The Use of Manipulative Materials in Teaching the Concept of Addition to Preschool Children

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ABSTRACT

This study investigates the use of manipulative materials in teaching the concept of addition among 6-year-old preschool children, with particular attention to their understanding and engagement in early mathematics learning. Motivated by the need to support young children's comprehension of abstract mathematical concepts through concrete and hands-on experiences, this study employed a qualitative case study approach. Data were collected from three preschool children selected based on their pre-test results to determine prior knowledge of the addition concept. Three main instruments were utilised: a pre-test, a structured observation checklist, and a post-test. Observations were conducted five times throughout the teaching and learning process using manipulative materials. Data were analysed descriptively to identify changes and developments in children's understanding before and after intervention. Findings show that children's observed understanding of the addition concept, together with their active participation and interest during mathematics lessons, increased over the course of the manipulative-based intervention. As the study did not include a comparison group receiving conventional instruction, these gains are reported as associated with, rather than definitively caused by, the use of manipulative materials. These results nonetheless suggest that manipulative-based instruction supports meaningful learning in early childhood mathematics, and the study recommends integrating manipulative materials as a promising teaching approach in preschool classrooms, alongside further research to confirm their comparative effectiveness.

Keywords: Manipulative Materials, Addition Concept, Early Mathematics, Preschool Children, Qualitative Case Study

INTRODUCTION

Early childhood education constitutes the cornerstone of an individual's lifelong development. In Malaysia, early childhood education encompasses programmes designed for children from birth to eight years of age, including care and education at nurseries, kindergartens, preschools, and primary schools (Bahrun & Jamil, 2023). At this stage, children undergo rapid development across cognitive, social, emotional, and physical domains. The quality of early learning experiences, particularly in mathematics, has been shown to significantly influence children's future academic achievement (Parviainen, 2019).

Mathematics in early childhood is not merely about numbers; it encompasses foundational skills in numeracy, spatial reasoning, patterning, and problem-solving. According to the National Preschool Standard Curriculum (KSPK, 2017), early mathematics has been identified as one of the core strands in Malaysian preschool curricula. However, challenges persist in the effective delivery of mathematical concepts, particularly the concept of addition, which represents a fundamental building block for subsequent mathematical learning.

Research consistently highlights that children encounter difficulties when mathematical concepts are presented in abstract or symbolic forms without adequate concrete grounding (Ping & Bakar, 2022). Malaysia's performance in international assessments such as PISA 2022, where the average mathematics literacy score declined to 416 points from 438 in 2018, underscores the urgency of re-examining pedagogical approaches in early mathematics instruction (PISA, 2022).

Manipulative materials, defined as physical objects that children can handle, move, arrange, and explore, have been widely advocated as effective tools for bridging the gap between concrete experiences and abstract mathematical understanding. Grounded in constructivist learning theories, manipulatives support active, inquiry-based learning and have been associated with improved mathematical comprehension, engagement, motivation, and positive attitudes toward mathematics (Ahmad & Siller, 2024; Taley, 2023).

Despite growing evidence supporting the effectiveness of manipulative-based instruction, the integration of such materials in Malaysian preschool settings remains inconsistent, with many teachers reporting insufficient resources and limited professional preparation (Siew & Tee, 2024). Against this backdrop, this study examines the role of manipulative materials in supporting preschool children's understanding of the addition concept.

Objectives Of the Study

This study was guided by three primary objectives:

i. To identify the level of mastery of the addition concept among preschool children prior to intervention.

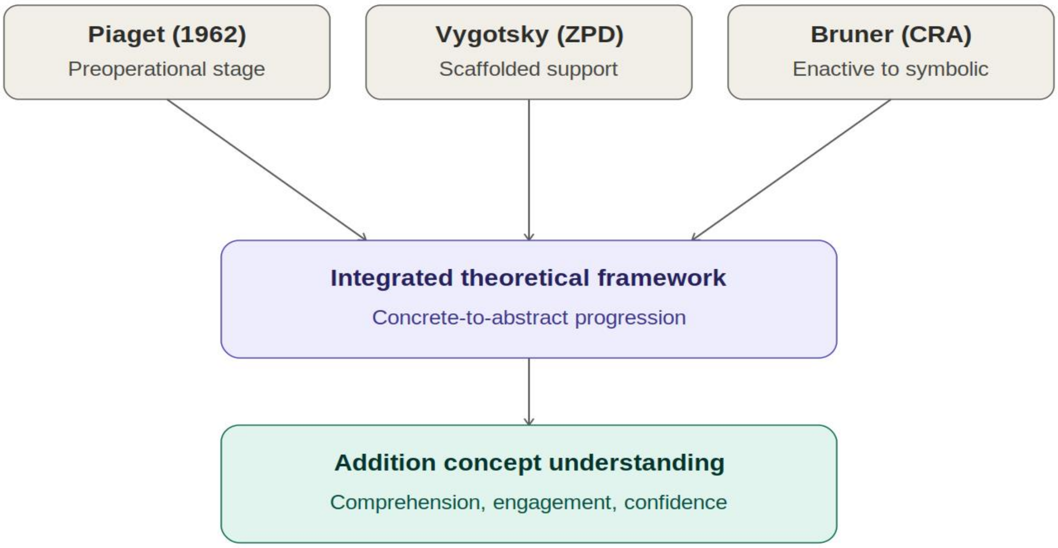
ii. To examine the influence of manipulative materials in supporting the learning of the addition concept among preschool children.

iii. To determine the effect of manipulative materials on children's achievement in the addition concept.

LITERATURE REVIEW

Theoretical Foundations

This study is anchored in three prominent learning theories that collectively explain how young children construct mathematical knowledge through interaction with concrete materials.



Piaget's Cognitive Development Theory (1962) posits that children's cognitive development progresses through distinct stages from birth through adolescence. Preschool-aged children (approximately 2–7 years) occupy the preoperational stage, during which they begin to think symbolically but remain heavily dependent on concrete, tangible representations to make sense of abstract concepts. For this reason, the use of concrete objects in early mathematics instruction is not merely supplementary but developmentally essential (Ping & Bakar, 2022).

Vygotsky's Sociocultural Theory introduces the concept of the Zone of Proximal Development (ZPD), which describes the gap between what a learner can accomplish independently and what can be achieved with the guidance of a more capable peer or adult. Scaffolding, as a pedagogical strategy aligned with ZPD, provides structured support that gradually diminishes as children gain competence. In the context of manipulative-based learning, the teacher's role is to scaffold children's interaction with materials, supporting the transition from concrete to abstract understanding (Yasmine, 2021).

Bruner's Cognitive Constructivist Theory describes three modes of representation through which children acquire knowledge: enactive (learning through direct physical action), iconic (learning through visual imagery), and symbolic (learning through abstract symbols and language). This progression, often operationalised as the Concrete-Representational-Abstract (CRA) framework, provides a structured pathway for mathematics instruction, beginning with hands-on manipulation and advancing toward symbolic representation (Sudarti et al., 2025; Ebner et al., 2024).

Manipulative Materials in Early Mathematics

Manipulative materials are pedagogical tools designed to facilitate active problem-solving and inquiry through direct exploration of physical objects that represent mathematical concepts. They may be classified into two broad categories: concrete manipulatives (such as pattern blocks, counting chips, fraction strips, and geoboards) and virtual manipulatives accessible via digital platforms (Ahmad & Siller, 2024).

The use of manipulative materials in mathematics education has been endorsed by the National Council of Teachers of Mathematics (NCTM) as a critical resource for enhancing mathematics instruction quality. Research demonstrates that manipulatives not only strengthen cognitive understanding but also positively influence the affective domain, fostering greater engagement, motivation, and reduced mathematics anxiety among young learners (Pingky et al., 2025; Taley, 2023).

A growing body of comparative studies supports these claims. Sofroniou et al. (2025) found that children who used construction-based manipulatives achieved significantly higher performance in counting and addition skills compared to those in traditional instruction groups. Similarly, Boz, Uludağ, and Erdoğan (2020), in a quantitative experimental study involving 45 preschool-aged children, reported significant improvements in early mathematics skills among the experimental group following six weeks of outdoor learning with manipulative materials. Farra et al. (2024) further demonstrated that both concrete and virtual manipulatives enhance conceptual understanding and achievement compared to conventional teaching, with concrete manipulatives being particularly effective for foundational concept development.

In the Malaysian context, Sia and Bakar (2022) confirmed that concrete and visual materials help preschool children better comprehend addition concepts, while Bakar and Rafi (2025) found that mathematical games, a form of manipulative-based activity, significantly improved number mastery among preschool students. Collectively, these studies establish a strong evidence base for manipulative-based instruction in early childhood mathematics education.

METHODOLOGY

Research Design

This study employed a qualitative case study approach, which enables in-depth, holistic exploration of a phenomenon within its real-life context (Mokhtar & Jamil, 2021). A case study design was considered particularly appropriate for this investigation because the research questions centred on how and why individual children responded to manipulative-based instruction, a form of inquiry that Yin (2018) and Merriam and Tisdell (2016) argue is best addressed through close, contextualised examination of a bounded number of cases rather than through the statistical generalisation associated with large-sample quantitative designs. The qualitative paradigm was selected to allow nuanced examination of children's learning processes, behavioural changes, and engagement patterns during manipulative-based instruction. The case study design facilitated detailed, contextualised analysis of individual participants, allowing the researcher to capture the complexity and richness of each child's learning experience. To strengthen the trustworthiness of the qualitative findings, the study drew on multiple sources of evidence, the pre-test, the five rounds of structured observation, and the post-test, so that patterns identified through the observation checklist could be corroborated against measurable changes in test performance, a form of data triangulation consistent with recommended practice in qualitative case study research (Yin, 2018).

Participants

The population comprised seven 6-year-old preschool children enrolled at a private preschool in Selangor (pseudonym used to protect the identity of the institution and participants). Following the administration of a pre-test to the full population, three participants were purposively selected as study samples based on their pre-test results, ensuring representation of varying prior knowledge levels. This targeted sampling approach ensured that the intervention could be meaningfully evaluated for its effects on children at different points of readiness.

Data Collection Instruments

Three instruments were employed in data collection:

i. Pre-Test: A written mathematics assessment comprising two sections, Section A (five symbolic addition questions using numerical symbols) and Section B (five visual addition questions using picture-based representations), was administered to all seven children prior to intervention to establish baseline knowledge.

ii. Structured Observation Checklist: A researcher-developed observation instrument comprising five constructs was used across five observation sessions during the intervention period. The five constructs evaluated were: (1) understanding of the addition concept, (2) skill in using manipulative materials, (3) engagement and attention during activities, (4) ability to solve addition problems, and (5) attitude and confidence in mathematics learning. Each item was rated on a three-point scale: 0 (skill not demonstrated), 1 (skill demonstrated with guidance), and 2 (skill demonstrated independently).

iii. Post-Test: A parallel assessment to the pre-test was administered following the intervention period to measure changes in the children's understanding and mastery of the addition concept, again comprising visual (Section A) and symbolic (Section B) components.

Instrument Validity

Content validity was established through expert review involving three specialists in early childhood education: one experienced preschool teacher with approximately five years of practice and two university lecturers with more than three years of experience in early childhood research and curriculum development. Expert feedback was used to refine instrument content, language clarity, conceptual accuracy, and practical applicability.

Data Analysis

Data were analysed using descriptive analysis, which involved systematic description, organisation, and summarisation of data to identify patterns and trends in children's learning before and after the intervention (Ayawaila et al., 2025). Observation data were presented as frequency scores per construct and per child, while pre-test and post-test results were compared to assess the magnitude of learning gains.

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FINDINGS

Pre-Test Results

The pre-test was administered to all seven children (labelled A through H) to establish baseline competency. Results are presented in Table 1.

Table 1: Pre-Test Results

Student	Addition - Symbolic (5)	Addition - Visual (5)	Total (10)
A	5/5	3/5	8/10
B	2/5	5/5	7/10
C	5/5	5/5	10/10
D	2/5	5/5	7/10
E	2/5	5/5	7/10
F	1/5	5/5	6/10
G	4/5	5/5	9/10
H	2/5	5/5	7/10

The pre-test results reveal a marked disparity between children's performance on visual and symbolic addition items. Seven out of eight participants achieved full marks on the visual addition section, while the majority scored only one to two marks on the symbolic addition section. This finding reflects the well-documented developmental pattern in which young children at the preoperational stage demonstrate stronger comprehension of concrete and pictorial representations compared to abstract symbolic notation (Piaget, 1962; Syafdaningsih et al., 2020).

Based on the pre-test outcomes, three children, referred to as Student D (Hadid), Student A (Adam), and Student G (Ayden), were selected for the intervention phase, representing a range of entry-level competencies.

Observation Results

Five structured observation sessions were conducted during the intervention. Children interacted with concrete manipulative materials, including spinner wheels, numbered boxes, star-shaped counters, and number tiles, to explore and practice the addition concept. Findings across five constructs are detailed below.

Understanding of the Addition Concept (Construct A)

Table 2: Scores for Addition Concept Understanding

Student	Identify two groups of objects	Physically combine objects	State sum correctly
D (Hadid)	2	2	2
A (Adam)	2	2	2
G (Ayden)	2	2	1

As presented in Table 2, both Hadid and Adam demonstrated independent mastery across all three indicators of addition concept understanding (score of 2 for each item). Ayden independently identified and combined object groups but required guidance when stating the sum, suggesting an emerging but not yet consolidated grasp of the final step in the addition process. Notably, no participant received a score of 0 on any indicator, indicating a baseline level of engagement with the concept across all participants.

Skill in Using Manipulative Materials (Construct B)

Table 3: Scores for Manipulative Usage Skills

Student	Handle materials appropriately	Count objects one by one	Use materials to solve problems
D (Hadid)	2	2	2
A (Adam)	1	2	2
G (Ayden)	2	2	2

Table 3 reveals high overall competency in manipulative material usage. Hadid and Ayden scored independently on all three indicators, while Adam required guidance only in appropriately handling the materials, despite being able to count and apply them to problem-solving independently. These findings align with Boz et al.'s (2020) assertion that hands-on interaction with concrete objects promotes fine motor engagement alongside mathematical concept development.

Engagement and Attention During Activities (Construct C)

Table 4: Scores for Engagement and Attention

Student	Attentive during activities	Actively uses manipulatives	Sustains focus until completion
D (Hadid)	2	2	1
A (Adam)	2	2	2
G (Ayden)	1	2	1

Engagement results presented in Table 4 reflect satisfactory overall involvement. Adam demonstrated the most consistent pattern, achieving independent performance on all three indicators. Hadid and Ayden both engaged actively with the materials but required guidance to sustain attention throughout the full activity duration. These findings highlight that while manipulative materials serve as effective engagement stimuli, the teacher's scaffolding role remains essential in maintaining children's sustained focus, an observation consistent with Vygotsky's concept of scaffolded support within the ZPD.

Ability to Solve Addition Problems (Construct D)

Table 5: Scores for Problem-Solving Ability

Student	Understands problem instructions	Combines groups with appropriate strategy	Provides correct answer
D (Hadid)	2	2	2
A (Adam)	1	1	1
G (Ayden)	2	1	2

Table 5 indicates variability in problem-solving competency across participants. Hadid demonstrated fully independent performance on all three indicators. Ayden independently understood instructions and produced correct answers but required guidance when selecting an appropriate strategy for combining object groups. Adam required guidance across all three indicators, suggesting that while manipulative materials facilitated some understanding, sustained teacher support was necessary for this participant. These results are consistent with Nayad and Lanante's (2025) observation that manipulatives are effective aids for problem-solving, but teacher modelling and scaffolding remain essential for children who have not yet internalised strategic thinking processes.

Attitude and Confidence in Mathematics (Construct E)

Table 6: Scores for Attitude and Confidence

Student	Shows confidence during activities	Attempts problems without fear	Shows satisfaction after completion
D (Hadid)	2	2	2
A (Adam)	1	1	2
G (Ayden)	1	2	2

The affective domain findings in Table 6 are noteworthy. All three participants independently demonstrated satisfaction upon completing tasks (score of 2), indicating a positive emotional response to the learning experience. Hadid demonstrated fully independent confidence and willingness to attempt problems. Ayden showed confidence in attempting problems independently but required encouragement for initial confidence expression. Adam required guidance in confidence and willingness, yet still showed independent satisfaction. These findings resonate with Bandura's concept of self-efficacy (as discussed in Purwati et al., 2025), wherein successful task completion through manipulative use generates positive mastery experiences that reinforce children's beliefs in their own mathematical capability.

Post-Test Results

Following the five observation-intervention sessions, the post-test was administered to the three selected participants. Results are presented in Table 7.

Table 7: Post-Test Results

Student	Addition - Visual (8)	Addition - Symbolic (8)	Total (16)
D (Hadid)	8/8	6/8	14/16
A (Adam)	8/8	5/8	13/16
G (Ayden)	8/8	7/8	15/16

Post-test results demonstrate substantial improvement across all participants. All three children achieved perfect scores on the visual addition section (8/8), representing a dramatic improvement from the pre-test, where visual addition scores ranged from 3/5 to 5/5. For symbolic addition, Ayden achieved 7/8, Hadid 6/8, and Adam 5/8, each demonstrating considerable gains from their pre-test performance in this domain. Overall totals of 15/16, 14/16, and 13/16 respectively are consistent with the intervention having supported gains in both forms of addition competency, although, in the absence of a comparison group receiving conventional instruction, this improvement cannot be attributed to the manipulative-based approach alone and may also reflect maturation, repeated testing, or ordinary classroom learning over the same period. The persistent marginal gap between visual and symbolic performance aligns with developmental expectations, as the transition from concrete to abstract symbolic representation typically requires extended practice and consolidation (Bruner, 1960; Ebner et al., 2024).

DISCUSSION

The findings of this study are consistent with and extend the existing body of research on manipulative-based mathematics instruction in early childhood settings. Three overarching themes emerge from the analysis.

First, the pre-test findings confirm that children entering the intervention possessed stronger visual-concrete mathematical understanding compared to symbolic-abstract competency. This aligns with Piaget's developmental framework, which asserts that children in the preoperational stage require concrete, perceptible representations as scaffolds for mathematical cognition. As Syafdaningsih et al. (2020) note, young children between birth and eight years of age are in developmental stages characterised by growing logical thinking, but only when that thinking is grounded in tangible, observable phenomena.

Second, the observation data reveal that manipulative materials functioned as effective pedagogical bridges, enabling children to develop procedural fluency alongside conceptual understanding of addition. The majority of observed behaviours were demonstrated at the independent level (score of 2), indicating that children progressively internalised the addition process through repeated hands-on engagement. This supports Sofroniou et al.'s (2025) experimental evidence that manipulative-based learning promotes visualisation and problem-solving. The finding also resonates with Pingky et al.'s (2025) report that children using manipulatives exhibit heightened motivation, willingness to participate, and a more exploratory learning orientation.

Third, the post-test results provide compelling evidence of learning gains attributable to the manipulative intervention. The achievement of perfect visual addition scores by all participants, coupled with meaningful improvements in symbolic addition, demonstrates that the Concrete-Representational-Abstract progression facilitates knowledge transfer from hands-on experience to more formal mathematical representation. This is consistent with Ebner et al.'s (2024) meta-analytic review affirming the effectiveness of the CRA approach for mathematics instruction, and with Kate Quane's (2024) findings that manipulative use is associated with improved achievement and more positive attitudes toward mathematics.

The variability in outcomes across participants also warrants attention. Differences in individual performance patterns underscore the importance of differentiated instruction and sustained teacher scaffolding, particularly for children such as Adam, who demonstrated consistent dependence on guidance. This echoes Vygotsky's insistence that optimal learning occurs within the ZPD, the zone where a learner can progress with appropriately calibrated adult support, moving incrementally toward independent performance.

CONCLUSION AND RECOMMENDATIONS

This study offers descriptive, in-depth case study evidence consistent with the effectiveness of manipulative materials in enhancing preschool children's understanding of the addition concept. Through a qualitative case study involving three 6-year-old children, the research suggests that hands-on engagement with concrete objects is associated with gains in conceptual understanding, skill development, active engagement, problem-solving ability, and mathematical confidence. The pre-test to post-test comparison reveals substantial and consistent learning gains, with all participants achieving perfect scores on visual addition and marked improvements on symbolic addition following the intervention, although, as noted below, the absence of a comparison group means these gains cannot be attributed to the intervention with certainty.

These findings carry meaningful implications for preschool pedagogy in Malaysia and beyond. Manipulative materials should be institutionalised as a standard component of early mathematics curricula rather than treated as supplementary resources. Teachers require sustained professional development to integrate manipulatives effectively, particularly in facilitating the progression from concrete manipulation to iconic representation and finally to abstract symbolic reasoning, as outlined in Bruner's framework and operationalised through the CRA approach.

Limitations of the Study

Three limitations of this study should be acknowledged. First, the qualitative evidence base relied primarily on numerical ratings from the structured observation checklist. While this instrument enabled systematic comparison across constructs and participants, it did not capture the fuller texture of children's reasoning that richer qualitative sources, such as verbatim transcripts of children's verbal explanations, semi-structured interviews with the class teacher, and the researcher's reflective field notes, would have provided. Future case studies of manipulative-based instruction should incorporate these additional sources to build a more deeply contextualised and trustworthy account of how children come to understand addition. Second, the intervention spanned only five observation sessions, a period too brief to draw conclusions about the long-term retention of the addition concept or the durability of the engagement gains observed. Extending the intervention over several weeks or months, with delayed follow-up assessments, would allow future studies to examine whether improvements are sustained over time. Third, this study did not include a control or comparison group receiving conventional, non-manipulative instruction. Consequently, while the pre-test to post-test gains reported here are encouraging, they cannot be firmly attributed to the manipulative materials as opposed to ordinary classroom teaching, repeated testing, or maturation over the intervention period. Incorporating a comparison group in future research would allow stronger causal inferences to be drawn regarding the specific contribution of manipulative-based teaching.

Building on these limitations, future research should extend the scope of this investigation by employing larger samples and a control or comparison group receiving conventional instruction to permit generalisability and stronger causal inference, examining long-term retention of manipulative-acquired knowledge through extended intervention periods and delayed post-testing, incorporating richer qualitative evidence such as classroom observations, children's verbal explanations, teacher interviews, and reflective field notes, exploring hybrid models that integrate physical and virtual manipulatives, and investigating the effects of manipulative-based instruction across diverse mathematical domains beyond addition.

Ultimately, this study affirms that when young children are afforded meaningful, structured opportunities to learn mathematics through active, concrete engagement, they develop not only stronger foundational skills but also the confidence and intrinsic motivation that underpin sustained mathematical success.

REFERENCES

1. Ahmad, S., & Siller, H. (2024). Investigating the effect of manipulatives on mathematics achievement: The role of concrete and virtual manipulatives for diverse achievement level groups. Journal on Mathematics Education, 15(3), 979–1002. https://doi.org/10.22342/jme.v15i3.pp979-1002
2. Abdul Rani, I. F., & Mat Nor, M. A. H. (2025). Analisis Keperluan Pembangunan Bahan Bantu Mengajar bagi Kemahiran Operasi Tambah dalam Kalangan Kanak-kanak Enam Tahun. Jurnal Pendidikan Sains Dan Matematik Malaysia, 15(2), 89–102.
3. Bahrun, N. A. N., & Jamil, N. (2023). Analisis Keperluan Pembangunan Math Addition Bag Untuk Meningkatkan Kemahiran Operasi Tambah Dua Digit Kanak-kanak Prasekolah. Jurnal Pendidikan Awal Kanak-kanak Kebangsaan.
4. Bakar, K. A., & Rafi, H. (2025). The effectiveness of using mathematical games in learning centers in improving number mastery among preschool students. International Journal of Academic Research in Business and Social Sciences, 15(3).
5. Boz, M., Uludağ, G., & Erdoğan, S. (2020). The effect of the manipulative materials on the early mathematical skills. Bartın University Journal of Faculty of Education, 9(3), 492–500.
6. Bruner, J. S. (1960). The process of education. Harvard University Press.
7. Ebner, S., MacDonald, M. K., Grekov, P., & Aspiranti, K. B. (2024). A meta-analytic review of the Concrete-Representational-Abstract math approach. Learning Disabilities Research and Practice, 40(1), 31–42.
8. Farra, N. K. A., Belbase, S., Tairab, H., Qablan, A., Opoku, M. P., & Safi, S. K. (2024). Impact of using virtual and concrete manipulatives on students' learning of fractions. Cogent Education, 11(1).
9. Kementerian Pendidikan Malaysia. (2017). Kurikulum Standard Prasekolah Kebangsaan (Semakan 2017). KPM.
10. Merriam, S. B., & Tisdell, E. J. (2016). Qualitative research: A guide to design and implementation (4th ed.). Jossey-Bass.
11. Mokhtar, M. M., & Jamil, N. (2021). Sudut Pandang Pelaksanaan Kajian Kes Kualitatif terhadap Naturalisasi Penyelidikan Pendidikan Bahasa Melayu. Jurnal Pendidikan Bahasa Melayu.
12. Nayad, M. G., & Lanante, M. G. A. (2025). Effect of problem-solving enrichment activities on mathematics achievement. International Journal of Studies in Education and Science (IJSES), 6(3), 271–280.

13. Parviainen, P. (2019). The development of early mathematical skills: A theoretical framework for a holistic model. Journal of Early Childhood Education Research, 8(1), 162–191.
14. Piaget, J. (1962). Play, dreams and imitation in childhood. Norton.
15. Pingky, N., Aziz, N. A. A., & Wahyuni, S. (2025). Innovative pedagogy: Improving early childhood numeracy skills using manipulative media. International Journal of Pedagogy, 3(2).
16. PISA. (2022). Laporan Awal Pencapaian Malaysia Dalam PISA 2022. Kementerian Pendidikan Malaysia.
17. Purwati, Tanujaya, B., & Istia, M. S. (2025). Mathematical self-efficacy and creative thinking in social arithmetic: Insight from Junior High School students in Papua. Jurnal VARIDIKA, 162–177.
18. Quane, K. (2024). The confluence of attitudes towards mathematics and pedagogical practice: Evaluating the use of mathematical manipulatives. Mathematics Education Research Journal, 37(2), 369–398.
19. Sia, S. P., & Bakar, K. A. (2022). Improving the addition of preschool children through the use of concrete and visual materials. Jurnal Pendidikan Awal Kanak-kanak Kebangsaan, 11, 103–113.
20. Siew, S. K., & Tee, Y. Q. (2024). Perspectives of early mathematics implementation among Malaysian public preschool teachers: Issues, challenges, and way forward. International Journal of Academic Research in Progressive Education and Development, 13(2).
21. Sofroniou, A., Premnath, B., Sisamos, C., Almpani, S., & Sisamou, E. (2025). Analyzing pre-primary students' mathematics performance through the use of educational construction toys. Journal of Mathematics Science and Technology Education, 2(1), 19–32.
22. Sudarti, S., Sumardjoko, B., Harsono, H., Narimo, S., & Surono, Y. (2025). Utilizing natural materials in early mathematics education: Applying Bruner's theory to early childhood learning in Surakarta. Journal of Posthumanism, 5(3).
23. Syafdaningsih, Rukiyah, & Utami, F. (2020). Educational game tools in early childhood mathematics learning. Proceedings of SULE-IC 2020.
24. Taley, I. B. (2025). Use of manipulatives for mathematics teaching and learning. www.academia.edu.
25. Yasmine, A. (2021). A theoretical exploration: Zone of Proximal Development as an ethical zone for teaching mathematics. Avances de Investigación en Educación Matemática, 20, 7–21.
26. Yin, R. K. (2018). Case study research and applications: Design and methods (6th ed.). SAGE Publications.