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Development of interactive e-worksheets to improve counting skills of children aged 5-6 years

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ABSTRACT

This research aims to develop a valid, practical, and effective interactive e-worksheet utilizing Canva, and Liveworksheets platforms based on Jerome Bruner's cognitive development theory (enactive, iconic, symbolic) to improve the counting abilities of children aged 5-6 years. Using the ADDIE (Analyze, Design, Develop, Implement, Evaluate) research and development (R&D) model, this study was conducted at TK Pautan Hati Sungai Tambang during the 2025/2026 academic year. The subjects consisted of 5 children for the pilot test and 20 children for the field test. Data were collected using expert validation sheets, teacher practicality questionnaires, and children's counting performance tests (pretest and posttest). Formative evaluation from media, material, and evaluation experts showed a cumulative validation score of 94.08% (Highly Valid). The teacher's practicality response reached 97.00% (Highly Practical). Furthermore, quantitative analysis demonstrated a significant increase in children's average counting scores from 53.25 (pretest) to 89.50 (posttest). The efficiency was confirmed by a Normalized Gain (N-Gain) score of 0.776 (High Effectiveness) and a Wilcoxon Signed Rank Test significance value of 0.000 ($p<0.05$). In conclusion, the developed interactive e-worksheet is highly feasible, practical, and effective to be implemented in early childhood numerative learning.

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Introduction

Early Childhood Education (ECE) represents a fundamental stage of education because it provides the foundation for children's subsequent cognitive, physical, language, social-emotional, and creative development. Early childhood, generally encompassing children aged 0–8 years, is characterized by rapid developmental changes that require appropriate and developmentally responsive learning experiences (Arwin et al., 2022). During this period, appropriate stimulation is particularly important for strengthening children's readiness to engage in more structured learning at the next educational level (Nengsih et al., 2022; Litna et al., 2025). Among the cognitive competencies that require early stimulation, numeracy is essential because it supports children's ability to recognize quantities, understand numerical relationships, and develop foundational mathematical reasoning.

In the Indonesian context, the importance of developing foundational competencies has been reinforced through the "Fun PAUD to Elementary School Transition Movement," which emphasizes a developmentally appropriate transition from early childhood education to primary school. This orientation requires early

numeracy to be introduced through meaningful and enjoyable learning experiences rather than through excessive academic drilling (Muharram & Karim, 2019; Sarte et al., 2021). For children aged 5–6 years, early numeracy involves recognizing numbers and number symbols, understanding numerical sequences and quantities, and performing simple addition and subtraction using concrete or meaningful representations (Utoyo, 2017; Handrianto et al., 2021). Therefore, learning experiences should enable children to progressively connect concrete actions, visual representations, and mathematical symbols rather than merely memorize numbers (Delfia & Mayar, 2019; Matt et al., 2022).

Despite its importance, developing early numeracy remains challenging when learning activities rely heavily on conventional worksheets and teacher-centered instruction. Although PISA data concern older students and cannot directly represent the numeracy competence of children aged 5–6 years, Indonesia's relatively low mathematics performance provides broader evidence of persistent challenges in mathematics learning (Zainil et al., 2024; Hasnur et al., 2025). More specifically, preliminary observations and teacher interviews at Link-Hati Sungai Tambang Kindergarten indicated that several children experienced difficulties recognizing number symbols, sequencing numbers, and correctly reproducing the symbols 3, 4, 5, 6, and 9 (Tatia & Wulansari, 2025). Classroom activities were also predominantly supported by printed worksheets, whiteboards, and relatively monotonous learning procedures with limited opportunities for interactive digital engagement (Gultom & Muchtar, 2020; Arwin et al., 2024). These conditions indicate a need for learning media that provide more visual, interactive, and developmentally appropriate numeracy experiences.

Interactive digital worksheets offer an opportunity to address these limitations by transforming conventional worksheets into learning environments that combine visual representation, interaction, feedback, and child-centered activities. Digital platforms such as Canva, Liveworksheets, and Wordwall can support attractive visual design, drag-and-drop activities, multimedia content, and interactive exercises that encourage children to participate actively rather than simply complete static tasks (Rumasoreng et al., 2023). From a developmental perspective, children aged 5–6 years are predominantly in Piaget's preoperational stage and therefore benefit from visual and concrete representations when developing symbolic mathematical understanding (Inhelder, 1969; Jusoh et al., 2023). Interactive multimedia involving images, animations, audio, and direct manipulation can consequently facilitate the transition from concrete experiences to numerical representations while maintaining children's engagement (Fitriana, 2024).

However, the use of digital media alone does not guarantee developmentally meaningful numeracy learning; its instructional structure must be grounded in an appropriate cognitive framework. Therefore, this study adopts Jerome Bruner's enactive, iconic, and symbolic stages as the primary framework for organizing numeracy activities, while Piaget's developmental perspective provides complementary justification for the use of concrete and visual representations. Previous studies have demonstrated the potential of digital and interactive media, yet limited attention has been given to interactive e-worksheets that systematically integrate these three Brunerian stages for early numeracy learning among children aged 5–6 years. This gap provides the basis for developing an Interactive E-Worksheet that integrates Canva, Liveworksheets, and Wordwall to progressively connect object manipulation, visual representation, and numerical symbols. Accordingly, this study aims to develop and evaluate an Interactive E-Worksheet based on Bruner's cognitive representation stages in terms of its validity, practicality, and effectiveness in improving the early numeracy skills of children aged 5–6 years.

Method

This research uses a Research and Development (R&D) approach by applying the ADDIE development model which consists of five systematic stages: Analyze, Design, Development, Implementation, and Evaluate (Safitri et al., 2023).

The test subjects in this study were group B children aged 5-6 years at Link-Hati Sungai Tambang Kindergarten. The data collected were qualitative (validator suggestions) and quantitative (questionnaire scores and test scores). The instruments used included a Likert scale questionnaire sheet for validity and practicality, as well as a performance observation sheet to measure the effectiveness of children's counting before and after the intervention. Data was collected through comprehensive instruments including: teacher needs analysis questionnaires, validation sheets of expert teams (media experts, material experts, and instrument experts), questionnaires on the practicality of use by classroom teachers, and observation sheets for children's initial numeracy ability tests (pretest and posttest) to test the level of product effectiveness empirically.

Table 1. ADDIE Model Development Stages

Stages	Main Activities	External/Yield
Analysis	Analysis of teachers/children's needs, analysis of the curriculum of PAUD calculations.	Identify learning problems & essential materials.
Design	Creating material maps, storyboards, layout design in Canva.	Initial design (prototype) cover and digital worksheet.
Development	Integration to Liveworksheets/Wordwall, validation by experts.	Test-ready products & validated instruments.
Implementation	Small group trials & field trials (large groups).	Practicality & effectiveness data (Pretest/Posttest).
Evaluate	Analysis of children's learning outcomes, final reflection on the effectiveness of media.	Final recommendations for the use of E-Worksheet products.

Results and Discussions

Analysis Stage

The initial stage of the research was carried out through filling out a need questionnaire and in-depth interviews with class B teachers.

Table 2. of Results of Analysis of Learning Media Component Needs

Yes	Indicator Needs Aspect	Real Field Conditions	Percentage (%)
1	Effectiveness of Early Counting Stimulation	Dominant use of monotonous printed LKS	85% Requirements
2	Visual Appeal & Digital Animation	Concrete media is limited, less interactive	90% Needs
3	21st Century Technology Integration (Digitalization)	Haven't taken advantage of structured interactive apps yet	95% Requirement
4	Children's Logic-Mathematics Stimulation	Children often write the numbers 3, 4, 5, 9 upside down	80% Requirement

Design & Development Stage

The design of the e-worksheet was developed through the integration of three main digital platforms: Canva for visual and graphic asset design, Liveworksheets for digital interactivity programming, and Wordwall for adaptive quiz creation. The content structure is internalized based on Jerome Bruner's Theory of Cognitive Development which divides instruction into three stages: 1) Enactive Stage: Integration of drag-and-drop interactive features of digital objects in the form of fruits and cute characters to simulate virtual manipulation of physical objects; 2) Iconic Stage: Presents a visualization of the number of objects using meaningful graphics and diagrams without being dominated by complicated written instruction texts for children; 3) Symbolic Stage: Connects the visualization of the number of objects directly with the symbol of formal conceptual numbers (numbers 1-20) as well as the introduction of simple addition and subtraction calculation operations.

Expert Validation and Formative Evaluation

Before being implemented in the field test, the interactive E-Worksheet was assessed by three expert validators using Likert scalebased instruments (Scores 1-4) and through a Focus Group Discussion (FGD) forum.

Table 3. Expert Validation Recapitulation Table on Interactive E-Worksheet

Yes	Expert Validation Category	Average Score	Percentage (%)	Eligibility Categories
1	Media Expert (Design, Graphics, Navigation Systems)	3.76	94.00%	Highly Valid
2	Material Expert (Bruner Stages & Constructivism)	3.85	96.25%	Highly Valid
3	Cognitive Evaluation Instrument Expert	3.68	92.00%	Highly Valid
-	Cumulative Average	3.76	94.08%	Highly Valid / Worthy

A pilot test on 5 children showed a percentage of smooth media operation of 88.5%. The product revision (Table 3) is focused on simplifying the size of the navigation buttons to make them more child-friendly and arranging the contrast of text colors against the background.

Implementation Stage: Practicality and Effectiveness

The field test was carried out on a large group with a sample of 20 children of group B. The results of the product practicality analysis based on the response of the teacher's assessment questionnaire obtained an average score of 3.88 (97.00%) which is included in the Very Practical criteria used in classroom learning management.

Table 4. of Results of Quantitative Analysis of Children's Early Numeracy Ability (N=20)

Measurement Conditions	Minimum Score	Maximum Value	Average (Mean)	Standard Deviation
Pretest (Before Digital Media)	45	65	53.25	6.42
Posttest (After Digital Media)	80	100	89.5	5.87

The product effectiveness analysis was calculated using the Normalized Gain (N-Gain Score) formula and non-parametric hypothesis test through the Wilcoxon Signed Rank Test due to early childhood scale data. The results of the effectiveness test are as follows: 1) Average Score of N-Gain: Obtained a value of g=0.776 (percentage 77.6%), which is included in the category of High Effectiveness/Effective; 2) Wilcoxon Statistical Test Results: Asymp value was obtained. Sig. (2-tailed) = 0.000. Because of the $p<0.05$ value, the null hypothesis (H0) is rejected and the alternative hypothesis (Ha) is accepted.

Based on the results of the statistical test, it was concluded that there was a significant difference between the child's initial numeracy ability before and after the intervention using the Interactive E-Worksheet. Interactive E-Worksheets integrated through the Canva and Liveworksheets platforms were empirically proven to be able to significantly improve the early numeracy skills of children aged 5-6 years (Group B). The success of this development product can be discussed in depth through three main indicator pillars: theoretical validity, practicality in the field, and effectiveness of learning outcomes.

Theoretical Validity and Suitability of Design Based on Children's Characteristics

The formative evaluation process through the assessment of expert validators (media, materials, and instruments) resulted in a cumulative average score of 94.08% which is in the Very Valid category. The high value of the validity of the material (96.25%) is due to the process of internalizing instructional learning which consistently adopts three stages of Jerome Bruner's cognitive development, namely enactive, iconic, and symbolic.

In this E-Worksheet, the enactive stage is digitally manipulated through drag-and-drop activities (Afnita et al., 2025; Auliya et al., 2025; Sudiana et al., 2024). Even though children do not physically touch concrete objects, visual-motor simulations when shifting fruit objects and animated characters on the device screen are able to trigger the child's sensory bridge to understand quantity directly. This activity is in line with Piaget's theory of constructivism which states that early childhood builds its knowledge through active action towards the surrounding environment (Husin et al., 2023; Hiltrimartin et al., 2024).

Furthermore, the iconic stage is realized by minimizing complicated written text instructions and replacing them with contrasting and interesting semi-abstract images/visual diagrams. This has been proven to be able to solve the problem of children who are often confused due to the limited ability to read conventional written instructions (Eriana et al., 2024; R. N. Sari et al., 2024; Widyawati et al., 2024). Finally, at the symbolic level, the child is directed to relate these concrete-iconic understandings directly to the formal number symbols (numbers 1–20) as well as to work on basic mathematical operations. Bruner's gradual structured approach has succeeded in eliminating common mistakes of children in the field, such as writing the numbers 3, 4, 5, and 9 in reverse, because the visual concept of numbers is firmly embedded in children's working memory before they are asked to reproduce it.

The Practicality of Media in Contemporary Learning Management

The analysis of the practicality of the product based on the teacher's response questionnaire obtained an absolute score of 97.00% (Very Practical). These very high numbers indicate that Interactive E-Worksheets provide high efficiency in classroom learning management compared to conventional printed Student Worksheets (LKS).

From the teacher's perspective, the E-Worksheet designed through Liveworksheets provides convenience in the process of evaluating learning outcomes in real-time (real-time evaluation) (Lin & Mariana, 2024; Putri et

al., 2025; M. I. Sari et al., 2020). Teachers no longer need to manually correct children's work one by one with a pen, because the digital system instantly checks the child's answers automatically once the assignment is completed online. This provides space for teachers to act as facilitators who focus more on children who need special assistance (scaffolding).

For children, practicality in the field was evidenced by the smooth operation of the media by 88.5% during the small group test. Post-revision design improvements in the form of increasing the size of the navigation buttons and setting the background color contrast have proven to be successful in creating a child-friendly user interface, thus fostering children's self-directed learning from an early age.

Empirical Effectiveness on Improving Early Numeracy Skills

The most crucial evidence of effectiveness was shown by the surge in the child's mean from 53.25 at the time of the pretest to 89.50 in the posttest measurement. This transformation of children's cognitive abilities is validly supported through the analysis of Normalized Gain (N-Gain) which shows an index of 0.776 (77.6%), a number that confirms that this product is in the High Effectiveness level.

This sharp increase in cognitive performance occurs because Interactive E-Worksheet is able to change the paradigm of early counting learning from a stressful activity into a fun digital gaming experience (gamification of learning). The use of the Wordwall platform as an adaptive quiz in the media provides immediate reinforcement in the form of a clap sound effect when the answer is correct or an encouraging sound when the answer is wrong. This interactive multimedia characteristic successfully maintains the attention span of children aged 5-6 years to stay focused for a longer duration without triggering cognitive overload.

The results of the non-parametric Wilcoxon Signed Rank Test with a significance value of Asymp. Sig. (2-tailed) = 0.000 ($p<0.05$) absolutely rejects H0, which confirms that the change in children's numeracy ability is not a coincidence but rather a direct intervention effect of the use of this structured digital media. These findings reinforce the urgency of implementing the Fun PAUD-SD Transition movement, where the introduction of basic numeracy literacy in children should not be forced through rigid paper-and-pencil drilling methods, but must be bridged by interactive media that is adaptive and stimulates children's natural curiosity.

Conclusions

The Interactive E-Worksheet developed through the ADDIE model and integrating Canva and Liveworksheets was found to be valid, practical, and effective in improving the early numeracy skills of children aged 5–6 years. The product achieved a validity score of 94.08% and a practicality score of 97.00%, indicating its suitability for early childhood learning. Its effectiveness was demonstrated by an increase in the mean score from 53.25 at pretest to 89.50 at posttest, with an N-Gain of 0.776 and a significant Wilcoxon test result ($p < 0.001$). These findings indicate that the Interactive E-Worksheet, structured according to Bruner's enactive, iconic, and symbolic stages, is a feasible digital learning medium for supporting early numeracy development in children aged 5–6 years.

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