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# Learning Through Color: A Narrative Inquiry into Teachers' and Children's Experiences of Color-Coded Worksheet Activities in Indonesian Early Childhood Education

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## ABSTRACT

**Background.** Early childhood cognitive development and early literacy are crucial for building logical thinking and understanding symbols and written language. During the golden age (ages 4-6), brain development peaks, making appropriate stimulation essential. However, innovative learning approaches for children aged 4-5 remain limited. Preliminary observations at Muslimat NU Nurul Islam Kindergarten (Kudus), Islam Plus Khozinatul Ulum Kindergarten (Blora), and Raudhotul Athfal Hidayah (Pati) showed that teachers mostly use conventional worksheets without attractive color variations, resulting in low attention, boredom, and less meaningful learning. Previous studies have examined color-based or worksheet-based interventions separately, but few have integrated color-coding strategies with cognitive and early literacy objectives in a single, developmentally appropriate product.

**Purpose:** This project aims to develop and validate Color-Coded Number Worksheets (LKABW) to support cognitive development and early literacy in children aged 4-5 years.

**Method:** This research and development (R&D) study used the ADDIE model at three locations involving 57 children. Data were collected through surveys, observations, and documentation using teacher questionnaires, observation sheets, and feasibility questionnaires. Media and material experts validated the product, followed by small-scale implementation and evaluation of feasibility and practicality.

**Results:** LKABW achieved very feasible scores from media experts (94.6%) and material experts (100%). Observations of cognitive development and early literacy reached 81.2%, and teacher responses reached 99.2%. These findings indicate that LKABW is feasible and shows potential to support cognitive development and early literacy.

**Conclusion:** This research advances early childhood education by offering an innovative, practical, and colorful alternative to conventional methods, integrating color-coding strategies with cognitive and early literacy activities. Further experimental research with larger samples is recommended to test its causal effectiveness and long-term impact.

## KEYWORDS

Cognitive Development, Color-Coded Worksheets, Early Childhood Education, Early Literacy, Research and Development (ADDIE).

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## INTRODUCTION

Early childhood education (PAUD) is the main foundation in building the quality of human resources, especially in the golden age (*Golden Age*) age 4–6 years at which brain development reaches its peak. Recent neurocognitive research reveals that functional maturation of the brain is directly correlated with improved cognitive performance in children (Kardan et al., 2025). Two aspects of development that are very crucial in this period are cognitive development and early literacy (Ted K. Turesky, Elizabeth Escalante, Megan Loh, 2024). Cognitive development is concerned with the ability to think, solve problems, and classify objects. Meanwhile, early literacy includes the ability of children to recognize symbols, letters, numbers, and understand simple reading (Hilmiyah, 2023).

Early childhood naturally has a high level of curiosity, but without proper stimulation cognitive potential and early literacy can be inhibited. Children need learning experiences that are concrete, fun, and involve a variety of senses (Piaget, 1950). Less innovative and monotonous learning approaches are still found in the field. Many teachers rely on lecture methods or worksheets that are less visually appealing (Arsyad et al., 2024). As a result, children get bored quickly, lack motivation, and do not gain meaningful learning experiences.

Initial observations in three locations, namely Muslimat NU Nurul Islam Kindergarten 23 children (Kudus), Islam Plus Khozinatul Ulum Kindergarten 18 children (Blora), and Raudhotul Athfal Hidayah 16 children (Pati) revealed similar problems. The availability of media for cognitive stimulation and early literacy is very limited, teachers tend to use conventional worksheets without attractive color variations. Children aged 4–5 years show low attention levels, get bored quickly, and don't understand what they're doing. The teachers admitted that they had never received *color-coding-based media development* training or integrated early literacy. In fact, the Independent Early Childhood Education Curriculum requires children to be able to recognize symbols and associate numbers with quantity.

This gap necessitates the development of practical, easy-to-use, yet effective learning media innovations (Endah Windiastuti et al., 2024), namely Color-Coded Number Worksheets (LKABW). The concept of *color-coding* assigns specific colors to numbers to help children distinguish, classify, and remember information more effectively. LKABW contains structured activities such as observing circles of numbers and colors, connecting numbers with colors, coloring images according to numerical instructions, and completing number sequences. This approach leverages the established finding that colors are more easily recognized and remembered by young children than abstract symbols alone (Melniczuk et al., 2025).

Activities *Color-coding* Practice cognitive abilities such as classification, matching, sequencing, and simple problem-solving (Hoffmann et al., 2013; Ubaidillah et al., 2024). This approach is supported by information processing theory which states that color functions as a visual marker that strengthens memory traces (Lestari, P., & Fitriani, 2026). For children in the pre-operational stage, the use of strong visual stimuli such as color bridges the gap between abstract symbols (numbers) and concrete understanding (Damayanti, 2024). The novelty of this research lies in the systematic integration of cognitive stimulation and early literacy within a single Color-Coded Number Worksheet (LKABW). Unlike existing color-based worksheets that focus on isolated skills or use color merely for decoration, LKABW deliberately employs color as a pedagogical scaffold—associating specific colors with numbers to simultaneously enhance number recognition, classification, sequencing, and early literacy skills such as observation and symbol writing. This integration offers a holistic, child-centered approach that addresses multiple developmental domains

in one practical and engaging medium, filling a critical gap in developmentally appropriate learning resources for children aged 4–5 years in Indonesian early childhood education.

This research contributes to the development of early childhood education, especially the design of integrated learning media that targets two aspects of development that are often taught separately. LKABW is designed for the context of Muslimat NU Nurul Islam Kindergarten Kudus, Islam Plus Khozinatul Ulum Kindergarten Blora, and Raudhotul Athfal Hidayah Pati. Practically, the results of this research are expected to be a guide for PAUD teachers in developing similar media that is cheap and easy to make. Thus, the main objective of this project is to develop and validate Color-Coded Number Worksheets to support early childhood cognitive development and literacy in all three locations.

## RESEARCH METHODOLOGY

### Research Design

This study employs a Research and Development (R&D) approach to create and validate Color-Coded Number Worksheets (LKABW) for children aged 4–5 years. The ADDIE model (Analysis, Design, Development, Implementation, Evaluation) was selected over other instructional design models—such as the 4D or ASSURE models—due to its flexible, iterative structure that allows for formative evaluation at each stage, which is essential when addressing the varied cognitive and literacy abilities of young learners (Sari et al., 2026). Unlike linear models focused on dissemination or technology-based instruction, ADDIE's systematic yet practice-oriented phases enable thorough needs assessment, iterative product refinement through expert validation, and field testing in authentic classroom settings before finalization. This responsiveness to contextual and learner-specific factors makes ADDIE particularly suitable for developing print-based learning media that require multiple cycles of validation and revision in early childhood education contexts (Sugiyono, 2019). Each stage produces tangible, evidence-based outputs that inform subsequent phases, ensuring the final LKABW product is both theoretically grounded and practically relevant to the needs of teachers and children in the participating institutions.

### Analysis

The analysis stage was conducted through classroom observations and semi-structured interviews with six teachers (two from each of three institutions: Muslimat NU Nurul Islam Kindergarten Kudus, Islam Plus Khozinatul Ulum Kindergarten Blora, and Raudhotul Athfal Hidayah Pati. Observations focused on five indicators: media availability, children's engagement, teaching strategies, children's responses to worksheets, and integration of cognitive and literacy activities. Semi-structured interviews (30–45 minutes each) explored current practices, challenges, and teacher expectations. Interview transcripts were inductively coded to identify recurring themes, while observational data were categorized based on the five indicators. These findings directly informed the design of the Color-Coded Number Worksheets (LKABW), ensuring alignment with identified needs and institutional contexts.

### Design

Based on the results of the analysis, LKABW was designed by determining learning objectives, indicators of cognitive development and early literacy, and activity mechanisms. Learning indicators include the ability to recognize numbers 1–10, associate numbers with colors, connect numbers and colors, fill in numbers according to color codes, color according to

instructions, and complete sequence of numbers. The visual components are designed simply with contrasting colors to attract the attention of early childhood (Susanti & Anhar, 2025).

**Development**

The development of LKABW was conducted in two stages: product creation and expert validation. The product was developed as a color-printed worksheet containing ten structured activities targeting number recognition, color association, classification, sequencing, and observational skills. Expert validation involved two validators: a media expert (master's in educational technology, 10+ years of experience) and a material expert (doctorate in early childhood education). Validation used a Likert scale (1–5) across five media criteria (quality, illustration, attractiveness, safety, durability) and five material criteria (content accuracy, developmental alignment, clarity, relevance, and *color-coding* integration). Feasibility was determined using the formula: (obtained score / maximum score) × 100, with scores of 81%–100% categorized as "very feasible" (usable without revision), 61%–80% as "feasible" (usable with minor revisions), and below 60% requiring major revision or rejection. Qualitative feedback was also collected to guide product improvement before field testing.

**Implementation**

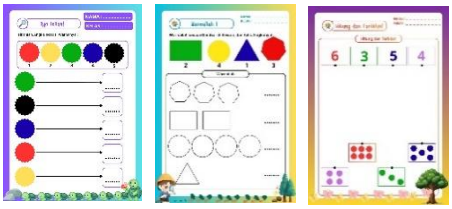
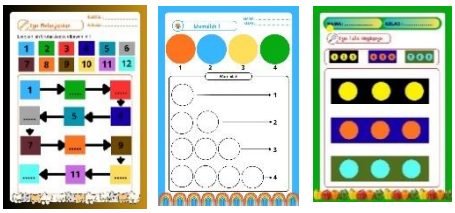
The implementation stage involves the implementation of LKABW at Muslimat NU Nurul Islam Kindergarten 23 children, Islam Plus Khozinatul Ulum Kindergarten 18 children (Blora), and Raudhotul Athfal Hidayah 16 children (Pati). The trial was carried out in two stages, namely a small group trial (3–5 children per location) followed by a large group trial (all children). During implementation, researchers observed the child's response, active engagement, and understanding of the concepts of numbers and colors.

**Evaluation**

Evaluation is carried out formatively at each stage of ADDIE and summative based on the results of implementation (Komang Tri Widianingsih, I Nyoman Jampel, 2025). The instruments used included teacher response questionnaires, observation sheets on children's early cognitive development and literacy, and media and material feasibility questionnaires. Input from children and teachers in the three locations was used to make final improvements to the developed products.

**Table 1.** Design of Development and Validation of Color-Coded Number Worksheets to Support Early Cognitive Development and Literacy in Early Childhood Education

| Code | Image | Activities |
|---|---|---|
| 1. |  | The child observes the circle of numbers and colors, then fills the box with, pairs of the corresponding colors, The child writes the numbers 1,2,3,4,5,6,7,8,9,10 sequentially into the circle. |

| Code | Image | Activities |
|---|---|---|
| 2. |  | The child draws a line from the number to the corresponding colored point (e.g., the red number is connected to the red dot), The child fills each colored box with a predetermined number (e.g.: red=1, blue=2, yellow=3, green=4, purple=5), The child colors the apple with the corresponding color of the number 2, a book with the color of the number 4, a ball with the color of the number 1, pencil with the number 3, then write down the number of numbers. |
| 3. |  | The child counts the number of objects in each group, then draws a line from the picture to the number that represents the quantity, the child writes the missing numbers in order 1-12 in order, the child colors the numbers 1,2,3,4 with a predetermined color (e.g., 1 red, 2 blue, 3 yellow, 4 green). |

**Subject and Sampling Techniques**

The subjects of the study were early childhood who were selected through purposive sampling techniques (Pratiwi & Budisetyani, 2013). The selection criteria include: (a) the child is at a developmentally relevant stage for cognitive stimulation and early literacy (age 4–5 years), (b) the implementation of the research is possible and easily accessible at all three locations, and (c) in accordance with the nature of the initial trial in the R&D research. NU Nurul Islam Kudus Muslimat Kindergarten (23 children), and IP Khozinatul Ulum Blora Kindergarten (18 children) with a total of 57 children.

**Research Instruments**

Data collection instruments include observation sheets on children's cognitive development and early literacy, teacher response questionnaires, and validation questionnaires for media experts and material experts. The validity of the instrument is guaranteed through expert judgment based on the suitability of the development of children aged 4–5 years, relevance to learning indicators, and clarity of instruction. Reliability is improved by inter-observer agreement to ensure consistency of observation results across the three research sites.

**Data Analysis Techniques**

Data were analyzed using descriptive, qualitative, and quantitative techniques. Quantitative data from expert validation and teacher questionnaires were analyzed using the formula: $P = (\Sigma x / \Sigma xi) \times 100\%$, where P is the feasibility percentage, $\Sigma x$ is the total obtained score, and $\Sigma xi$ is the maximum possible score. The resulting percentage was interpreted using four categories: 81%–100% (very feasible), 61%–80% (feasible), 41%–60% (moderately feasible), and 0%–40% (not feasible). A product was deemed valid if it achieved a minimum score of 61%. Observational data

were coded based on two domains: cognitive development (number recognition, color classification, sequencing) and early literacy (symbol recognition, observation, matching). Scores for each child across ten indicators were tabulated, and the overall percentage of achievement was calculated using the same formula. Triangulation analysis was conducted by comparing and synthesizing data from multiple sources (experts, teachers, and children across all three institutions) to ensure the validity and comprehensiveness of the findings.

**Research Ethics**

Given that the participants were early childhood, ethical guidelines were strictly adhered to by obtaining parental consent (informed consent) before data collection at all three locations. Children's identities are kept confidential, and all learning activities are designed to prioritize the safety, comfort, and suitability of the development of children aged 4-5 years. Researchers consider a variety of physical, psychological, and social risks to ensure each study subject is treated humanely and fairly.

**Bias Control Strategy**

This study employed multiple strategies to reduce researcher bias. To address observer bias, a structured observation sheet with predetermined indicators was used, observers underwent calibration sessions prior to data collection, observations were conducted over multiple days, and inter-observer agreement was established through independent observations of 20% of sessions (Selvi et al., 2024). To minimize interpretation bias, data triangulation from multiple sources was conducted, peer review of data interpretation was performed, and member checking with participating teachers was carried out to confirm the accuracy of interpretations (Lincoln & Guba, 1985). To reduce confirmation bias, researchers maintained a reflexive journal to document assumptions, developed validation instruments based on established theoretical frameworks rather than personal preferences, employed negative case analysis to actively seek disconfirming evidence, and involved independent expert validators as an external check (Patton, 1999). Additionally, the conduct of research across three different locations enabled cross-site comparison to identify consistent patterns and distinguish context-specific variations. All procedures were systematically documented to enable external scrutiny and replication.

## RESULT AND DISCUSSION

### Media Expert Validation Results

Media Media expert validation achieved a score of 63 out of 65 (94.6%), categorizing LKABW as "Sangat Layak" (Very Feasible). The expert praised the bright color designs, child-appropriate typography, and safety features. However, the expert recommended three revisions: (1) enhancing color contrast between numbers and background for better visibility, (2) adding visual cue icons to clarify instructions for non-readers, and (3) increasing line thickness for connecting activities to support children's fine motor development. Based on this feedback, the color palette was revised (e.g., replacing pastel yellow with darker orange), visual icons (hand, pencil, line, magnifying glass) were added to each page, and line thickness was increased from 1.5 pt to 3.0 pt. The expert reviewed the revised product and confirmed that all criteria were met without further revisions. This iterative process ensured that LKABW became more accessible, usable, and responsive to children's developmental needs.

**Material Expert Validation Results**

The results of the validation of the subject matter expert showed a feasibility percentage of 100% with a perfect score of 65 out of 65, so it was included in the "Very Feasible" category. The material experts assessed that the material presented in the LKABW included the recognition of numbers 1-10, the association of colors with numbers, classification activities, sequencing, and early literacy skills in a factual, simple, and in accordance with the stages of cognitive development of children aged 4-5 years. Thus, LKABW is considered appropriate in terms of content and accuracy of learning messages.

**Implementation Results (Field Trials)**

The LKABW trial was carried out on 57 children aged 4–5 years across three early childhood education institutions: RA Hidayah Pati (16 children), TK Muslimat NU Nurul Islam Kudus (23 children), and TK IP Khozinatul Ulum Blora (18 children). The observation results showed an average achievement percentage of 81.2%, which falls into the "Layak" (Feasible) category. The highest achievements were observed in three indicators: children's enthusiasm when engaging with LKABW activities (88.2%), the ability to distinguish colors (86.8%), and the ability to complete LKABW tasks independently and effectively (84.2%).

Across all three locations, children demonstrated positive responses, active engagement, and noticeable improvements in their ability to recognize numbers, distinguish colors, and perform basic observational and classification tasks. These findings suggest that LKABW successfully captures children's interest and facilitates meaningful learning experiences through its visually stimulating and structured activities. The consistently positive responses across institutions—despite their different socio-cultural contexts—indicate that LKABW has broad applicability and is responsive to the developmental needs of children aged 4–5 years. However, it is important to note that these results reflect children's engagement and performance during the trial, not a comparative measure of learning gains, as the study did not employ a pre-test/post-test design to measure individual developmental progress over time.

**Results of Teacher Responses**

The responses from the three teachers in the three research locations, namely Heni Muchasonah (Raudhotul Athfal Hidayah Pati), Nurya Sinta (Muslimat NU Nurul Islam Kindergarten Kudus), and Isnaini Nurul Jannah (Islam Plus Khozinatul Ulum Kindergarten Blora) showed very positive results with a feasibility percentage of 99.2% in the "Very Feasible" category. Aspects such as ease of use, children's interest, suitability with the characteristics of 4-5 years old, cognitive stimulation, early literacy stimulation, clarity of instructions, and safety of LKABW all received perfect scores (100%). The teachers assessed that LKABW was practical, easy to implement, and helped convey the concept of numbers and early literacy in a concrete and fun way.

**LKABW Eligibility**

The study evaluated the feasibility of the LKABW as a learning medium rather than its effectiveness. In this context, feasibility refers to the extent to which the product meets quality standards in terms of design, content accuracy, safety, and classroom practicality. Effectiveness, on the other hand, refers to the product's impact on improving learning outcomes and requires an experimental design with pre-test and post-test comparisons. Therefore, the term feasibility is used consistently throughout this study. As presented in Table 2, the media expert assigned a feasibility score of 94.6%, while the material expert rated the product 100%, indicating that LKABW fulfilled

both technical and pedagogical requirements. Classroom observation involving 57 children yielded a feasibility score of 81.2%, whereas teacher responses reached 99.2%. Overall, the average feasibility score from all respondents was 93.8%, indicating that LKABW is Very Feasible for use in early childhood learning.

**Table 2.** Feasibility Evaluation Results of LKABW

| Respondents | n | Percentage (%) | Feasibility Category |
|---|---|---|---|
| Media Expert | 1 | 94.6 | Very Feasible |
| Material Expert | 1 | 100.0 | Very Feasible |
| Child Observation | 57 | 81.2 | Very Feasible |
| Teacher Response | 6 | 99.2 | Very Feasible |
| Overall Average | 62 | 93.8 | Very Feasible |

Feasibility Criteria (Sugiono, 2019)

81–100% = Very Feasible

61–80% = Feasible

1–60% = Fairly Feasible

≤40% = Not Feasible

The high feasibility ratings from both experts indicate that LKABW satisfies the essential quality standards expected for early childhood instructional media. The media expert emphasized the attractiveness of the visual design, appropriate typography, and safety of the materials, whereas the material expert highlighted the suitability of the learning content with children's cognitive and literacy development. These findings suggest that integrating color-coding into worksheet activities provides an innovative approach that combines cognitive stimulation with early literacy experiences within a single learning medium.

Children's performance across ten learning indicators is presented in Figure 1, while the detailed percentages are summarized in Table 3.

**Table 3.** Children's Achievement on Each Learning Indicator (n = 57)

| No | Indicator | Percentage (%) | Category |
|---|---|---|---|
| 1 | Distinguishing colors | 86.4 | High |
| 2 | Showing enthusiasm | 87.7 | High |
| 3 | Matching numbers with colors | 82.3 | High |
| 4 | Counting simple objects | 79.5 | Moderate |
| 5 | Matching pictures with numbers | 80.9 | High |
| 6 | Coloring according to instructions | 79.1 | Moderate |
| 7 | Filling numbers using color codes | 78.6 | Moderate |
| 8 | Completing activities | 83.6 | High |
| 9 | Writing numbers | 75.9 | Moderate |
| 10 | Completing number sequences | 70.9 | Moderate |

Source: Primary data processed by the authors (2026). Figure 1. Children's Achievement on Each Learning Indicator during LKABW Field Trial (n = 57).

As illustrated in Figure 1, children's highest achievement was found in showing enthusiasm (87.7%), followed by distinguishing colors (86.4%) and completing learning activities (83.6%). These findings indicate that the visual characteristics of LKABW successfully attracted children's attention and sustained their engagement throughout the learning process. The combination of color-coded activities and varied tasks appears to support active participation, which is consistent with multisensory learning principles for early childhood education. Conversely, the lowest scores

were observed in completing number sequences (70.9%) and writing numbers (75.9%). These tasks require higher-order cognitive processing, sequential reasoning, and fine motor coordination, which are still developing among children aged four to five years. Rather than indicating weaknesses of the learning media, these findings suggest that such activities require additional teacher scaffolding and repeated practice. Therefore, future refinement of LKABW may include differentiated worksheets or teacher guidance specifically designed to support number sequencing and writing skills. Overall, the pattern of results demonstrates that LKABW is particularly effective in facilitating children's engagement and basic concept recognition, while more cognitively demanding numerical tasks remain developmental challenges that require instructional support.

**The Effectiveness of LKABW in Cognitive Development**

The results of field trials proved that LKABW was effective in stimulating the cognitive development of children aged 4-5 years at the three study sites. The child's achievement in distinguishing colors reached 86.8%, matching numbers with colors 82.9%, and completing the sequence of numbers 1-10 by 71.9%. A color-coding approach that associates each number with a specific color utilizes the principle that colors are easier to recognize and remember in early childhood than abstract symbols, so that they are able to train simple classification, matching, sequencing, and problem-solving skills according to the child's cognitive development stage (Piaget, 1950).

**LKABW's Contribution to Early Literacy**

LKABW also makes a significant contribution to children's early literacy through systematic observation activities, number symbol recognition, and communication of observation results. The results of the observation showed that 80.3% of children were able to count simple objects (1-5) and 79.8% of children were able to color pictures according to numerical instructions, where coloring activities as well as writing numbers integrated fine motor with numerical concepts as a form of integrated early literacy. Thus, LKABW not only teaches numbers but also builds basic process skills that are important for children's early literacy.

**Teachers' Responses and Practical Implications**

The very positive responses from the three teachers (99.2%) showed that LKABW was considered practical, easy to implement, and able to help convey the concept of numbers and early literacy in a concrete, structured, and fun way. The practical implication of this study is that LKABW is ready to use and can be used by teachers at Muslimat NU Nurul Islam Kindergarten Kudus, Islam Plus Khozinatul Ulum Kindergarten Blora, and Raudhotul Athfal Hidayah Pati, as well as other kindergartens as an alternative to conventional media. In addition, the LKABW can be modified according to the needs and characteristics of each PAUD institution.

**Research Limitations**

This research has three main limitations. First, the trial was only carried out in three locations with relatively similar characteristics, so the results could not be generalized to all PAUD institutions that had different conditions and backgrounds. Second, the short duration of implementation caused this study to not be able to measure the long-term effects of the use of LKABW on children's cognitive development and early literacy. Third, the number of samples of 57 children is still relatively small, so further research with larger samples and experimental designs

(e.g. pretest-posttest control group design) is needed to test the effectiveness of LKABW more rigorously and comprehensively.

LKABW was declared feasible as a learning media based on the validation of media experts (94.6%) and material experts (100%) with the category of "Very Feasible", and supported by the results of trials on 57 children in three locations which showed an achievement percentage of 81.2% and teacher responses of 99.2%. However, this study focuses on product development and validation, not on proving causal cause-and-effect relationships. Theoretically, the color-coding approach in LKABW strengthens children's understanding of number symbols through multisensory and meaningful learning experiences, in line with play-based learning theory that emphasizes that early childhood builds an understanding of abstract concepts through concrete, sensory-rich, and socially mediated experiences (Anggrian & Saefurahman, 2025). Activities in LKABW-such as observing circles of numbers and colors, associating numbers with colors, coloring images according to code, and completing sequence of numbers-involve the senses of sight, fine motor, and cognitive processes, which are in line with the Montessori principle that children learn most effectively when they engage all the senses through active engagement with the environment and structured props (Van Aswegen, 2019).

The positive acceptance of LKABW is in line with international studies showing that game-based and manipulative learning media increase children's engagement and meaning-forming processes, where the approach *Guided Play* Allows children to explore number concepts through hands-on guided play (Mustapa & Tatminingsih, 2026). The study found that 81.2% of children showed a positive response to LKABW, while the three teachers from the three locations gave a 99.2% eligibility percentage, which is equivalent to the findings of media development*flashcard*interactive that achieves a 94.2% eligibility level of media experts (Maulidina, A., & Hidayati, 2024). The contribution of this research to the existing literature is to provide an empirically validated learning media model that integrates*Color-coding*, cognitive stimulation, and early literacy in early childhood settings in three different locations. However, these findings were limited by the small sample size (57 children) and the absence of comparative size*Pretest-Posttest*, so claims of causal effectiveness are still limited and future research is recommended using experimental design as well as broader contexts to strengthen empirical evidence of media-based use *Color-coding*(Nabila, R., & Prasetyo, 2024).

**Theoretical and Practical Implications**

The findings of this study strengthen the early childhood learning paradigm that positions play-based and visual activities as the foundation for the formation of abstract concepts such as numbers, classification, and number sequences (Maryam et al., 2025). The use of LKABW shows that the visual (color) approach serves as a medium of building knowledge through direct experience and meaningful social interaction, in line with Vygotsky's constructivist perspective (Sulistiani, W., & Rahmawati, 2025). Cross-cultural research confirms that color-coding approaches are effective across a wide range of education systems, especially for children from low socio-economic backgrounds (Wijayanti, D. A., & Nugroho, 2024). Thus, LKABW can be positioned as a media model that integrates the principles of color-coding, experiential learning, as well as cognitive stimulation and early literacy in an integrated manner. This theoretical contribution provides a conceptual foundation to develop a theory of early childhood learning media that is more contextual, inclusive, and responsive to the needs of children's development (Nabila, R., & Prasetyo, 2024).

Practically, LKABW makes a real contribution to PAUD teachers at Muslimat NU Nurul Islam Kindergarten Kudus, Islam Plus Khozinatul Ulum Kindergarten Blora, and Raudhotul Athfal Hidayah Pati in introducing the concepts of numbers, colors, classifications, and sequence of numbers in a positive, contextual, and fun way (Hasanah, U., & Dewi, 2025). This media encourages active participation of children, improves fine motor skills, and strengthens pedagogical interaction between teacher and child (Apriliani et al., 2026). For media developers, the results of this research are the foundation for designing color-coding-based media that responds to the real needs of PAUD institutions, considering that media with a simple but creative design can have a significant impact on children's learning processes (Wahyuni, S., & Hasanah, 2024). These findings open up opportunities for the development of similar media that are more contextual, adaptive, and sensitive to the stage of child development, both in print and digital formats (Mannweiler, M. D., 2025). This practical implication is expected to enrich early childhood education practices and improve the overall quality of children's learning experience (Putri, D. A., & Kurniawan, 2025).

**Future Research Directions**

Future research is recommended to examine the use of LKABW on a broader scale by involving diverse PAUD backgrounds, socio-cultural backgrounds, and varied characteristics of learners (Sulistiani, W., & Rahmawati, 2025). Expanding the subject and context of the research is expected to provide a more comprehensive understanding of the effectiveness and flexibility of LKABW as a learning medium (Permata, S., & Lestari, 2024). Future research may also explore the development of LKABW in a technology-based digital or interactive format to adapt to the demands of 21st century learning (Mannweiler, M. D., 2025). A comparative study between the print version and the digital version will be very relevant to evaluate the effectiveness of each format (Putri, D. A., & Kurniawan, 2025).

Future research should investigate the long-term effects of the use of LKABW on children's cognitive development, early literacy skills, school readiness, and the formation of positive attitudes towards learning (Nabila, R., & Prasetyo, 2024). Longitudinal and experimental research (pretest-posttest control group design) is needed to test the sustainability impact of color-coding media on early childhood development (Ariyanti, T., Suryani, N., & Hidayat, 2025). Research with a quasi-experimental design can also be conducted to compare the group using LKABW with the group using conventional methods. In this way, future research can strengthen the empirical evidence while advancing the sustainable theoretical and practical development of early childhood education.

## CONCLUSION

This study successfully developed and validated the Color-Coded Number Worksheet (LKABW) as a feasible and practical learning medium to support cognitive development and early literacy in children aged 4–5 years. Designed to address the limited availability of developmentally appropriate and engaging resources, LKABW effectively facilitates number recognition, color association, classification, sequencing, and basic observational skills-all of which are foundational to cognitive growth and early literacy. Teacher responses further confirmed that the worksheet is practical, easy to integrate into classroom activities, and supports meaningful pedagogical interactions. The study confirms that a color-coding approach, embedded in structured yet playful worksheet activities, offers a concrete and enjoyable pathway for building early cognitive and literacy competencies. LKABW provides early childhood educators with a viable, child-centered, and visually stimulating alternative to conventional teaching methods, enriching learning experiences and supporting school readiness in early childhood settings.

## DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used ChatGPT (OpenAI) to assist with language refinement, grammar correction, and paragraph restructuring. After using this tool, the authors carefully reviewed, revised, and validated all content and take full responsibility for the final manuscript..

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## AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; Investigation.

Author 3: Data curation; Investigation.

Author 4: Data curation; Investigation.

Author 5: Data curation; Investigation.

## DECLARATION OF COMPETING INTEREST

The author(s) declare that there are no financial, professional, or personal relationships that could be perceived as influencing the results or interpretation of this study.

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