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CHILDREN'S SEMIOTIC AND MULTIMODAL MEANING-MAKING IN NUMERICAL STORY PROBLEMS

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ABSTRACT

This study addresses a gap in early childhood mathematics research: while previous studies have largely emphasized number-symbol representation and correct answers, limited attention has been paid to children's semiotic, multimodal, and meaning-making processes when solving numerical story problems. This study employs a descriptive qualitative approach. Data were collected through observation of children while working on numerical story problems, interviews with teachers regarding how children learn, and documentation of scribbles, drawings, and mathematical symbols produced by children. This study was conducted with 25 kindergarten children aged 5–6 years (Group B) at RA Anggrek. Data were collected through classroom observations, contextual interviews with children and teachers, and documentation of children's drawings, scribbles, gestures, verbal counting, and mathematical symbols. The findings show that children predominantly used drawings as primary semiotic representations, accompanied by gestures, verbal counting, scribbles, and emerging use of number symbols. These modes did not appear separately; rather, they interacted dynamically as thinking tools in the children's meaning-making process. The child's meaning-making process toward the signs they created shows that these representations function as thinking tools. From Vygotsky's perspective, the Zone of Proximal Development (ZPD) emerges when children transition from concrete to abstract thinking, whereas according to Piaget, children are in the preoperational stage, which still relies on concrete objects. This study highlights that children's mathematical understanding develops through multimodal semiotic activity, not merely through formal symbols or final answers. Pedagogically, the findings suggest that early childhood numeracy instruction should provide space for drawing, moving, marking, and talking as legitimate parts of mathematical thinking.

Keywords: Multimodality, Child Semiotics, Meaning-Making, Numerical Story Problems, Early Childhood Mathematics.

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INTRODUCTION

Early childhood numeracy is a foundational aspect of cognitive development because it supports children's ability to think logically, understand quantity, recognize numerical relationships, and solve everyday problems meaningfully. Contemporary research also shows that early mathematics learning should not be reduced to symbol recognition alone but should involve rich pedagogical experiences, meaningful assessment, and opportunities for children to express mathematical thinking in ways that match their developmental level. In this sense, early mathematics learning is closely related to children's representational development and to the quality of instructional practices that support conceptual understanding (Björklund et al., 2020; Clements et al., 2023; Outhwaite et al., 2024). (Missall et al., 2014; Purpura & Lonigan, 2013).

One important context for examining children's mathematical thinking is the use of numerical story problems. Story-based numerical tasks can create opportunities for children to connect language, quantity, and lived experience while engaging in mathematical talk and reasoning. Recent studies suggest that number stories can stimulate meaningful mathematical engagement because children respond not only to the numerical content of a task, but also to the social and contextual meanings embedded in it. Thus, numerical story problems are not merely tools to obtain correct answers; they can also function as spaces where children construct mathematical meaning through diverse forms of expression (Graven & Jorgensen, 2024).

In early childhood mathematics, these expressions often appear through drawings, marks, gestures, spoken counting, and other forms of representation. Recent research has shown that children's drawings can provide important access to their mathematical strategies and understanding during problem solving, especially when children are not yet able to communicate their reasoning through formal written symbols alone. Likewise, studies on young children's use of mathematical signs indicate that their inscriptions, drawings, and emergent notations play a significant role in the development of mathematisation and meaning-making. This means that children's signs should not be treated as peripheral products of learning, but as central resources for thinking and communicating mathematically (Cartwright, 2023; Worthington et al., 2024).

However, classroom practice in early childhood settings still often emphasizes correct answers, number writing, and school-readiness outcomes more than the process through which children build understanding (Quane, 2025). Previous research has only discussed children's representation of mathematical number symbols and numeracy skills alone (Sarama & Clements, 2009). Field conditions, based on initial observations at TK Anggrek, indicated that numeracy activities were still largely directed toward recognizing numbers, writing symbols, and producing predetermined answers. Such practices provide limited room for children to show how they think through visual, bodily, and verbal modes. This condition is problematic because recent studies highlight that children's attitudes, engagement, and mathematical sense-making are strongly shaped by how learning environments allow them to interact with representations, manipulatives, and communicative resources during learning. Based on interviews with Group B teachers, preliminary findings were obtained that the numeracy learning process was only centered on the final outcome, in preparation for elementary school (Fitria et al., 2022). Yet children should learn through play. Children enjoy learning numbers and understanding mathematical concepts.

Initial research at TK Anggrek yielded findings that learning became mechanical and gave little room for children to construct their own understanding, teachers tended to pay more attention to whether children's answers were right or wrong, rather than how children arrived at those answers, when children were able to provide correct answers, the process they went through was rarely examined more deeply, when children gave wrong answers, teachers often corrected them immediately without exploring the children's way of thinking (Rahayu & Hartati, 2022). This shows that the process of representing and using semiotic signs by children has not yet become a main focus in learning. Yet through this process, teachers can understand how children make meaning of the mathematical concepts presented.

This issue highlights a gap between the developmental characteristics of early childhood learning and the instructional approaches commonly used in practice. Although recent studies have examined early numeracy, children's mathematical drawings, and the pedagogical role of representations, research that specifically focuses on child semiotics and multimodal meaning-making in solving numerical story problems remains limited. Existing studies tend to discuss children's representations either as indicators of achievement or as isolated forms of expression, rather than as interconnected semiotic resources that work together during problem solving. Therefore, there is still a need for studies examining how gestures, visual representations, scribbles, and verbal utterances interact in children's meaning-making processes when responding to numerical story problems (Björklund et al., 2020; Cartwright, 2024; Worthington et al., 2024).

Understanding children's representation and semiotic expression processes, learning is expected to no longer focus solely on right or wrong, but also on the thinking process behind it (Sfard, 2008). This is important for creating more meaningful learning, appreciating the diversity of children's ways of thinking, and optimally supporting their cognitive development. Accordingly, it is important to understand that the combination of various semiotic forms, gesture, visual representation, and verbal utterance not only functions as an expression, but also as an integral part of children's mathematical thinking strategies (Alibali & Nathan, 2012; McNeill, 2005). Through the coordination of these three modes, children construct, organize, and modify their understanding of the numeracy situation they face. Therefore, this study emphasizes the effort to reveal how these semiotic combinations shape children's mathematical thinking strategies for solving story problems, so that the meaning-making process can be understood more deeply and comprehensively.

Based on this gap, the present study investigates how Group B children construct mathematical meaning while solving numerical story problems through multimodal and semiotic resources. This study aims to identify the semiotic patterns that emerge, describe children's multimodal combinations during problem solving, and interpret how these signs function as thinking tools in the meaning-making process. By doing so, this study is expected to contribute to a more process-oriented understanding of early childhood numeracy and to provide pedagogical insight for designing mathematics learning that values children's diverse ways of representing and understanding mathematical ideas.

METHOD

This study uses a qualitative approach with a descriptive design to deeply understand the process of representation and semiotic expression of children in solving numeracy problems (Creswell, 2014). This study employed a descriptive qualitative design to explore how children construct meaning as they solve numerical story problems using semiotic and multimodal resources. A qualitative approach was selected because the study's focus was not on measuring learning outcomes statistically but on understanding children's representational processes, expressions, and strategies during mathematical activity. The study was conducted in RA Anggrek and focused on Group B children, as this age group is in an important developmental phase for the emergence of early symbolic and representational thinking.

The research subjects were Group B children at RA Anggrek, totaling 25 children, consisting of 17 boys and 8 girls, with no children with special needs. Interviews were also conducted with children contextually, while they were working on numeracy problems, with the aim of understanding the meaning-making process they were doing (Moleong, 2017). The participants were selected as a whole-class group because the study aimed to capture naturally occurring patterns of children's meaning-making in regular classroom numeracy activities. The classroom teacher was also involved as an additional source of contextual information, particularly to explain the children's learning habits, classroom practices, and the class's general orientation to numeracy learning.

Documentation was used as supporting data in the form of scribbles or drawings made by children while solving numeracy problems. This visual data became an important part of analyzing children's semiotic representations, particularly in visual and symbolic forms (Monteira et al., 2024).

The main task used in this study was a set of numerical story problems designed to reflect early childhood numeracy learning contexts. The problems involved simple addition and subtraction that were familiar to children's daily experiences, such as objects being added, taken away, or counted in short stories. These story problems were chosen because they provided opportunities for children to interpret mathematical situations and express their understanding through various modes, including gesture, drawing, scribbling, verbal counting, and emergent symbols. The tasks were administered across five learning meetings to observe changes and patterns in children's semiotic expressions over time, as reflected in the study's results section.

Data were collected through observation, contextual interviews, and documentation. Observation was conducted during children's engagement with numerical story problems in classroom activities. During the observation, the researcher focused on how children responded to the story situations, how they used gestures, drawings, marks, verbal utterances, and number symbols, and how these modes were coordinated during problem solving. Contextual interviews were conducted directly with children during or immediately after the activity in order to understand the meaning of the signs they produced. These interviews were brief, flexible, and adjusted to the children's responses, for example, by asking what they drew, why they crossed out certain objects, or how they arrived at an answer. Documentation was collected in the form of children's worksheets, scribbles, drawings, written symbols, and field notes on visible actions and verbal expressions.

Data obtained were analyzed qualitatively through the process of data reduction, coding, categorization, and interpretation (Miles et al., 2020). First, all observational notes, interview records, and visual documents were organized and reduced based on relevance to the research focus. Second, the data were coded to identify semiotic forms in the children's responses, such as gestures, visual representations, verbal utterances, internal verbal indications, number symbols, and scribbles. Third, these coded data were grouped into broader categories to identify recurrent semiotic patterns and multimodal combinations across the five meetings. Finally, the categorized data were interpreted to explain how these signs functioned as thinking tools in children's meaning-making processes while solving numerical story problems. In this study, the analysis emphasized not only individual signs but also the coordination among signs, since the meaning-making process was understood as multimodal.

To enhance the trustworthiness of the findings, data were triangulated across three sources: classroom observation, contextual interviews, and children's visual products. The interpretation of children's responses was also checked against the teacher's classroom context to ensure the researcher did not rely solely on a single mode of evidence. Repeated observation across five meetings further helped identify stable patterns rather than incidental behaviors. In addition, the categorization process was conducted consistently by referring to the recurring forms of children's semiotic expressions found across tasks and meetings. This procedure helped strengthen the credibility of the analysis.

Ethical considerations were also taken into account because the participants were young children. The study was conducted in coordination with the school and classroom teacher, and classroom data were collected only during regular learning activities. Children were observed in a natural learning setting without pressure, and the researcher prioritized children's comfort during observation and contextual interviews. All data were used solely for research purposes and were described in a manner that protected participants' identities.

RESULT

The results of this study show that children used various semiotic resources in solving numerical story problems. These resources did not appear separately, but emerged in combinations throughout the problem-solving process. Across the five meetings, the children's responses indicated three main semiotic forms: gestures, visual representations, and verbal expressions. In addition, several children also used scribbles and emergent number symbols as part of their efforts to construct meaning. Overall, the findings suggest that children's mathematical responses were dynamic and multimodal rather than purely symbolic.

Table 1. Types of Children's Abilities Emerging During Mathematical Activities

Meeting	Child Activity	Gesture	verbal	Dominant Semiotic Type	Semiotic Description
1	Moving balls while counting	x	v	Gestur + Verbal	A child uses object-moving motion as a quantity representation while counting verbally
2	Moving objects between containers while counting	x	v	Gestur + Verbal	Gesture serves as the main tool in understanding quantity through concrete activities
3	Counting pictures on paper	v	v	Gestur + Verbal	Child begins shifting to visual representation; symbolic error (writes 11 for 2)
4	Counting many objects	x	v	Gestur + Verbal	A child relies on gestures and verbal cues to manage cognitive load
5	Drawing quantity representations	v	v	Gestur + Verbal	A child uses drawing as a primary representation in understanding quantity

Semiotic Patterns Across the Five Meetings

Based on observational results, there are three main semiotic forms used by children, namely gesture, visual, and verbal (Radford, 2003). Gesture appeared when children used fingers, hand movements, or object manipulation while counting. Visual representations appeared as drawings, marks, and simple inscriptions produced by children in response to the story problems. Verbal expression was evident when children counted aloud, mentioned number sequences, or explained what they were doing. In several cases, these forms appeared simultaneously within the same activity.

At the first meeting, children tended to rely on direct and concrete forms of representation. After listening to the story problem and participating in classroom activities, they redrew the objects or events involved in the task. For example, children who had engaged in ball activities represented the balls as circles in their drawings, and some added numerals to indicate quantity. In the second and third meetings, the same tendency continued. Children still represented objects visually according to their physical appearance, such as circles for balls and squares for puzzle pieces. However, variation began to appear: some children only drew objects, while others combined drawings with number symbols.

In the second and third meetings, the same pattern persisted. Children drew objects according to their actual shape. For example, when the object in question was a ball, the child drew it as a circle; when it was a puzzle piece, the child drew it as a square. However, there were variations in the resulting representations. Some children drew only the shape of the object, without adding number symbols, while others began combining drawings with number symbols to indicate the number of objects represented.

By the fourth and fifth meetings, changes in representation became more visible. Children no longer relied solely on object drawings but began to use marks, crossings, and simple number notation to show changes in quantity. In subtraction-type problems, several children used cross marks on their drawings to indicate that some objects were taken away. This shows that children were not only reproducing story elements visually but also using visual signs as part of the calculation process. Figures 1 and 2 in the manuscript illustrate this pattern, particularly the use of drawings and crossed-out marks to represent addition and subtraction situations.

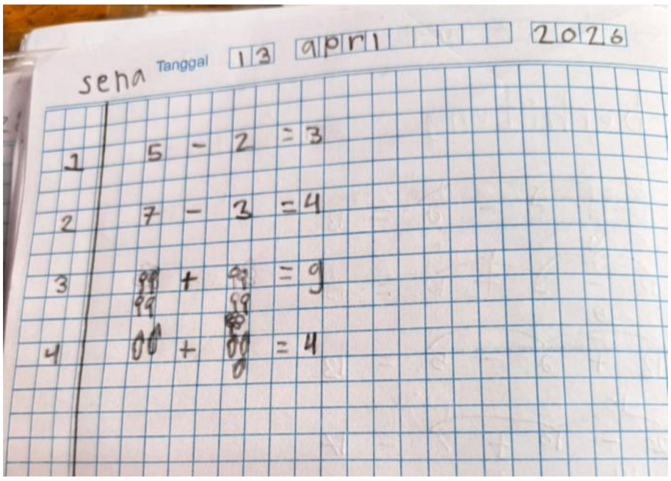

Figure 1. Types of Children's Semiotic Signs That Emerge

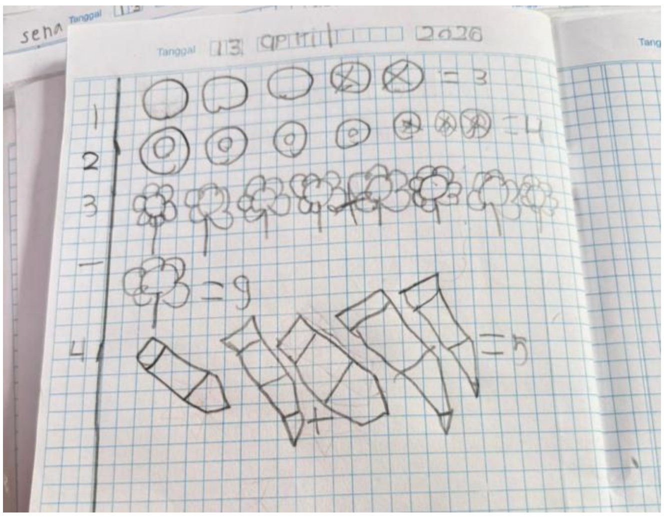

Figure 2. Types of Semiotic Signs Emerging in Subtraction Problems

The figures above show that children use a cross to represent the removal of objects in a subtraction operation. The child attempts to engage in self-directed problem-solving, seeking the correct answer through a unique process, different from peers, because they try to find the problem-solving process on their own (Worthington & Carruthers, 2003).

Table 2. Semiotic Patterns That Emerge

Meeting	Semiotic Pattern	Development	Analysis Notes
1	Gesture -> Verbal	Concrete stage	Child greatly assisted by real objects
2	Gesture -> Verbal	Concrete reinforcement	Same pattern, showing stability of understanding
3	Visual -> Verbal	Transition to symbolic	Representational errors begin to emerge
4	Gesture + Verbal	Strategy adaptation	Used when problems are more complex
5	Visual	Independent representation	A Child begins to build meaning through drawing

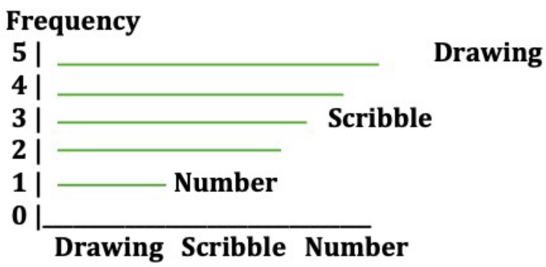

Figure 3. Semiotic Graph

Analysis results show that children's semiotic representation is dominated by drawings, followed by scribbles, and the use of number symbols (Deguara & Nutbrown, 2018; Gil et al., 2025). The dominance of drawings shows that children are more inclined to represent understanding through visual forms resembling real objects. Meanwhile, scribbles are used as a simple form of representation in showing quantity. The use of number symbols remains limited, suggesting that children are in the early stages of understanding numbers as quantitative representations.

Multimodal Combination Patterns

Another important finding is that children did not rely on a single semiotic mode. Instead, they combined several modes while solving the numerical story problems. The most common combinations involved gesture, verbal counting, and scribbles. At the first and second meetings, children frequently counted with their fingers while vocalizing numbers and making simple marks to represent quantities. This pattern shows that bodily action, spoken language, and graphic marks functioned together in supporting the thinking process.

At the third meeting, more complex combinations began to emerge. Some children began writing number symbols while still using verbal counting and scribbles. At the fourth meeting, almost all identified modes appeared together in some children’s responses, including gestures, verbal utterances, internal verbal indications, number symbols, and scribbles. By the fifth meeting, some children showed less reliance on overt vocalization and more reliance on internal verbal thinking accompanied by drawing, scribbling, or writing numbers. Table 3 demonstrates that multimodal combinations became richer over time, although the dominant pattern varied among children.

Figure 4. Children Showing Mathematical Gestures

These findings suggest that children's problem-solving processes were non-linear. Rather than moving in a single fixed sequence, children shifted between different representational modes depending on the problem and their level of comfort with the task. In this sense, multimodality was not an additional feature of problem solving, but a core characteristic of how children responded to numerical situations.

Table 3. Students' Multimodal Pattern

Meeting	Gesture	Verbal (Aloud)	Verbal Internal	Numbers	Scribbles	Multimodal Pattern	Description
1	V	V	X	X	V	G + V + C	Child counts with fingers while vocalizing and makes simple scribbles as quantity representation
2	V	V	X	X	V	G + V + C	Gesture and verbal are still dominant; scribbles begin to be used as quantity markers
3	X/V	V	V	V	V	V + VI + A + C	Child begins writing numbers; some still use scribbles and verbal

4	V	V	V	V	V	G + V + VI + A + C	All modes appear to help understand larger quantities
5	V	X/V	V	V	V	G + VI + A + C / V + A + C	Child thinks more internally, writes numbers, and uses scribbles

The data above show that, in addition to gestures, verbal and number symbols, scribbles also emerge as an important form of representation in children's thinking processes. Scribbles serve as a transitional representation that helps children bridge the gap from concrete experience to number symbols. As learning progresses, children tend to integrate multiple modes, with a decrease in vocal verbal use and an increase in internal verbal and number-symbol use.

Children's Mathematical Thinking Strategies

From the combinations of semiotic resources identified in the data, four main mathematical thinking strategies were found. First, children used a concretization strategy, in which they transformed the story situation into bodily action or imagined concrete objects. This was evident when children counted on their fingers or mentally linked the story problem to familiar objects. Second, children used a visualization strategy, in which they represented the problem through drawings or scribbles before arriving at an answer. These drawings often served as intermediate representations that helped children keep track of relationships between quantities.

Third, children used a verbal counting strategy, in which number sequences were spoken aloud or repeated quietly to maintain the flow of counting. This strategy was especially evident when children needed support to maintain the numerical order. Fourth, the data revealed an integrative multimodal strategy in which children coordinated gestures, verbal expressions, scribbles, and number symbols in a single problem-solving sequence. This was the most complex pattern found in the study because it showed that children could draw on multiple semiotic resources simultaneously. Table 4 summarizes these patterns of semiotic combination across the meetings and shows that children’s responses were flexible and adaptive rather than fixed.

Fourth, the integrative multimodal strategy is the most complex, in which children combine gestures, visual representations, and verbal utterances simultaneously. In this strategy, children do not only use one semiotic mode, but coordinate various modes simultaneously to build a more complete understanding of the problem faced (Azhari & Indah, 2025). This strategy demonstrates higher cognitive engagement, as children are able to integrate various sources of representation in one thinking process (Liu et al., 2025).

In summary, the results indicate that children’s responses to numerical story problems were characterized by diverse semiotic forms, shifting developmental patterns, and multimodal coordination. Drawings, scribbles, gestures, verbal counting, and emergent symbols all appeared as meaningful components of children’s mathematical activity. These findings confirm that solving numerical story problems in early childhood involves a rich meaning-making process that cannot be understood solely from final answers.

Table 4. Students’ Combination of Various Semiotic Forms According to the Needs and Difficulty Level

Meeting	Semiotic Combination	Category
1	G + VB	Simple multimodal

2	G + VB	Stable multimodal
3	V + VB	Transitional multimodal
4	G + VB	Adaptive multimodal
5	V (+-VB)	Limited multimodal / visual dominant

The integrative multimodal strategy demonstrates that children are able to coordinate various semiotic forms in one thinking process (Nichols et al., 2025).

DISCUSSION

Children's Semiotic Patterns in Relation to Vygotsky's ZPD Concept

The findings show that children's responses to numerical story problems were not limited to number symbols or final answers, but involved drawings, scribbles, gestures, verbal counting, and emergent symbolic notation as semiotic resources for constructing meaning (Purwasih et al., 2023). In this study, drawings and scribbles were not merely supporting products, but functioned as cognitive tools that helped children organize quantity, track changes, and make sense of addition and subtraction situations.

In the first to third meetings, visual representations dominated, as children drew objects according to their actual forms, such as circles for balls and squares for puzzle pieces, indicating an iconic meaning-making stage in which quantity was understood through similarity to real objects (Byrne et al., 2023). From a semiotic perspective, drawings function as signs that have a direct relationship with their referent (object), thus making it easier for children to understand situations in story problems (Deacon, 1997).

Additionally, the use of number symbols combined with drawings began to emerge. However, these symbols are not yet fully interpreted as representations of quantitative values, but as signs accompanying objects. This shows that children are in a transitional stage from visual to symbolic representation (Hughes, 1986; Munn, 1998). In the fourth and fifth meetings, development in semiotic use was observed, particularly in the context of mathematical operations. Children began using cross marks (scribbles) as a strategy to represent subtraction. The act of crossing out part of a drawing shows that children understand the concept of subtraction as 'visually reducing', rather than through the manipulation of number symbols. In this case, scribbles function as indexical signs that have a direct relationship with the process or action performed (reducing) (Arzarello et al., 2009; Radford, 2009). This finding shows that children build operational understanding through action on visual representations.

From a developmental perspective, these findings align with Piaget's view that children in the preoperational stage still depend on concrete and early symbolic representation. The use of fingers, object-like drawings, repeated marks, and spoken counting shows that children anchor abstract numerical ideas in observable action and imagery. At the same time, the emergence of simple symbols and crossings suggests movement toward internalized symbolic reasoning. This supports the idea that semiotic representation functions not only as a communication tool but also as a thinking tool that helps children construct solutions independently (Wertsch, 1985).

In this process, mathematical symbols become meaningful only when linked to visualization and concrete experience (Bruner, 1966; Tall, 2013). These findings are also consistent with Vygotsky's perspective that higher mental processes are mediated by signs and develop gradually from external activity to internal thought (Vygotsky, 1978). Drawings, scribbles, gestures, and verbal utterances, therefore, act as mediational tools that support mathematical meaning-making, while teacher guidance and scaffolding remain important in helping children move from concrete signs toward more formal symbolic understanding, especially when children experience difficulty (Rahayu & Hartati, 2022). Thus, the interaction between children and adults in the ZPD enables the transformation from concrete to symbolic understanding.

Another important contribution of this study is its focus on meaning-making rather than answer correctness alone. In many early childhood classrooms, numeracy learning is often evaluated by whether children produce correct answers or write numerals correctly. The study also contributes to the literature by showing that children's representations should not be treated as isolated products. Instead, the data indicate that gesture, visual representation, verbal expression, scribbles, and emergent symbols function together as interconnected semiotic resources. This is an important contribution because previous classroom practice and some previous studies have tended to focus more narrowly on symbolic outcomes, number recognition, or correctness.

Children's Multimodal Patterns in Concrete Preoperational Maturity

The findings also show that children's mathematical thinking is multimodal. Teachers, therefore, need to observe not only whether children produce correct answers but also how they draw, gesture, count aloud, make marks, and explain their ideas during problem-solving. These expressions provide important information about children's understanding, confusion, and strategy use, and numerical story problems offer a useful context for connecting mathematical ideas with actions, images, and language (Piaget, 1952; Yilmaz, 2011).

In Piaget's perspective, children at the preoperational stage are not yet able to think fully logically and abstractly, so they rely on real or imaginary representations. This can be seen in gestures such as finger counting, which concretize the thinking process through physical action. Likewise, verbal utterances help children regulate and structure their cognition, especially in maintaining number order, even when quantitative meaning is not yet fully stable (Mustofa et al., 2021; Vygotsky, 1978). Children who recite numbers in sequence are actually strengthening their understanding of number order, even though they don't yet fully understand the quantitative meaning in depth.

Interestingly, some children also showed internal verbal processing, indicating the beginnings of internalization. Although Piaget described preoperational children as predominantly external and egocentric thinkers, this finding suggests an early transition toward more internal cognitive control (Kesselring & Mueller, 2011). The frequent combination of gesture and verbal utterance, such as counting with fingers while vocalizing, further indicates that children have not yet fully separated physical action from mental process (Congdon & Levine, 2023; Goldin-Meadow, 2011). In Piaget's framework, this is natural because children at the preoperational stage are still integrating concrete experience with symbolic representation. They have not yet fully been able to perform mental operations internally, so they need support from action and language simultaneously.

Instead, they integrate action, language, and representation simultaneously. The fact that children moved flexibly among gesture, verbal, internal verbal, and writing depending on task difficulty also reinforces the idea that thinking at this stage is transitional and not yet fully systematic. Thus, children's use of multiple semiotic forms reflects preoperational mathematical thinking that still depends on concrete and early symbolic supports(Marwaha et al., 2017; Piaget, 1952). This process shows that children's mathematical understanding is not formed directly through abstract symbols, but through the gradual interaction of action, language, and representation.

The Meaning-Making Process

Research results also show that children go through several stages in building an understanding of story problems (Fitria et al., 2022). This process begins with an initial understanding of the story, continues with semiotic exploration through gesture, visual representation, and verbal expression, and culminates in the production of an answer. However, children often do not arrive at an answer immediately; instead, they revise drawings, recount, or shift strategies, indicating that meaning-making is adaptive and multimodal. In general, children first interpret problems through concrete activities such as finger counting or object movement, showing dependence on direct action to understand quantity. They then move toward visual representations, including drawings and scribbles, which help them organize information and represent quantity in a more manageable form (Bruner, 1966; Kress, 2010; Worthington & Carruthers, 2003). In subtraction situations, crossing out drawings serves as a representation of reducing quantity, while in addition situations, children begin to combine drawings with simple mathematical symbols such as the plus sign, although these still depend heavily on visual support (Powell & Fuchs, 2012).

Verbal and internal verbal utterances also play an important role in this process. Spoken counting helps children maintain number sequence, while internal verbal reflects the emergence of silent mental activity during problem solving (Liang et al., 2026). Overall, children's meaning-making can be understood as moving through several interconnected stages: a concrete stage marked by gesture and direct activity, a visual representation stage marked by drawings and scribbles, a simple operational stage involving symbols such as the addition sign and crossing marks for subtraction, and an internalization stage marked by internal verbal. These stages are not strictly linear, because children may return to earlier strategies when faced with more complex tasks (Longobardi et al., 2015). Thus, children do not immediately understand mathematical operations through formal symbols alone, but build meaning gradually through the interaction of drawings, scribbles, simple symbols, and verbal processes. In this sense, drawings and scribbles should be understood not merely as final products, but as thinking tools that support children's developing understanding of addition and subtraction (Campbell & Cunningham, 2025; Worthington et al., 2019).

Despite these contributions, this study has limitations. The research was conducted in a single early childhood classroom with a limited number of participants and focused specifically on numerical story problems within that learning context. Therefore, the findings cannot be generalized broadly without caution. In addition, the interpretation of children's semiotic responses remains closely tied to the classroom setting and the tasks provided. Future research may extend this work by involving different early childhood settings, comparing age groups, or designing interventions that intentionally use multimodal and semiotic approaches in numeracy learning. Such studies would help deepen understanding of how children's meaning-making develops across contexts and instructional designs.

CONCLUSION AND SUGGESTIONS

This study concludes that children's meaning-making when solving numerical story problems is semiotic and multimodal. Children did not rely solely on written number symbols or final answers but used gestures, drawings, scribbles, verbal counting, and emergent symbols as interconnected resources for thinking and problem-solving. The findings show that these representations functioned as cognitive tools that helped children organize quantity, track changes, and construct mathematical meaning. Children's responses also shifted from more concrete, action-based forms toward increasingly visual and symbolic ones, although this development was flexible rather than strictly linear. Thus, early childhood mathematical thinking should be understood not merely by answer correctness but by the representational processes children use to build meaning.

Based on these findings, teachers are encouraged to pay attention not only to children's final answers but also to the gestures, drawings, scribbles, and verbal expressions that arise during mathematical activities, as these forms provide important insights into children's understanding and strategy use. Numeracy learning should therefore provide opportunities for children to respond in multiple modes, making learning more meaningful and developmentally appropriate. For future research, similar studies may be conducted in broader contexts, across different age groups or mathematical topics, and may also develop instructional designs that intentionally integrate multimodal and semiotic approaches in early childhood numeracy learning.

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