy should therefore be understood as a developmental process rather than merely the acquisition of arithmetic skills. Meaningful mathematical experiences during early childhood enable children to construct conceptual understanding through exploration, interaction, and reflection. Learning environments that encourage active engagement and contextual experiences contribute significantly to strengthening children's mathematical thinking. Consequently, early childhood mathematics education should emphasize conceptual understanding instead of procedural memorization. Establishing strong numeracy competence during preschool is therefore considered an essential prerequisite for lifelong mathematical learning.

The integration of digital technology into early childhood education has transformed the ways mathematics can be introduced to young learners. Interactive learning environments provide opportunities for children to actively participate in learning through exploration, manipulation, immediate feedback, and engaging multimedia experiences (Adeyele, 2024; Balcha et al., 2025; Marougkas et al., 2023). Compared with conventional instructional approaches, interactive learning encourages greater motivation, attention, and persistence during mathematical activities. Interactive instructional media also accommodate different learning styles by combining visual, auditory, and kinesthetic experiences within a single learning environment. Such characteristics are particularly important for preschool children whose learning is closely associated with play, exploration, and direct interaction with learning materials. Interactive worksheets have emerged as an innovative instructional resource because they combine structured learning activities with multimedia elements that stimulate children's curiosity and participation (Herianto et al., 2022; Muton et al., 2026). These learning resources also allow teachers to facilitate mathematics instruction more systematically while maintaining children's interest throughout learning sessions. Furthermore, interactive learning environments encourage children to construct mathematical concepts independently through guided discovery rather than passive observation. As educational technology continues to develop, interactive instructional materials have become increasingly relevant for improving the quality of early childhood mathematics education. Therefore, integrating interactive technology into preschool numeracy instruction represents a promising direction for enhancing children's mathematical learning experiences.

Contemporary mathematics education increasingly recognizes the importance of connecting mathematical learning with children's cultural backgrounds and everyday experiences. Culturally responsive education emphasizes that meaningful learning occurs when instructional activities reflect learners' social, cultural, and environmental contexts (Anyichie et al., 2023; Lau & Shea, 2024). Within mathematics education, this perspective has been strengthened through the development of ethnomathematics, which explores mathematical ideas embedded in cultural practices, traditions, architecture, crafts, and daily activities. Integrating local wisdom into mathematics instruction allows abstract mathematical concepts to become more concrete and relevant to children's lived experiences (Hendriana et al., 2025; Leton et al., 2025). Such contextual learning not only supports conceptual understanding but also promotes children's appreciation of local culture and cultural identity. Children are more likely to engage in learning activities when instructional materials represent familiar objects, traditions, and environments that they encounter in everyday life. In addition, culturally responsive learning contributes to inclusive education by acknowledging the diversity of learners' cultural backgrounds (Markey et al., 2021; O'Leary et al., 2020). The incorporation of local wisdom into mathematics education therefore extends beyond preserving cultural heritage and becomes an effective pedagogical strategy for improving learning quality. Despite its educational value, the practical integration of local wisdom into digital instructional media for preschool mathematics remains relatively limited. Consequently, combining interactive learning technology with local cultural contexts offers considerable potential for developing innovative mathematics learning resources for young children.

Instructional media play a central role in facilitating meaningful learning experiences for preschool children because they translate abstract concepts into concrete learning activities. Worksheets have long been used to support children's learning by providing structured exercises that reinforce conceptual understanding. However, conventional worksheets frequently emphasize repetitive tasks that provide limited opportunities for exploration, interaction, and immediate feedback. The emergence of interactive worksheets has addressed these limitations by incorporating multimedia elements, animation, audio, and learner interaction into instructional activities. Interactive worksheets encourage children to actively construct knowledge while receiving immediate responses to their learning performance (L.-A. Liu & Hwang, 2024; Nadeem et al., 2023; Zhao et al., 2021). Such learning experiences increase engagement and reduce children's dependence on teacher-centered instruction. In addition, interactive worksheets enable teachers to organize learning systematically while accommodating children's developmental characteristics (Evans & Cleghorn, n.d.; Genovesi et al., 2025). When instructional media are designed using contextual examples and culturally meaningful content, they become more relevant and engaging for learners. Therefore, the development of interactive worksheets should integrate principles of instructional design, child development, mathematics education, and cultural relevance to maximize learning effectiveness (Clements et al., 2023; Evans & Cleghorn, n.d.; Sutarni et al., 2024). These characteristics position interactive worksheets as an important instructional innovation for improving preschool mathematics education.

The literature indicates that effective preschool mathematics education requires the integration of several complementary educational perspectives rather than relying on a single instructional approach. Early numeracy provides the developmental foundation upon which later mathematical competence is established. Interactive learning contributes to increasing children's engagement, motivation, and conceptual understanding through active participation (Blyznyuk & Kachak, 2024; Wang, 2023). Culturally responsive pedagogy emphasizes the importance of contextualizing mathematical learning within children's cultural experiences and everyday environments (Abdulrahim & Orosco, 2020; Kolovou, 2023b). Ethnomathematics further

strengthens this perspective by demonstrating that mathematical concepts can be meaningfully represented through local cultural practices and traditions (Batiibwe, 2025; Kabuye Batiibwe, 2024; Payadnya et al., 2024). Meanwhile, interactive worksheets offer an instructional platform capable of integrating technology, structured learning activities, and contextual learning experiences into a single educational resource. Combining these perspectives creates opportunities to develop mathematics instruction that is simultaneously interactive, meaningful, culturally relevant, and developmentally appropriate. Such integration is particularly important for preschool children because learning at this stage depends heavily on concrete experiences, active exploration, and familiar contexts. Accordingly, the present study develops a Jambi local wisdom-based interactive worksheet as an innovative instructional resource designed to enhance preschool children's numeracy skills through the integration of interactive digital learning and culturally responsive mathematics education. The proposed instructional innovation is expected to contribute not only to improving children's numeracy competence but also to expanding the application of culturally contextualized digital learning resources in early childhood mathematics education.

METHOD

Research Design

This study employed a Research and Development (R&D) approach to develop and evaluate a Jambi local wisdom-based interactive worksheet designed to improve the numeracy skills of preschool children aged 5–6 years. Research and Development is an educational research approach that systematically integrates product design, validation, implementation, and evaluation to produce instructional materials that are pedagogically appropriate and empirically effective. The present study adopted the ADDIE instructional design model, consisting of five sequential phases: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected because it provides a systematic, flexible, and iterative framework that facilitates the development of instructional products aligned with learners' developmental characteristics and curriculum requirements. Moreover, the model enables continuous refinement throughout the development process by incorporating expert feedback and empirical evidence obtained during product implementation. The development process began with identifying instructional needs and classroom problems related to preschool numeracy learning. Information gathered during this phase was subsequently used to formulate learning objectives, determine instructional content, and design interactive learning activities integrating elements of Jambi local wisdom. The resulting prototype was then developed and subjected to expert validation before being implemented in classroom learning. Product implementation was followed by an evaluation process that examined its validity, practicality, and effectiveness through both qualitative and quantitative evidence. Consequently, the ADDIE framework ensured that the developed interactive worksheet was systematically designed, validated, implemented, and evaluated before being recommended as an instructional resource for preschool mathematics education.

Table 1. Research design of the study

Component	Description
Research approach	Research and Development (R&D)
Development model	ADDIE (Analysis, Design, Development, Implementation, and Evaluation)
Product developed	Jambi local wisdom-based interactive worksheet
Learning domain	Early childhood numeracy
Target users	Preschool children aged 5–6 years

Research objectives	To develop, validate, and evaluate the practicality and effectiveness of the interactive worksheet
Research setting	TK Islam An-Nizham, Jambi City, Indonesia

The implementation of the ADDIE model in the present study is illustrated in **Figure 1**, which presents the sequential stages undertaken during the development process. Each phase informed the subsequent stage, allowing continuous refinement of the instructional product until it met the established quality criteria. The iterative nature of the model also ensured that improvements identified during expert validation and classroom implementation were incorporated into the final version of the interactive worksheet before its effectiveness was evaluated.

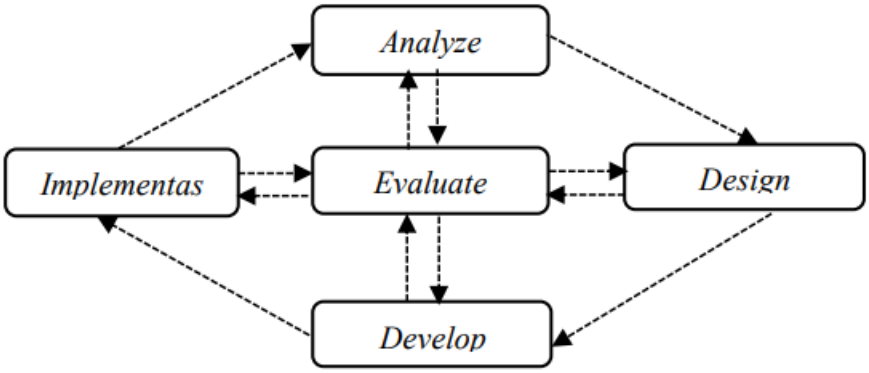

Figure 1. The ADDIE instructional development model.

Participants

The study was conducted at TK Islam An-Nizham, Jambi City, Indonesia, involving preschool children enrolled in the kindergarten program during the academic year of the study. Participants were selected purposively because they represented the intended users of the instructional product and were actively engaged in numeracy learning activities. A total of 27 children aged 5–6 years participated in the research. The implementation process consisted of two stages, namely a small-group trial involving 12 children from Class B2 (Apple Class) and a large-group field trial involving 15 children from Class B3 (Orange Class). These two stages enabled the researchers to identify potential weaknesses of the instructional product before conducting broader classroom implementation. In addition to the child participants, classroom teachers were involved throughout the study by participating in the needs analysis, evaluating the practicality of the interactive worksheet, and providing recommendations for product refinement. Expert validators specializing in early childhood education, mathematics learning, and instructional media also participated in the development process by evaluating the quality of the worksheet prior to classroom implementation. Their evaluations focused on the appropriateness of instructional content, media design, language, usability, and learning activities. The involvement of multiple stakeholder groups ensured comprehensive evaluation from pedagogical, technical, and practical perspectives. Such triangulation strengthened the credibility and quality of the developed instructional product before its effectiveness was examined in authentic classroom settings.

Table 2. Characteristics of the research participants

Participant	Number	Role in the study
Preschool children (small-group trial)	12	Preliminary implementation and product refinement
Preschool children (large-group trial)	15	Field implementation and effectiveness testing
Total preschool children	**27**	Main participants

Classroom teachers	2	Needs analysis, practicality evaluation, and classroom implementation
Material expert	1	Content validation
Media expert	1	Media design validation
Early childhood education expert	1	Pedagogical validation

The participant composition was designed to support each stage of the Research and Development process. Children served as the primary users during classroom implementation, whereas teachers and expert validators provided complementary evidence regarding the instructional feasibility, usability, and educational quality of the developed worksheet. This collaborative evaluation process enabled the researchers to obtain comprehensive feedback from individuals directly involved in early childhood mathematics education, thereby supporting the refinement and validation of the final instructional product.

Instruments and Data Collection

Multiple research instruments were employed to collect data throughout the development process, ensuring that each stage of the Research and Development framework was supported by appropriate empirical evidence. Data collection was aligned with the objectives of each ADDIE phase, including needs assessment, product validation, practicality evaluation, and effectiveness testing. During the analysis phase, teachers completed a structured needs analysis questionnaire and participated in semi-structured interviews to identify existing instructional practices, learning challenges, technological readiness, and the need for culturally contextualized learning resources. The information obtained from these instruments served as the primary basis for designing the interactive worksheet and selecting Jambi local wisdom as the contextual learning content. Following product development, the prototype underwent expert validation involving specialists in instructional content, educational media, and early childhood education. The validation instruments assessed curriculum alignment, content accuracy, pedagogical appropriateness, language clarity, visual design, accessibility, and instructional usefulness. After revisions based on expert recommendations, classroom implementation was conducted to examine the practicality and effectiveness of the developed worksheet. Practicality data were collected through teacher response questionnaires evaluating ease of use, instructional feasibility, learner engagement, and perceived usefulness during classroom implementation. Product effectiveness was measured using a numeracy performance assessment administered before and after the intervention through a one-group pretest–posttest design. The assessment evaluated children's competencies in number recognition, classification, comparison, pattern recognition, simple arithmetic operations, and measurement. The use of multiple instruments enabled comprehensive evaluation of the instructional product from pedagogical, technical, and learning outcome perspectives, thereby strengthening the credibility of the development process.

Table 3. Research instruments and data collection

Research stage	Instrument	Participants	Purpose	Data generated
Analysis	Needs analysis questionnaire	Teachers	Identify classroom conditions, instructional needs, and technology readiness	Quantitative
Analysis	Semi-structured interview	Teachers	Explore instructional challenges and learning needs	Qualitative
Development	Content validation questionnaire	Material expert	Evaluate curriculum alignment and instructional content	Quantitative

Development	Media validation questionnaire	Media expert	Evaluate interface design, accessibility, and usability	Quantitative
Development	Pedagogical validation questionnaire	Early childhood education expert	Evaluate developmental appropriateness	Quantitative
Implementation	Practicality questionnaire	Teachers	Assess usability and instructional feasibility	Quantitative
Implementation	Numeracy assessment (Pretest)	Preschool children	Measure baseline numeracy skills	Quantitative
Implementation	Numeracy assessment (Posttest)	Preschool children	Measure learning improvement after intervention	Quantitative

The collected data represented complementary sources of evidence that informed each stage of product development. Qualitative findings obtained from teacher interviews supported the interpretation of quantitative questionnaire results by providing contextual explanations regarding classroom practices and instructional needs. Similarly, expert validation findings guided product revision before classroom implementation, while teacher evaluations and children's learning outcomes were used to determine the overall quality of the developed interactive worksheet. The integration of qualitative and quantitative evidence ensured comprehensive evaluation of the instructional product throughout the development process.

Data Analysis

The collected data were analyzed using descriptive and inferential statistical techniques according to the objectives of each stage of the development process. Quantitative data obtained from the needs analysis questionnaire were summarized using descriptive statistics, including mean scores and response frequencies based on a five-point Likert scale. Qualitative data collected through teacher interviews were analyzed descriptively to identify instructional challenges, classroom conditions, and expectations regarding culturally responsive instructional media. These findings served as the foundation for determining the specifications of the interactive worksheet during the design stage. Product validity was evaluated using expert judgment scores, which were converted into percentage values to determine the level of validity of the instructional product. In addition, the content validity of each instrument was examined using Aiken's V coefficient, enabling the researchers to determine the degree of agreement among expert validators regarding the relevance of each evaluation item. Product practicality was analyzed by comparing the obtained questionnaire scores with the maximum possible scores and converting the results into percentage values that were subsequently classified into predetermined interpretation categories. To evaluate instructional effectiveness, children's numeracy scores obtained from the pretest and posttest were first examined using the Shapiro–Wilk normality test. When the data met the normality assumption, differences between pretest and posttest scores were analyzed using a paired-samples *t*-test. Conversely, when the normality assumption was violated, the Wilcoxon Signed-Rank Test was employed as the appropriate non-parametric alternative. Furthermore, the magnitude of learning improvement was calculated using the normalized gain (N-Gain) to determine the effectiveness of the developed worksheet in improving preschool children's numeracy skills. All statistical analyses were conducted using a significance level of 0.05, indicating statistically significant differences when the probability value was less than or equal to the established threshold.

Table 4. Summary of data analysis procedures

Research objective	Data source	Analysis technique	Expected outcome
Identify instructional needs	Questionnaire	Descriptive statistics (mean and frequency)	Description of classroom needs
Explore classroom challenges	Interview	Qualitative descriptive analysis	Identification of instructional problems
Evaluate product validity	Expert validation	Percentage analysis and Aiken's V	Validity level
Evaluate product practicality	Teacher questionnaire	Percentage analysis	Practicality level
Evaluate product effectiveness	Pretest–posttest	Shapiro–Wilk normality test	Data distribution
Test learning improvement	Pretest–posttest	Paired-samples *t*-test or Wilcoxon Signed-Rank Test	Statistical significance
Measure effectiveness	Pretest–posttest	Normalized Gain (N-Gain)	Magnitude of learning improvement

Research Procedure

The research procedure followed the five sequential stages of the ADDIE instructional design model, ensuring that the instructional product was developed systematically and continuously refined throughout the research process. During the analysis stage, researchers examined curriculum requirements, classroom learning conditions, children's developmental characteristics, and teachers' instructional needs through questionnaires and interviews. The findings obtained during this stage were used to identify learning problems and establish the instructional specifications of the interactive worksheet. During the design stage, learning objectives, worksheet structure, numeracy activities, interface design, and the integration of Jambi local wisdom were systematically planned in accordance with the developmental characteristics of preschool children. The development stage involved producing the initial prototype of the interactive worksheet, followed by expert validation to evaluate instructional content, media quality, pedagogical appropriateness, and overall usability. Recommendations provided by expert validators were incorporated into the revised version of the instructional product before classroom implementation. Subsequently, the implementation stage consisted of small-group and large-group classroom trials involving preschool children to examine product practicality and instructional effectiveness under authentic learning conditions. Teachers also evaluated the usability of the worksheet during classroom instruction and provided additional feedback for product refinement. Finally, the evaluation stage integrated evidence obtained from expert validation, teacher responses, classroom observations, and children's numeracy learning outcomes to determine whether the developed worksheet satisfied the predetermined criteria of validity, practicality, and effectiveness. The evaluation findings also served as the basis for producing the final version of the Jambi local wisdom-based interactive worksheet. Overall, the systematic application of the ADDIE model ensured that the developed instructional product underwent continuous improvement while generating empirical evidence supporting its implementation in early childhood mathematics education.

RESULTS AND DISCUSSION

Results

Needs Analysis

The needs analysis was conducted at TK Islam An-Nizham, Jambi, from September 8 to 11, 2025, through classroom observations, teacher interviews, and a needs assessment questionnaire. Classroom observations indicated that the numeracy skills of children aged 5–6 years had not developed optimally. Several children experienced difficulties recognizing number symbols, extending simple patterns, comparing quantities, and understanding measurement concepts. Teacher interviews further revealed that numeracy instruction predominantly relied on conventional concrete media, including blocks, beads, puzzles, and number cards. Although these materials were useful for introducing basic mathematical concepts, teachers reported that they were not always sufficient to sustain children's attention and provide interactive learning experiences. The questionnaire results confirmed the need for a more contextual and technology-supported learning medium. The overall needs assessment produced a mean score of 4.27 out of 5.00, equivalent to 85.4%, indicating a very high level of need for an interactive worksheet integrating Jambi local wisdom. As presented in Table 5, the highest mean scores were recorded for the need for numeracy materials (M = 4.75) and local wisdom-based learning media (M = 4.76). These findings indicate that teachers considered culturally contextualized digital media particularly important for strengthening early numeracy learning.

Table 5. Summary of the Needs Analysis

Component	Mean	Percentage (%)	Category
Current learning condition	4.07	81.3	High
Learning problems	3.64	72.8	High
Need for local wisdom-based media	4.76	95.2	Very High
Need for numeracy materials	4.75	95.0	Very High
Teachers' technological readiness	4.07	81.3	High
Overall	**4.27**	**85.4**	**Very High**

Product Design

Based on the needs analysis, the interactive worksheet was designed following the ADDIE instructional design model. The learning objectives were aligned with the cognitive learning outcomes of the Indonesian Merdeka Curriculum, focusing on seven early numeracy competencies: recognizing numbers from 1–20, classifying objects, identifying and extending patterns, comparing quantities, performing simple addition, performing simple subtraction, and understanding standard measurement concepts. The worksheet combined instructional texts, culturally relevant illustrations, audio narration, interactive exercises, and game-based evaluation activities. Visual elements representing Jambi local wisdom, including traditional foods, musical instruments, and regional landmarks, were developed using Ibis Paint X and integrated into Canva. The product consisted of a cover page, navigation menu, learning objectives, instructional materials, interactive activities, and assessment tasks. Interactive feedback was provided through touchscreen activities displayed on a Smart Interactive Flat Panel television, accompanied by positive audio reinforcement for correct responses and encouraging feedback for incorrect answers.

Product Validation

The developed prototype underwent expert validation involving specialists in educational media, instructional content, and early childhood numeracy assessment. As presented in Table 2, all validation components achieved very high validity.

Table 6. Expert Validation Results

Validator	Percentage (%)	Category
Media Expert	91.6	Very Valid
Content Expert	100	Very Valid
Numeracy Instrument Expert	94.2	Very Valid

The educational media expert awarded a validity score of 91.6%, indicating that the worksheet demonstrated excellent visual quality, layout organization, readability, usability, and instructional presentation. The content expert assigned a perfect validity score of 100%, confirming that the instructional materials were fully aligned with curriculum requirements and appropriate for the developmental characteristics of children aged 5–6 years. Likewise, the numeracy assessment expert reported a validity score of 94.2%, demonstrating that the assessment indicators appropriately represented early childhood numeracy competencies, including classification, pattern recognition, counting, arithmetic operations, and measurement.

Product Revision

Following expert validation, several revisions were implemented to improve the instructional quality of the product. The revisions included refining the learning objectives, increasing font size and readability, reorganizing numeracy indicators according to children's developmental sequence, replacing the problem-solving indicator with pattern recognition activities, adding more classification components, and improving the visual precision of measurement illustrations. These revisions enhanced the consistency between instructional objectives, learning activities, and assessment indicators prior to classroom implementation.

Focus Group Discussion

The revised product was subsequently evaluated through a Focus Group Discussion involving five early childhood teachers. Teachers assessed the worksheet across fifteen indicators related to visual appearance, curriculum alignment, instructional language, interactivity, usability, and overall feasibility. The overall teacher evaluation reached 91%, indicating a very good level of feasibility. Teachers particularly appreciated the clarity of illustrations, curriculum relevance, interactive learning activities, and ease of classroom implementation. Minor suggestions primarily focused on increasing the variety of learning activities and refining several visual elements before large-scale implementation.

Table 7. Summary of Focus Group Discussion

Evaluation Aspect	Percentage	Category
Overall teacher evaluation	91%	Very Good

Large-Group Implementation

The large-group implementation was conducted with 15 children enrolled in Class B3 at TK Islam An-Nizham. A one-group pretest–posttest design was employed to evaluate children's numeracy development after using the interactive worksheet. During classroom implementation, children demonstrated high levels of engagement throughout the learning sessions. They actively interacted with touchscreen activities, answered questions enthusiastically, and frequently requested to repeat completed tasks. Classroom observations suggested that integrating interactive multimedia with culturally contextualized learning materials effectively increased children's participation and learning motivation.

Improvement in Numeracy Ability

The descriptive analysis demonstrated a substantial improvement in children's numeracy performance following the intervention. The mean pretest score increased from 14.20 to 25.73, representing an average improvement of 11.53 points.

Table 8. Comparison of Pretest and Posttest Scores

Variable	Mean	Category
Pretest	14.20	Developing
Posttest	25.73	Very Well Developed

Before the intervention, eight children were categorized as Developing, whereas seven children were categorized as Well Developed. Following implementation, fourteen children reached the Very Well Developed category, while only one child remained in the Well Developed category. Importantly, every participant demonstrated improvement between the pretest and posttest assessments.

Statistical Analysis

The Shapiro–Wilk test indicated that the pretest scores were normally distributed (p = .096), whereas the posttest scores were not normally distributed (p = .015). Consequently, differences between the pretest and posttest scores were analyzed using the Wilcoxon Signed-Rank Test.

Table 9. Statistical Analysis

Analysis	Statistic	p-value
Shapiro–Wilk (Pretest)	W = .900	.096
Shapiro–Wilk (Posttest)	W = .844	.015
Wilcoxon Signed-Rank Test	Z = –3.413	.001

The Wilcoxon Signed-Rank Test revealed a statistically significant improvement in children's numeracy performance following implementation of the interactive worksheet (Z = –3.413, p = .001). These findings indicate that the interactive worksheet significantly improved early numeracy achievement during the large-group implementation.

Learning Effectiveness

To determine the magnitude of learning improvement, normalized gain (N-Gain) analysis was performed. The mean N-Gain score reached 0.8545, while the mean N-Gain percentage was 85.45%.

Table 10. N-Gain Analysis

Indicator	Mean	Category
N-Gain Score	0.8545	High
N-Gain Percentage	85.45%	Very Effective

The average N-Gain score exceeded the threshold of 0.70, indicating a high level of learning improvement, while the average percentage was categorized as very effective. These findings demonstrate that the interactive worksheet produced substantial improvements in children's numeracy abilities relative to their initial performance.

Practicality Evaluation

Following classroom implementation, the classroom teacher evaluated the practicality of the interactive worksheet using a ten-item questionnaire. The product obtained an overall practicality score of 95%, indicating a very practical level of usability.

Table 11. Practicality Evaluation

Component	Percentage	Category
Teacher Practicality	95%	Very Practical

The teacher reported that the worksheet was easy to operate, systematically organized, engaging for children, and highly effective in increasing learning motivation. Furthermore, the integration of local cultural contexts and interactive multimedia features facilitated children's understanding of numeracy concepts while supporting enjoyable classroom learning experiences.

Overall Product Evaluation

The overall evaluation demonstrated that the developed interactive worksheet satisfied the three principal quality criteria required for educational product development. Expert validation confirmed excellent product validity, teacher evaluations demonstrated high practicality and usability, and statistical analyses verified the effectiveness of the worksheet in improving children's numeracy performance. Collectively, the findings indicate that the Jambi local wisdom-based interactive worksheet is valid, practical, and effective for supporting numeracy learning among children aged 5–6 years. The integration of culturally meaningful learning contexts with interactive digital technology provides an engaging learning environment capable of strengthening children's understanding of early mathematical concepts while increasing classroom participation and learning motivation.

Discussion

The findings demonstrate that the Jambi local wisdom-based interactive worksheet effectively improved the numeracy abilities of children aged 5–6 years, as evidenced by the significant increase in posttest scores, the high normalized gain value, and the positive responses from teachers during classroom implementation. This improvement indicates that integrating interactive digital technology with culturally meaningful learning experiences creates a learning environment that is more engaging and developmentally appropriate for young children. The substantial improvement observed across all numeracy indicators suggests that children benefited not only from repeated exposure to mathematical concepts but also from learning activities situated within familiar cultural contexts, thereby facilitating more meaningful conceptual construction. From a constructivist perspective, children learn mathematical concepts more effectively when they actively interact with concrete representations and connect new knowledge with their prior experiences (Quigley, 2021; Vale & Barbosa, 2023). The interactive features embedded in the worksheet, including immediate feedback, touchscreen interaction, audio reinforcement, and contextual visual representations, likely enhanced children's cognitive engagement throughout the learning process (Aloizou et al., 2025; Ruslan et al., 2026; Xu et al., 2021). Such learning experiences reduce passive participation and encourage children to become active constructors of mathematical understanding rather than merely recipients of information. Moreover, the integration of traditional foods, musical instruments, and regional landmarks from Jambi transformed abstract numerical concepts into authentic learning situations that children could easily recognize and interpret. This contextualization appears to have strengthened children's conceptual understanding because mathematical ideas were presented within environments closely related to their daily lives. Consequently, the effectiveness of the developed worksheet should be interpreted not simply as the result of digital technology itself but rather as the combined influence of interactivity, contextual learning, and culturally relevant instructional design. These findings reinforce the argument that early childhood numeracy development can be substantially enhanced when digital learning environments simultaneously support cognitive engagement, contextual relevance, and active learner participation.

The present findings are consistent with previous studies reporting that interactive digital learning media contribute positively to children's mathematical achievement by increasing learning motivation, maintaining attention, and facilitating conceptual understanding. Recent research on context-based interactive PowerPoint media for early childhood numeracy similarly demonstrated that interactive multimedia significantly improved children's numeracy competencies by providing attractive visual representations and structured learning activities. Comparable findings were also reported in studies developing interactive digital worksheets for mathematics education, where digital worksheets were found to achieve high validity, practicality, and effectiveness in strengthening students' numeracy performance. Likewise, investigations into inquiry-based digital worksheets have shown that integrating interactive digital activities promotes higher engagement and improves mathematical reasoning through active exploration rather than passive instruction. The consistency between the present study and these previous investigations suggests that interactivity represents one of the primary mechanisms through which digital instructional media enhance mathematics learning (I.-H. Chen et al., 2020; Radović et al., 2020; Zhao et al., 2021). However, the current study extends previous findings by demonstrating that interactive worksheets can be successfully implemented in early childhood education while simultaneously incorporating local cultural elements into numeracy instruction. Whereas many earlier digital learning media emphasized technological innovation alone, the present worksheet integrates technology with meaningful cultural experiences familiar to children. This additional contextual dimension may explain the remarkably high practicality and effectiveness observed during classroom implementation because children interacted with mathematical problems situated within recognizable social and cultural environments. Consequently, the present study contributes additional empirical evidence that effective digital learning environments should not only provide technological sophistication but also establish meaningful relationships between instructional content and learners' everyday experiences. These findings therefore strengthen the growing body of evidence supporting the educational value of interactive digital worksheets as effective instructional media for improving early mathematics learning outcomes.

Another important finding concerns the integration of Jambi local wisdom into the instructional design, which appears to have contributed substantially to children's engagement and learning effectiveness. Embedding cultural elements within mathematics instruction allows children to connect abstract mathematical ideas with familiar objects, traditions, and experiences encountered in their daily environment. Such culturally responsive learning environments promote meaningful learning because new concepts are introduced through contexts that children already understand and value. Previous studies have likewise demonstrated that integrating local wisdom into digital learning media improves students' motivation, participation, and conceptual understanding across various educational contexts. Research on local culture-based interactive mathematics media has similarly reported significant improvements in children's mathematical abilities after learning activities were contextualized using familiar cultural representations (Asare, 2026; Sunzuma & Umbara, 2025; Zuliana et al., 2025). Comparable evidence has also been reported in studies examining augmented reality learning resources, culturally responsive digital worksheets, and multimedia teaching materials based on local wisdom, all of which concluded that contextual cultural integration enhances learning effectiveness beyond the contribution of technology alone (Pattaufi et al., 2025). These findings support the theoretical assumption that cultural relevance functions as an important mediator between instructional design and learner engagement because students are more willing to participate when learning activities reflect their social identities and everyday experiences. In the present study, the incorporation of Jambi traditional foods, musical instruments, and regional landmarks transformed mathematical exercises into authentic learning

experiences that were both educationally meaningful and culturally familiar. This contextual authenticity likely increased children's curiosity, sustained their attention during learning activities, and reduced the cognitive distance between mathematical symbols and real-world experiences. Therefore, the present study provides additional evidence that combining interactive technology with local cultural knowledge constitutes an effective pedagogical strategy for strengthening early childhood numeracy while simultaneously preserving cultural identity within contemporary educational practice.

The quality of the developed interactive worksheet is further reflected in its high levels of validity, practicality, and effectiveness, indicating that the product successfully fulfilled the essential quality criteria of educational product development. High expert validation scores demonstrate that the instructional content, interface design, assessment indicators, and technological features were well aligned with curriculum requirements and the developmental characteristics of children aged 5–6 years. This finding supports previous development studies reporting that expert validation is a fundamental stage for ensuring instructional accuracy, media usability, and pedagogical appropriateness before classroom implementation. The positive responses obtained during the Focus Group Discussion and the high practicality score further indicate that the worksheet was considered feasible, understandable, and easy to implement within authentic classroom settings. These findings are consistent with previous Research and Development studies showing that educational products receiving iterative expert feedback and teacher evaluation tend to demonstrate higher implementation quality and greater classroom acceptance (Torres-Peña et al., 2024; Xing et al., 2025; Zeng, 2020). The revisions conducted following expert recommendations, including improvements to typography, instructional objectives, assessment indicators, and visual representations, illustrate the importance of formative evaluation throughout the ADDIE development process. Such iterative refinement enables developers to improve both instructional effectiveness and user experience before conducting field implementation. The convergence of high validity, practicality, and effectiveness observed in this study suggests that these three dimensions are mutually reinforcing rather than independent indicators of product quality. Consequently, the success of the developed worksheet should be attributed not only to its technological features but also to the systematic instructional design process that integrated expert review, teacher feedback, and classroom evaluation into continuous product improvement. Therefore, the present findings provide further empirical evidence supporting the effectiveness of the ADDIE model as a comprehensive framework for developing culturally responsive digital learning media in early childhood mathematics education.

The present study contributes to the growing body of literature on early childhood mathematics education by demonstrating that integrating interactive digital technology with local cultural knowledge can simultaneously enhance learning quality and preserve children's cultural identity. Unlike many previous studies that focused primarily on technological innovation or multimedia design, this research incorporated culturally meaningful contexts into every stage of numeracy instruction, allowing mathematical concepts to be learned through authentic representations of children's everyday environment. This integration represents the principal novelty of the study because local wisdom functioned not merely as supplementary content but as an instructional context that structured children's mathematical experiences. Such an approach extends current perspectives on culturally responsive mathematics education by illustrating how digital instructional media can strengthen conceptual understanding while maintaining cultural relevance. Furthermore, the findings suggest that contextualizing mathematical learning through familiar cultural objects may reduce cognitive abstraction and facilitate children's transition from concrete experiences to symbolic mathematical thinking (Altindis & Fonger, 2025; Aprinastuti &

Kovács, 2025; Breive, 2022). The study also demonstrates that technological innovation alone is insufficient to maximize learning outcomes unless it is accompanied by instructional strategies that are developmentally appropriate and culturally meaningful. Consequently, future educational media should prioritize the integration of pedagogical principles, technological affordances, and local cultural resources rather than emphasizing digital features in isolation. Although the present investigation was conducted within a limited developmental setting, the consistently positive results indicate considerable potential for adapting similar culturally responsive interactive worksheets to other regions with different local cultural characteristics. Future studies employing larger samples, experimental designs, and longitudinal observations would provide stronger evidence regarding the long-term effectiveness and broader applicability of this instructional approach. Overall, the findings reinforce the view that culturally grounded interactive learning media represent a promising direction for promoting sustainable, engaging, and meaningful numeracy education in early childhood settings.

Implications

The findings of this study have important theoretical, pedagogical, and practical implications for the development of early childhood numeracy education. Theoretically, this study extends the understanding of culturally responsive mathematics learning by demonstrating that the integration of local wisdom into interactive digital media can provide meaningful contexts that support children's conceptual construction of early numeracy. The results also reinforce the Cognitive Theory of Multimedia Learning by showing that the combination of visual representations, audio feedback, and interactive activities can facilitate young children's processing of mathematical information through multiple cognitive channels. From a pedagogical perspective, the study highlights the importance of designing numeracy instruction that actively engages children through contextual learning experiences rather than relying solely on conventional teacher-centered approaches. The integration of Jambi traditional foods, musical instruments, and regional landmarks illustrates how local cultural resources can transform abstract mathematical concepts into concrete learning experiences that are more accessible and meaningful for young learners. For teachers, the developed interactive worksheet provides an alternative instructional resource that is not only valid and practical but also capable of increasing children's motivation, participation, and engagement during classroom learning activities. The high practicality scores further suggest that the product can be implemented effectively without requiring sophisticated technological expertise, thereby increasing its potential for adoption in diverse early childhood education settings. For curriculum developers and educational institutions, the findings demonstrate the value of incorporating culturally relevant digital learning resources into the implementation of the Merdeka Curriculum to strengthen children's numeracy competencies while simultaneously preserving local cultural heritage. The study also provides evidence that systematic educational product development using the ADDIE model can generate instructional media that satisfy the essential criteria of validity, practicality, and effectiveness before wider dissemination. Furthermore, the research offers a practical reference for educational technology developers seeking to design digital learning environments that balance pedagogical quality, technological functionality, and cultural relevance. At the policy level, these findings support initiatives encouraging the integration of local wisdom and digital innovation within early childhood education as part of broader efforts to improve foundational numeracy skills and strengthen cultural identity among young learners. Overall, this study demonstrates that culturally grounded interactive learning media represent a promising and sustainable approach for enhancing early childhood numeracy education while fostering meaningful learning experiences that connect mathematics with children's everyday cultural environment.

Limitations and Suggestions for Future Research

This study has several limitations that should be considered when interpreting its findings and planning future investigations. First, the effectiveness evaluation was conducted using a one-group pretest–posttest design without a control group, limiting the ability to establish causal relationships between the intervention and the observed improvements in children's numeracy performance. Second, the study involved a relatively small sample of only 15 children from a single early childhood education institution, which may restrict the generalizability of the findings to broader educational contexts. Third, the implementation period was relatively short, preventing the examination of the long-term retention of numeracy skills and the sustainability of children's learning outcomes after the intervention. Fourth, the developed interactive worksheet focused specifically on foundational numeracy competencies, including number concepts, pattern recognition, comparison, basic arithmetic operations, and measurement, without extending to other domains of early mathematical thinking such as geometry, spatial reasoning, or problem-solving. Fifth, the integration of local wisdom was limited to cultural elements from Jambi Province, and therefore the findings may not fully represent the effectiveness of culturally responsive learning media in regions with different sociocultural characteristics. In addition, the practicality assessment relied primarily on teacher perceptions, while broader evaluations involving parents, school administrators, and other educational stakeholders were not included. Future research is therefore recommended to employ more rigorous experimental or quasi-experimental designs involving comparison groups to provide stronger evidence regarding the effectiveness of culturally responsive interactive learning media. Studies involving larger and more diverse samples across multiple schools and geographical regions would also strengthen the external validity and generalizability of the findings. Longitudinal research is further needed to examine whether the improvements in children's numeracy abilities are maintained over extended periods and whether repeated use of the interactive worksheet contributes to sustained mathematical development. Future studies should also explore the integration of additional mathematical domains and emerging educational technologies, such as augmented reality, artificial intelligence, or adaptive learning systems, to create more personalized and immersive learning experiences. Finally, comparative investigations involving local wisdom from different cultural regions would provide valuable insights into how culturally responsive digital learning media can be adapted to diverse educational settings while preserving local identity and enhancing early childhood numeracy development.

CONCLUSION

This study successfully developed and evaluated a Jambi local wisdom-based interactive worksheet designed to enhance the numeracy abilities of children aged 5–6 years through the systematic implementation of the ADDIE development model. The needs analysis confirmed a strong demand for interactive and culturally contextualized digital learning media that align with the developmental characteristics of young children and the objectives of the Merdeka Curriculum. The expert validation results demonstrated that the developed worksheet achieved very high levels of validity in terms of educational media design, instructional content, and early childhood numeracy assessment, indicating that the product is suitable for classroom implementation. Revisions based on expert recommendations further improved the instructional quality, visual presentation, and developmental appropriateness of the worksheet prior to field testing. Teacher evaluations obtained through the Focus Group Discussion and practicality assessment consistently indicated that the worksheet was highly feasible, easy to use, and capable of supporting enjoyable classroom learning experiences. The large-group implementation revealed a substantial improvement in children's

numeracy performance, reflected by the significant increase in posttest scores compared with pretest scores and confirmed by the Wilcoxon Signed-Rank Test. The high normalized gain score further demonstrated that the interactive worksheet was highly effective in strengthening children's understanding of number concepts, pattern recognition, comparison, basic arithmetic operations, and measurement. These findings suggest that combining interactive multimedia features with culturally meaningful learning contexts can create engaging educational experiences that promote active participation and meaningful conceptual learning among young children. The integration of Jambi traditional foods, musical instruments, and regional landmarks provided authentic learning contexts that helped reduce the abstraction of mathematical concepts while simultaneously strengthening children's connection to their local cultural environment. Beyond improving numeracy achievement, the developed worksheet illustrates how educational technology can simultaneously support curriculum implementation, preserve local cultural heritage, and foster developmentally appropriate learning experiences. The study therefore contributes to the growing body of research on culturally responsive digital learning by providing empirical evidence that local wisdom can function as an effective instructional context rather than merely as supplementary content within technology-enhanced mathematics education. Overall, the findings demonstrate that the Jambi local wisdom-based interactive worksheet is a valid, practical, and highly effective instructional medium with considerable potential to support early childhood numeracy education and to serve as a model for developing culturally responsive digital learning resources in diverse educational settings.

AUTHOR CONTRIBUTIONS STATEMENT

Anniska Nuria contributed to the conceptualization of the study, research design, data collection, product development, data curation, formal analysis, visualization, and preparation of the original manuscript draft. Stiyo Utoyo contributed to the research methodology, supervision of the development process, validation of the instructional design, interpretation of the findings, and critical revision of the manuscript. Delfi Eliza contributed to the validation of the educational content, methodological refinement, interpretation of the results, and manuscript review and editing. Nenny Mahyuddin contributed to the supervision of the research, evaluation of the instructional product, validation of the research outcomes, and critical review of the manuscript for important intellectual content. All authors reviewed, approved, and agreed to the final version of the manuscript prior to submission.

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