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Training on the Development of Creative Numeracy Media to Improve Early Childhood Teachers' Competencies

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ABSTRACT

Numeracy learning in early childhood education (ECE) in Cirebon Regency is frequently constrained by conventional worksheet-based methods due to teachers' limited skills in designing varied, concrete play-based media. This community service program aimed to improve teachers' competence in designing innovative numeracy media. Guided by constructivism and Jean Piaget's theory, the program tested the hypothesis that hands-on participatory training significantly enhances teachers' media development skills. The implementation methods included lectures, demonstrations, practical media creation, presentations, and evaluative mentoring through reflection forums. The subjects comprised 20 ECE teachers in Cirebon Regency. The results demonstrated a significant increase in the participants'

conceptual understanding and practical skills, with a 100% target achievement rate in producing manipulative media (number cards, counting boards, educational games). Utilizing a stimulant budget of Rp1,000,000, the program successfully encouraged teachers to independently integrate exploratory play strategies in classrooms. It is concluded that this participatory training model effectively strengthens the institutional capacity of ECE centers to foster child-centered learning environments. It is recommended that this program be replicated sustainably with a broader scope of participants.

Introduction

Numeracy skills represent a foundational competence in early childhood education (ECE) that encompasses number recognition, spatial patterns, and basic mathematical reasoning. To foster these abilities effectively during the preoperational cognitive stage, learning must be delivered through concrete, manipulative stimulation rather than abstract instruction. Although the national *Kurikulum Merdeka* framework mandates play-based and exploratory numeracy environments, field practices in regional ECE centers continue to struggle with traditional, worksheet-heavy delivery. Therefore, this study evaluates an andragogy-based participatory training program designed to enhance the conceptual understanding, material design skills, and pedagogical readiness of ECE teachers in Cirebon Regency.

While prior scholarship emphasizes the value of concrete media and teacher professional development, an analytical synthesis of existing empirical studies reveals key conceptual and operational inconsistencies. Studies focusing on child-level interventions (e.g., Aisyah, 2022; Nurhayati, 2023) consistently show that manipulative media and educational games improve children's counting skills and focus. However, these studies evaluate pre-manufactured media implemented by researchers, failing to account for how teachers acquire the technical capacity to design such tools independently. On the other hand, research examining teacher training programs (e.g., Fadillah, 2021; Rahmawati, 2021) demonstrates improved teacher creativity following professional workshops, yet these interventions predominantly rely on top-down, theoretical lectures or expensive commercial materials. This creates a critical disconnect: standard training models improve theoretical awareness but fail to establish long-term material self-reliance, leaving teachers dependent on costly commercial supplies or defaulting back to cheap, traditional worksheets.

This community service initiative directly bridges this empirical gap and addresses the identified training limitations. The primary novelty of this study lies in its **andragogy-driven, participatory hands-on workshop model**, which shifts ECE teachers from passive consumers of pre-made commercial props into active designers of low-cost manipulative media utilizing local recycled materials. Unlike prior

studies that isolated theoretical lectures from practical design or evaluated short-term media usage (e.g., Rahmawati, 2021; Aisyah, 2022), this program integrates physical material transformation, peer-review micro-mentoring, and direct alignment with the *Kurikulum Merdeka* framework. By explicitly evaluating the transformation of teachers' pedagogical competencies, this study provides empirical evidence on how participatory capacity-building creates sustainable, localized solutions for early childhood numeracy instruction in resource-constrained environments.

The urgency of developing media in early numeracy learning is strongly supported by various scientific literatures published within the last ten years. Research by Susanto (2018) and Suyadi (2020) emphasizes that the psychology of early childhood learning demands the utilization of the surrounding environment and concrete objects so that mathematical knowledge can be meaningfully constructed through play-based activities. Furthermore, empirical studies by Rahmawati (2021) demonstrate that interventions in the form of training for creative instructional media development for ECE teachers exert a significant positive implication on upgrading teachers' professional capacity and classroom creativity. In the specific context of numeracy, findings from Aisyah (2022) and Nurhayati (2023) also indicate that the implementation of number-based educational games and manipulative media is capable of escalating number recognition, focus, and simple

problem-solving skills in children aged 5–6 years far more effectively compared to conventional methods.

Despite the widespread recognition of the importance of manipulative media, empirical facts in the field reveal a striking gap between the ideal mandates of the Kurikulum Merdeka and the reality of teachers' pedagogical competence in Cirebon Regency. Initial observations indicate that most ECE teachers remain confined to conventional methods centered on student worksheets and monotonous rote techniques due to limited skills in transforming local materials or recycled goods into varied educational props. The novelty of this community service program lies in the integration of an andragogy-based participatory training model with hands-on practice in creating low-cost manipulative media that leverage the local environmental ecosystem, which is then directly integrated into the framework of the ECE Kurikulum Merdeka. Through the intensive involvement of 20 ECE teachers in Cirebon Regency, this initiative carries high urgency to be implemented immediately to eradicate early numeracy literacy failure and build a solid foundation for safe, adaptive, and entirely child-centered classroom governance.

Methods

This study employed a one-group pretest-posttest mixed-methods evaluation design embedded within a participatory action community service framework (Creswell & Creswell, 2018; Sugiyono, 2020). The

program aimed to evaluate the improvement of early childhood education (ECE) teachers' competencies following a hands-on media development training. The program was conducted over a two-month period (May–June 2026) across partnering ECE centers in Cirebon Regency, West Java, Indonesia. The participants were selected through purposive sampling and comprised 20 active ECE teachers responsible for daily classroom instruction.

Data were collected using both quantitative and qualitative instruments:

- **Quantitative Questionnaires and Observation Rubrics:** The primary quantitative instrument consisted of a pre- and post-evaluation rubric using a 100-point rating scale covering four specific competence domains: *(1) Conceptual Understanding of ECE Numeracy* (5 items on preoperational mathematical logic), *(2) Material Transformation and Design Skills* (5 items on fabricating concrete props from local recycled goods), *(3) Classroom Integration & Lesson Planning* (5 items on designing active play-based lesson plans/RPPH), and *(4) Active, Child-Centered Climate Fostering* (5 items on facilitating exploratory learning). Structured observation checklists evaluated participants' real-time practical execution during workshops based on material functionality, durability, and safety.
- **Instrument Validity and Reliability:** Content validity for both questionnaires and observation rubrics was established through

expert judgment by two senior ECE curriculum specialists, yielding a Content Validity Index (CVI) exceeding 0.85. Quantitative instrument reliability was confirmed using Cronbach's alpha ($\alpha = 0.88$).

- **Qualitative Reflection Sheets:** Qualitative data were gathered through structured post-workshop reflection sheets and peer-review discussion logs. Qualitative trustworthiness (credibility and confirmability) was maintained through investigator triangulation and member checking (Miles et al., 2014).

Data Analysis Procedures The manuscript utilized distinct quantitative and qualitative analytical pipelines:

- **Quantitative & Inferential Statistical Analysis:** Descriptive statistics (mean score M and standard deviation SD) were calculated for pre-test and post-test values across all four domains. To evaluate whether the score improvements were statistically significant, a non-parametric Wilcoxon signed-rank test (and paired-sample t-test) was executed using SPSS, selected due to the sample size (N = 20). Statistical significance was established at $p < .05$.
- **Qualitative Content Analysis:** Qualitative reflections and observational notes were analyzed using the interactive data condensation, display, and conclusion-verification model proposed by Miles, Huberman, and Saldana (2014). Data were

inductively coded into key thematic categories: *material design constraints*, *pedagogical ownership,* and *classroom climate adaptation*.

To measure performance benchmarks and ensure program validity, data collection techniques utilized dual quantitative-qualitative instruments, including pre- and post-program evaluation questionnaires, structured observation checklists, and interactive reflection sheets. The processing of the research instruments involved strict content validity checking by academic experts, while reliability was verified using descriptive statistical comparison to map out pre-intervention skill constraints against post-training proficiency outcomes.

The programmatic steps carried out by the facilitators were executed in a sequence of four progressive phases. During the initial preparation phase, the team coordinated closely with institutional partners to manage administrative logistics, assemble baseline raw materials, and finalize evaluation instruments. In the subsequent training phase, facilitators delivered foundational concepts regarding concrete mathematics stimulation for the preoperational developmental stage, followed by an interactive demonstration on how to transform local recycled items and simple raw materials into low-cost manipulative devices. The execution phase required the 20 teachers to engage in collaborative, hands-on group workshops to design, assemble, and refine a variety of physical props, including custom number cards, tactile counting boards, and shape-matching educational games. The

final mentoring and evaluation phase focused on independent classroom integration and structural reflection, where participants presented their final outputs and joined peer-review circles to diagnose field constraints. The benchmark for success was quantified by a 100% completion and functional mastery rate in the physical production of the innovative numeracy props. Qualitative data derived from the reflection notes were analyzed using interactive data condensation and display models to verify that the developed tools effectively stimulated logical thinking, heightened student engagement, and established an active, child-centered school climate.

Result and Discussions

The community service initiative yielded substantial measurable outcomes regarding teacher professional capacity and pedagogical transformation across the participating institutions. The quantitative data collected via pre- and post-program evaluation rubrics underwent inferential statistical testing using the non-parametric Wilcoxon signed-rank test. As summarized in Table 1, all four evaluated performance domains demonstrated statistically significant improvements ($p < .01$).

Table 1. *Pre-Test and Post-Test Evaluation Scores Across Competence Domains (N = 20)*

Evaluation Domains	Pre-Test M	Post-Test M	Mean Gain	Completion Rate (%)	p-value

	(SD)	**(SD)**			
Conceptual Understanding of ECE Numeracy	52.40 (4.50)	91.20 (2.10)	+38.80	100%	< .01*
Material Transformation and Design Skills	44.80 (5.20)	88.60 (3.40)	+43.80	100%	< .01*
Classroom Integration & Lesson Planning	58.10 (3.80)	90.40 (1.90)	+32.30	100%	< .01*
Active, Child-Centered Climate Fostering	55.30 (4.10)	89.50 (2.60)	+34.20	100%	< .01*

*Note: *Wilcoxon signed-rank test indicates statistical significance at p < .05.*

Prior to the intervention, the lowest competency was recorded in *Material Transformation and Design Skills* (M = 44.80, SD = 5.20), driven by an over-reliance on traditional, worksheet-bound instruction. Following the participatory workshop, this domain achieved the highest mean gain (+43.80), reaching a post-test score of 88.60 (SD = 3.40). To triangulate the quantitative gains, real-time structured observations and written participant reflections were qualitative analyzed.

1. **Observational Evidence of Material Fabrication:** Observational checklists administered during the practical workshops revealed a marked shift in teachers' dexterity and material

resourcefulness. During Phase 1, 85% of participants expressed hesitance in utilizing loose parts and recycled cardboard. However, by Phase 3, 100% of the participants independently constructed durable, non-toxic, and functional manipulative media, including tactile counting boards, customized number spinners, and pattern-matching blocks.

2. **Participant Reflections and Narrative Excerpts:** Qualitative thematic analysis of post-workshop reflection sheets provided direct insights into teachers' internal shifts regarding self-efficacy and pedagogical mindset:

"Previously, I felt overwhelmed by the Kurikulum Merdeka requirement for play-based numeracy because commercial educational toys are expensive. Training with recycled bottle caps and cardboard taught me that high-value math media can be created at almost no cost. My classroom is no longer silent and bored over worksheets." (Participant T-07, Written Reflection)

Another educator highlighted the structural impact on lesson planning and student engagement during peer micro-teaching:

"When presenting our custom counting board during micro-teaching, I realized how concrete objects instantly spark children's curiosity. Moving from abstract numbers on paper to tactile media makes teaching math natural and stress-free for both teacher and child." (Participant T-14, Discussion Log)

The integration of quantitative metrics, observational data, and participant narratives demonstrates that an andragogy-driven

participatory model effectively bridges the gap between theoretical understanding and practical material creation. The dramatic increase in design skills (+43.80) aligns with Jean Piaget's constructivist framework, reinforcing that educators must experience hands-on manipulation of pedagogical tools before they can successfully design manipulative learning environments for children. By removing financial barriers through the use of localized recycled goods, the program fosters sustainable teacher self-efficacy, ensuring long-term pedagogical transformation beyond the training intervention.

The statistical summaries presented in Table 1 reveal a uniform and significant upward trajectory across all four evaluated performance benchmarks following the execution of the training program. Prior to the intervention, the baseline data indicated a critically low level of material design skills and pedagogical readiness, with the mean score for material transformation sitting at 44.80, heavily restricted by an over-reliance on traditional worksheet-based learning methods. Following the collaborative, hands-on workshop sequence, a definitive post-test surge was observed, wherein the completion and functional mastery rate across the cohort reached an ideal threshold of 100%. The hypothesis testing, calculated through a paired-sample analysis, confirmed that the differences between the pre-test and post-test values were statistically significant, as demonstrated by the uniform significance value of less than .01 across all technical domains, thereby

validating the efficacy of the participatory model.

The distinct phases of material development carried out during the collaborative workshop sessions are captured visually to highlight the interactive engagement and physical realization of the pedagogical products. The active involvement of the educators during the practical implementation stages is presented below.

The profound shift from abstract, rigid worksheets to an active, manipulative-based numeracy ecosystem confirms that integrating adult learning principles with participatory action models is highly effective for professional capacity building. The marked improvement in material transformation and design skills, which saw the largest mean gain of 43.80, stems directly from removing barriers to active participation; by providing direct, collaborative group mentoring, teachers successfully transitioned from passive consumers of expensive commercial tools to independent creators of localized learning materials.

The substantial post-intervention gains observed across all competency domains—most notably the +43.80 mean increase in *Material Transformation and Design Skills* ($p < .01$)—demonstrate that adult educators thrive when professional development shifts from passive theoretical delivery to active, experiential manipulation. Grounded in Jean Piaget's constructivist framework, young children require concrete manipulative materials to internalize preoperational mathematical logic. However, this study reveals an underlying

pedagogical parallel: *teachers themselves require a concrete, hands-on learning phase to internalize media design logic before they can successfully facilitate exploratory environments for children*. The significant score surge occurred because the training eliminated technical intimidation by breaking down media assembly into collaborative, low-cost steps using familiar local materials (e.g., recycled cardboard, bottle caps). This contextualized approach lowered cognitive resistance, allowing participants to instantly bridge theory and practice.

While existing literature (e.g., Aisyah, 2022; Nurhayati, 2023) consistently demonstrates that manipulative media enhance children's early numeracy, those studies focused on evaluating pre-manufactured commercial tools deployed directly by researchers. Conversely, general teacher-training research (e.g., Rahmawati, 2021) established that creative workshops improve teacher awareness, yet those models relied on top-down lectures that left educators dependent on commercial kits.

This study extends current scholarship by generating a novel operational concept: sustainable teacher capacity is achieved when educators transition from passive consumers of commercial props into independent, localized media creators. Unlike prior interventions, our andragogy-driven participatory model integrated material design directly with localized curriculum adaptation (*Kurikulum Merdeka*) and peer micro-teaching. The qualitative evidence confirms that this structural integration built enduring pedagogical ownership, enabling

teachers to overcome budget constraints by transforming free environmental waste into functional early math games.

The novelty claimed in the Introduction—namely, the integration of low-cost localized material transformation with an andragogical peer-mentoring framework—is fully substantiated by the findings. The observational data and participant reflection logs (e.g., T-07, T-14) prove that providing a Rp1,000,000 stimulant budget was sufficient to trigger complete institutional self-reliance across all 20 participants. By demystifying media creation, the program permanently displaced worksheet-bound instruction and established a resilient, child-centered classroom ecosystem without reliance on external supply chains.

Despite these positive outcomes, several methodological limitations must be acknowledged:

1. **Sample Size and Geographical Scope:** The intervention involved a small sample size ($N = 20$) restricted to ECE centers in Cirebon Regency, which limits the direct statistical generalizability of the quantitative findings to larger urban or different regional contexts.
2. **Evaluation Timeline:** Competency improvements were measured immediately post-intervention and during short-term mentoring; thus, long-term retention of media fabrication practices over multiple academic years remains unassessed.
3. **Indirect Measure on Child Outcomes:** In alignment with the

study's scope, evaluation focused on teacher competencies rather than tracking direct, longitudinal cognitive growth metrics among young learners.

Future research should address these constraints by conducting multi-region longitudinal studies, integrating digital-physical hybrid media, and directly measuring children's long-term mathematical achievement gains.

Conclusion

This community service evaluation demonstrates that an andragogy-based participatory training model significantly improves early childhood education (ECE) teachers' competencies in developing creative numeracy media. The empirical quantitative findings confirm statistically significant score gains ($p < .01$) across all four evaluated competence domains, with the most prominent improvement observed in *Material Transformation and Design Skills* (+43.80 mean gain). Qualitative reflection logs and structured observational data further confirm that all 20 participating teachers successfully achieved 100% functional mastery in fabricating low-cost, concrete manipulative props—such as tactile counting boards and custom number cards—out of local recycled materials.

The core novelty of this study lies in establishing a practical capacity-building framework that effectively transforms ECE teachers from passive consumers of expensive commercial educational props

into independent, localized media creators. By integrating physical material fabrication with peer micro-teaching and direct alignment with the *Kurikulum Merdeka* framework, the program successfully eliminates technical intimidation and reliance on traditional worksheet-bound instruction.

In terms of practical implications, this study provides evidence that low-cost, participatory workshops can bridge the pedagogical execution gap in resource-constrained regional ECE centers. To build upon these findings, local education authorities are encouraged to support sustainable peer-mentoring networks among ECE educators. Future research should evaluate the long-term retention of these teacher competencies over extended academic cycles and assess their direct impact on children's mathematical learning outcomes.

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