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Enhancing Number Recognition Through Concrete Media-Based Project Learning: An Action Research Study with Children at Risk of Learning Difficulties

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Abstract
Number recognition represents a fundamental cognitive milestone in early childhood development, yet children with learning difficulties often struggle with abstract mathematical concepts. This study investigated the effectiveness of concrete media-based project learning in enhancing number recognition abilities among kindergarten children at risk of learning difficulties. An action research design following the Kemmis and McTaggart model was implemented over three iterative cycles from January to May 2025. The participant was a 5-6 year-old child identified with learning difficulties at TK Negeri Pembina, East Kalimantan, Indonesia. The intervention employed Project-Based Learning methodology through a "Mini Market" theme utilizing concrete manipulatives including toy fruits, play money, price cards, and calculators. Data collection involved structured oral assessments measuring numerical symbol recognition, quantity-symbol matching, and project participation, alongside qualitative observations. Performance was evaluated using a four-point scale, with success criteria set at ≥76% achievement. Substantial performance improvement was achieved from baseline 25% to final assessment 91.6%, representing a 66.6 percentage point increase. Progressive gains were documented across cycles: Cycle I (25% to 58.3%), Cycle II (66.6% to 75%), and Cycle III (83.3% to 91.6%). Qualitative observations revealed enhanced engagement, increased confidence, and improved social interaction during mathematical activities. The participant progressed from requiring extensive teacher assistance to independent task completion and peer collaboration. Concrete media-based project learning significantly enhanced number recognition abilities in children with learning difficulties. The systematic, multi-cycle intervention provides a replicable framework combining Piaget's developmental theory with contemporary project-based pedagogical approaches. These findings support inclusive educational practices emphasizing differentiated instruction through authentic, contextualized learning experiences.

INTRODUCTION

Number recognition represents a fundamental cognitive milestone in early childhood development, serving as a cornerstone for mathematical literacy and academic success. This ability encompasses the identification of numerical symbols, understanding quantity relationships, and establishing connections between abstract mathematical concepts and concrete representations. According to Indonesia's National Standards for Early Childhood Education (Permendiknas No. 137/2014), young children must develop competencies in recognizing numerical symbols, understanding number concepts, and acquiring basic counting skills through concrete, meaningful experiences.

The theoretical foundation for using concrete materials in mathematical instruction can be traced back to Piaget's (1978) developmental theory, which posits that children cannot comprehend abstract concepts merely through verbal explanations (Golafshani, 2013). Knowledge acquisition is conceptualized as a constructive process wherein learners actively seek to make meaning from their

experiences (Driscoll, 2005; Liggett, 2017; Piaget, 1978). Building upon this understanding, educators have historically employed tangible objects and real-world examples to facilitate comprehension of abstract mathematical principles (Laski et al., 2015; Trninic et al., 2020; Wong, 2007). While some researchers have questioned the effectiveness of concrete manipulatives, suggesting they may introduce extraneous information that diverts attention from relevant mathematical structures (Kaminski et al., 2008), substantial evidence indicates that concrete materials enhance connections between mathematical concepts and learners' prior experiences (Fyfe et al., 2014; McNeil et al., 2009; Trninic et al., 2020).

Contemporary research has demonstrated the efficacy of various concrete media approaches in developing number recognition skills. Studies have shown that card-based games significantly improve children's numerical symbol recognition abilities (Agustina & Radiansyah, 2023), while contextual learning models enhance cognitive understanding of number concepts (Andriyani et al., 2016). Similarly, pictorial number cards have proven effective in developing numerical concept comprehension (Dilah et al., 2021), and interactive media such as magic pouches have successfully improved number recognition in 5-6 year-old children (Hayati et al., 2023). Additional investigations have revealed that puzzle games enhance numerical symbol recognition (Mulyaningsih & Palangngan, 2021; Sumiyati & Hermawan, 2024), number card activities improve recognition of numerals 1-10 (Paramansyah et al., 2023; Survia & Mulanirum, 2023), manipulative media enhances number concept understanding (Susilowati, 2014), and loose parts materials effectively develop numerical recognition in 4-5 year-old children (Triatna, 2021).

Project-based learning (PjBL) represents an inquiry-based instructional methodology that engages learners in knowledge construction through meaningful project completion and real-world product development (Brundiers & Wiek, 2013; Krajcik & Shin, 2014). The approach encompasses six essential characteristics: driving questions, focus on learning objectives, participation in educational activities, student collaboration, utilization of scaffolding technologies, and creation of tangible artifacts (Krajcik & Shin, 2014). Among these features, the development of artifacts addressing authentic problems distinguishes PjBL from other student-centered pedagogies (Blumenfeld et al., 1991; Helle, Tynjälä, & Olkinuora, 2006). Although John Dewey introduced the concept through his "learning by doing" philosophy in 1897, practical implementation began during the 1960s in health sciences education (Hitt, 2010). Since then, PjBL has emerged as a powerful teaching strategy that enhances student motivation and promotes self-directed learning with educators serving as facilitators (Blumenfeld et al., 1991; Smith et al., 2005).

Research demonstrates that PjBL improves teaching and learning quality, cognitive development, innovative problem-solving, planning, communication, authentic research, and self-directed learning (Yang & Cheng, 2010; Dehdashti et al., 2013). Students engaged in PjBL exhibit higher intrinsic motivation, significantly enhanced critical thinking skills, and greater appreciation for peer learning (Holmes & Hwang, 2016). Additional benefits include increased engagement that stimulates curiosity and discovery, enhanced motivation (Chu et al., 2012), and improved perceptions of skills, participation utility value, and career aspirations (Beier et al., 2019). PjBL prepares students for twenty-first-century success by exposing them to real-world problems and facilitating extended inquiry processes that enhance communication skills and interdisciplinary learning through prior knowledge application (Toledano-O'Farrill, 2019; Pan et al., 2019).

Despite these pedagogical advances, significant challenges persist in early childhood mathematics education, particularly for children with learning difficulties. Approximately 20% of children are diagnosed with learning disabilities, typically identified during the first two years of schooling (Al-Mahrezi, 2016; Franz et al., 2017). These disabilities may manifest as general academic difficulties or specific impairments in mathematical or language skills (American Psychiatric Association, 2013). Beyond academic challenges, children with learning disabilities face emotional difficulties including poor social interactions, compromised self-concept and self-esteem, anxiety,

depression, and stigma (Greenboim-Zimchoni, 2019; LD Online, n.d.). Such experiences significantly influence how children with learning disabilities perceive themselves throughout development.

Children at risk of learning difficulties in number recognition face particular challenges in abstract learning environments. They demonstrate persistent difficulties in sequential number naming, struggle to match numerical symbols with corresponding quantities, and exhibit reduced engagement when instruction relies heavily on abstract approaches. These learners require multisensory educational approaches that incorporate direct experiences and concrete materials to facilitate mathematical concept comprehension.

The integration of concrete media within project-based learning frameworks offers promising solutions for addressing these educational challenges. This approach aligns with constructivist learning principles while providing the structured, experiential learning opportunities essential for children with learning difficulties. Through authentic projects such as "Mini Market" simulations, children can engage with numerical concepts in meaningful, contextual settings that bridge abstract mathematical knowledge with concrete, lived experiences.

This study aims to investigate the effectiveness of concrete media-based project learning in enhancing number recognition abilities among kindergarten children at risk of learning difficulties. Specifically, the research examines how project-based learning approaches utilizing concrete manipulatives can improve children's sequential number naming, numerical symbol-quantity matching, and overall mathematical engagement. The significance of this investigation extends beyond individual learning outcomes to inform pedagogical practices that support inclusive early childhood education and provide evidence-based strategies for addressing diverse learning needs in mathematical instruction.

METHODS

This study employed an action research design following the Kemmis and McTaggart model, utilizing a mixed-methods approach that integrated qualitative descriptive and quantitative methodologies. The research was conducted through three iterative cycles, each comprising four phases: planning, action implementation, observation, and reflection. This design was selected for its capacity to address classroom learning challenges directly while enabling continuous, systematic improvement of instructional practices.

The study was conducted at TK Negeri Pembina, located in North Sangatta District, East Kutai Regency, East Kalimantan Province, Indonesia, from January to May 2025. The research site was chosen for its adequate facilities, inclusive learning environment, and diverse student population representing various cultural and socioeconomic backgrounds. The target population consisted of 20 children aged 5-6 years in Group B, with one child identified as having learning difficulties characterized by challenges in understanding basic number concepts, difficulty matching quantities with numerical symbols, limited attention span, and slow recall of number sequences.

The intervention implemented Project-Based Learning (PjBL) methodology through a "Mini Market" theme, utilizing concrete media including baskets, artificial fruits, toy money, price cards, scales, calculators, receipt papers, and small whiteboards. The PjBL framework followed five systematic phases: orienting students to real-world problems, dividing tasks and planning projects, organizing work steps and media, implementing projects and problem-solving, and presenting and reflecting on results. Each cycle progressively increased in complexity, beginning with basic number recognition activities and advancing to collaborative transactions involving addition, subtraction, and change-making calculations.

Data collection employed multiple instruments to ensure comprehensive assessment. Quantitative data were gathered through structured oral assessments measuring three key competencies: numerical symbol recognition (ability to verbally state numbers 1-20 in sequence), quantity-symbol matching (counting objects according to numerical indicators), and active project participation (engagement in Mini Market role-playing activities). Performance was evaluated using a

four-point scale: 1 (unable to complete tasks despite assistance), 2 (completion with substantial guidance), 3 (completion with minimal assistance), and 4 (independent, accurate completion). Qualitative data were collected through structured classroom observations aligned with PjBL phases, photographic documentation, and student work samples. Observation protocols systematically recorded teacher actions, student responses, and learning processes across opening activities, core instruction, and closing reflection phases.

Instrument validity was established through content validation by two early childhood education experts and experienced kindergarten practitioners, ensuring alignment between assessment indicators and number recognition learning objectives. Reliability was confirmed through pilot testing with comparable Group B students from another kindergarten, achieving Cronbach's alpha coefficients ≥ 0.70. Data trustworthiness was enhanced through triangulation techniques, including data source triangulation (combining observations, documentation, and reflections), member checking (validating observations with classroom teachers), and peer debriefing (consulting fellow early childhood educators).

Quantitative analysis converted raw scores to percentages using the formula: Percentage = (Σn/N) × 100%, where Σn represents total respondent scores and N indicates ideal score totals. Performance categories were classified as: excellent (91-100%), good (76-90%), adequate (61-75%), poor (51-60%), and very poor (≤50%). Qualitative analysis followed the Miles and Huberman model, involving data reduction (selecting relevant information), data presentation (descriptive and tabular formats), and conclusion drawing aligned with research objectives and success indicators. Success criteria required ≥76% of students achieving minimum scores of 3, demonstrated average score improvement from pre-action through Cycle III, and significant progress by the child with learning difficulties in number recognition, identification, and matching capabilities.

RESULTS AND DISCUSSION

Results

This action research study was conducted to evaluate the effectiveness of concrete media-based project learning in enhancing number recognition abilities among kindergarten children at risk of learning difficulties. The intervention was implemented through three iterative cycles following the Kemmis and McTaggart model, with each cycle consisting of planning, action implementation, observation, and reflection phases.

Pre-Action Assessment Results

Prior to implementing the intervention, a baseline assessment was conducted to determine the child's initial number recognition capabilities. The pre-action evaluation revealed significant challenges in fundamental numerical competencies. As presented in Table 1, the participant achieved a score of 3 out of 12 possible points, representing only 25% of the maximum performance level.

Table 1. Pre-Action Assessment Results

Subject	Maximum Score	Pre-Action Score	Percentage
Y	12	3	25%

The pre-action assessment encompassed three core competency areas: sequential number recitation (1-20), number-quantity matching using concrete objects, and active participation in Mini Market role-playing activities. The participant demonstrated particular difficulties in verbal number sequencing and struggled to establish connections between numerical symbols and their corresponding quantities. These baseline results confirmed the presence of learning challenges that necessitated targeted intervention strategies.

Cycle I Implementation and Results

The first intervention cycle was conducted over two sessions (April 21 and 24, 2025) focusing on basic number recognition through Mini Market project activities. During these sessions, the

participant engaged with concrete materials including toy fruits, play money, price labels, and shopping baskets while assuming various roles as seller, buyer, and cashier.

Progressive improvement was observed throughout Cycle I, as documented in Table 2. The participant's performance increased from the baseline 25% to 41.5% in the first session and further improved to 58.3% by the second session.

Table 2. Cycle I Performance Results

Session	Maximum Score	Achievement Score	Percentage
Pre-action	12	3	25%
I	12	5	41.5%
II	12	7	58.3%

These results indicated that the concrete media-based project learning approach successfully engaged the participant and began facilitating numerical concept development. However, performance levels remained below the target threshold of 76%, necessitating refinements for subsequent cycles.

Cycle II Implementation and Results

Building upon Cycle I insights, the second cycle incorporated enhanced materials and more structured activities. Additional concrete manipulatives were introduced, including number cards, weighing scales, and calculators, while maintaining the Mini Market theme. The intervention occurred over two sessions (May 5 and 8, 2025) with increased focus on individual guidance and scaffolding.

Table 3 demonstrates continued performance improvement during Cycle II, with achievement scores reaching 66.6% and 75% respectively across the two sessions.

Table 3. Cycle II Performance Results

Session	Maximum Score	Achievement Score	Percentage
I	12	8	66.6%
II	12	9	75%

The enhanced media variety and increased teacher scaffolding contributed to more substantial gains in number recognition abilities. The participant demonstrated greater confidence in numerical tasks and showed improved engagement with concrete materials. However, performance remained slightly below the 76% success criterion, indicating the need for further optimization.

Cycle III Implementation and Results

The final intervention cycle (May 19 and 22, 2025) represented a culmination of previous learning experiences with emphasis on independent performance and collaborative activities. Advanced Mini Market scenarios were implemented, including complex transactions involving addition, subtraction, and change-making calculations. The participant worked within small groups while receiving minimal teacher assistance.

Cycle III results, presented in Table 4, demonstrated significant achievement gains with scores of 83.3% and 91.6% across the two sessions.

Table 4. Cycle III Performance Results

Session	Maximum Score	Achievement Score	Percentage
I	12	10	83.3%
II	12	11	91.6%

The final session performance of 91.6% exceeded the predetermined success criterion of 76%, indicating successful intervention implementation. The participant demonstrated mastery in sequential number recitation, accurate number-quantity matching, and active participation in collaborative project activities.

Overall Performance Trajectory

The comprehensive intervention results reveal a substantial improvement trajectory from pre-action through Cycle III completion. The participant's performance increased from an initial 25% to a final achievement of 91.6%, representing a 66.6 percentage point improvement over the five-month intervention period.

Qualitative observations throughout the study documented enhanced engagement, increased confidence, and improved social interaction during mathematical activities. The participant progressed from passive participation requiring extensive teacher assistance to independent task completion and peer collaboration within group settings.

Discussion

The findings from this action research study provide compelling evidence for the effectiveness of concrete media-based project learning in supporting number recognition development among children at risk of learning difficulties. The substantial performance improvement observed aligns with established theoretical frameworks and contemporary research in early childhood mathematics education.

The successful intervention outcomes strongly support Piaget's (1978) developmental theory, which emphasizes the importance of concrete operational experiences in early childhood learning. The participant's progression from 25% to 91.6% performance demonstrates that children with learning difficulties can achieve significant mathematical competency when provided with appropriate concrete manipulatives and experiential learning opportunities. This finding corroborates Golafshani's (2013) assertion that abstract mathematical concepts become accessible through tangible, hands-on experiences.

The project-based learning framework employed in this study aligns with contemporary pedagogical approaches that emphasize active knowledge construction. Krajcik and Shin (2014) identified collaborative engagement and authentic problem-solving as hallmarks of effective project-based instruction, elements that were successfully integrated through the Mini Market theme. The participant's enhanced engagement and performance improvements reflect the benefits of meaningful, contextualized learning experiences described by Blumenfeld et al. (1991).

The systematic introduction and refinement of concrete materials across the three intervention cycles proved instrumental in facilitating number recognition development. Initial materials including toy fruits and play money provided foundational experiences, while progressive additions of number cards, scales, and calculators offered increasingly sophisticated learning opportunities. This graduated approach aligns with Fyfe et al.'s (2014) research demonstrating that concrete manipulatives enhance connections between mathematical concepts and learners' prior experiences.

The effectiveness of concrete media observed in this study contrasts with Kaminski et al.'s (2008) concerns regarding extraneous information from concrete materials. Rather than creating distraction, the carefully selected and systematically implemented concrete objects served as cognitive bridges, enabling the participant to develop increasingly abstract numerical understanding through concrete experiences.

The successful outcomes achieved with a participant identified as having learning difficulties provide important insights for inclusive education practices. The progressive improvement from baseline to final assessment suggests that children at risk of mathematical learning challenges can achieve grade-level competencies when provided with appropriate instructional modifications and support. This finding supports Greenboim-Zimchoni's (2019) emphasis on addressing both academic and emotional components of learning difficulties through engaging, non-threatening educational experiences.

The scaffolding approach employed throughout the intervention, where teacher support was gradually reduced as the participant's competence increased, reflects Vygotsky's zone of proximal development concept. The participant's progression from requiring extensive assistance to

independent task completion demonstrates the effectiveness of responsive instructional support in fostering mathematical development.

The performance improvements documented in this study are consistent with previous investigations of concrete media effectiveness in early childhood mathematics education. Agustina and Radiansyah (2023) reported similar benefits from card-based games in numerical symbol recognition, while Dilah et al. (2021) found pictorial number cards effective in developing numerical concept comprehension. The 66.6 percentage point improvement observed in this study exceeds gains reported in these previous investigations, potentially reflecting the comprehensive, multi-cycle intervention approach employed.

The project-based learning component of this intervention aligns with Holmes and Hwang's (2016) findings that PBL approaches enhance intrinsic motivation and critical thinking skills. The participant's increased engagement and confidence observed throughout the study reflect these motivational benefits, suggesting that project-based approaches may be particularly beneficial for children with learning difficulties who may experience reduced motivation in traditional instructional settings.

The successful implementation of this intervention within an inclusive classroom setting demonstrates the feasibility of supporting children with learning difficulties through differentiated instructional approaches. The Mini Market project provided authentic learning contexts that engaged all participants while addressing individual learning needs. This approach aligns with Beier et al.'s (2019) research on project-based learning benefits, including enhanced engagement and improved skill perceptions.

The systematic documentation of intervention refinements across the three cycles provides a replicable model for educators seeking to support children with mathematical learning challenges. The progressive complexity and reduced teacher scaffolding approach offers a framework for individualized instruction that maintains high expectations while providing necessary support.

Several limitations warrant consideration in interpreting these findings. The single-participant case study design limits generalizability to broader populations of children with learning difficulties. Additionally, environmental factors including irregular school attendance due to flooding and health issues may have influenced intervention consistency and outcomes.

Future research should investigate the long-term retention of skills developed through concrete media-based project learning and examine the effectiveness of this approach with diverse populations of children with learning difficulties. Comparative studies investigating different concrete media types and project themes would further inform best practices in inclusive mathematics education.

CONCLUSION

This action research study demonstrates the significant effectiveness of concrete media-based project learning in enhancing number recognition abilities among children at risk of learning difficulties. The intervention resulted in substantial performance improvement from 25% to 91.6% over three systematic cycles, exceeding the predetermined success criterion of 76%. The Mini Market project approach successfully engaged the participant through authentic, hands-on experiences that facilitated meaningful connections between abstract numerical concepts and concrete representations.

The research contributes to early childhood mathematics education by providing empirical evidence for the integration of project-based learning methodologies with concrete manipulatives in inclusive educational settings. This study extends existing literature by demonstrating the effectiveness of systematic, multi-cycle interventions specifically designed for children with learning difficulties, offering a replicable framework that combines theoretical foundations from Piaget's developmental theory with contemporary project-based pedagogical approaches.

The findings have significant implications for inclusive educational practice, suggesting that children with learning difficulties can achieve grade-level mathematical competencies when provided with differentiated instruction incorporating concrete materials and authentic learning contexts.

Educators can implement similar Mini Market projects to support diverse learners while maintaining engagement and motivation. The progressive scaffolding approach documented in this study provides a practical model for individualized instruction that gradually increases independence while maintaining high expectations.

Several limitations warrant consideration, including the single-participant case study design that limits generalizability and environmental factors such as irregular attendance that may have influenced intervention consistency. Future research should investigate long-term skill retention, examine effectiveness across diverse populations of children with learning difficulties, and explore comparative studies of different concrete media types and project themes. Additionally, research examining the scalability of this approach within regular classroom settings would inform broader implementation strategies. Investigation of teacher training requirements and resource allocation necessary for successful implementation would further support educational policy development and practice enhancement.

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