CSCanada
Cross-Cultural Communication
Vol. 21, No. 1, 2025, pp. 38-45
DOI:10.3968/13764

ISSN 1712-8358[Print]
ISSN 1923-6700[Online]
www.cscanada.net
www.cscanada.org

Research on Early Numeracy Development

LI Jing[a],*

[a] Yunnan College of Business Management, Yunnan, China.
*Corresponding author.

Received 7 February 2025; accepted 22 March 2025
Published online 26 March 2025

Abstract

This research paper examines the significance of early childhood numeracy development in fostering 21st-century skills within a globalized and technology-driven context. Through observational studies in a childcare center and a home environment, the author explores how play-based activities such as Sudoku, memory chess, building blocks, and Lego enhance children's numeracy competencies, including counting strategies, spatial awareness, problem-solving, and relational understanding. Findings reveal that structured yet flexible activities in familiar settings significantly improve children's mathematical thinking, particularly when aligned with their developmental stages. The study emphasizes the critical role of collaboration between families and educators in nurturing numeracy skills, advocating for guided support, encouragement of mistakes as learning opportunities, and tailored pedagogical approaches to address individual differences. Key observations highlight that children demonstrate higher engagement and success in activities that balance challenge and familiarity, such as age-appropriate Sudoku puzzles or pattern-based block arrangements. The paper concludes by underscoring the long-term impact of effective numeracy practices on foundational mathematical achievement and calls for further research into factors like gender, age, and environmental influences on numeracy development. Practical recommendations include integrating numeracy into daily routines, fostering relational understanding through problem-solving, and leveraging mistakes to build resilience and curiosity in young learners.

Key words: Early numeracy development; Play-based learning; Home-school collaboration; Problem-solving skills; Individual differentiation

Li, J. (2025). Research on Early Numeracy Development. *Cross-Cultural Communication, 21*(1), 38-45. Available from: http//www.cscanada.net/index.php/ccc/article/view/13764
DOI: http://dx.doi.org/10.3968/13764

1. INTRODUCTION

Nowadays technology and numeracy skill are crucial parts of 21st-century skills in our globalized world. People with better numeracy skill will have more career options in the digital world. It is consistent with the demand for enterprise skills. To prepare our children for the ever-changing world, the initiation of a mathematical mindset is of vital importance. It is particularly emphasized on the importance of early literacy and numeracy via play-based learning by the early years learning framework for Australia (Department of Education & Council of Australian Governments, 2009).

I observed the same group of children in a childcare centre and at home for two days. On the first day in the childcare centre, five different age of children range from 2 years old to 6 years old. This was a large L-shaped classroom divided into two areas, one side is the learning area equipped with five colourful tables assembled into a flower shape . There were several teaching aids and toys in the classroom. Two thinking memory chess, one hourglass timer, a set of Sudoku, a colourful Hanoi tower, and a box of colour pencils were put on the middle of the table. Another side is the playing and reading area with a piece of large carpet on the ground. Besides the carpet, there was a bookshelf full of children's books. Four adults were present in the classroom, one is the teacher, two guardians of the children, one was the mother of a two-year-old girl Anna, she accompanied Anna beside the carpet. The other one is the mother of four-year-old girl Rilla. I was a visitor and observed a playing-based class for 30 minutes.

The second day, I visited Rilla's home, Henry was playing with Rilla on the balcony where is their playing area full of toys. Both of them were 4 years old. Rilla's mother played with them with building blocks and Lego for half an hour. This is a familiar environment for children, where they can be inhibited.

This article started by describing the numeracy concept and the activities I observed. Then, I will evaluate these activities from counting strategies, subitizing and special arrangement, problem-solving and relational understanding. after that I will provide some numeracy learning suggestions from family, school and learning from mistakes aspects. At last, there will be a conclusion for these activities' analysis.

2. KEY NUMERACY CONCEPT AND ACTIVITIES OBSERVED

2.1 key numeracy concept

The concept of numeracy is easily misunderstood in a narrow sense as a discipline about numbers. However, numeracy is far more complex than that. The numerical abilities of young children focus on their counting abilities, logical operations, numeral estimations, and spatial awareness (Kleemans et al., 2012; Perry, 2000). As the early years learning framework of Australia (2009) stated that Children are able to understand numbers, measurement, patterns, and data as well as reasoning and counting. They can bring their mathematics understanding through daily problem-solving.

As defined by the Australian curriculum, assessment and reporting authority (2010), numeracy is a combination of underpinning mathematical concepts and skills from interdisciplinary--- numerical, spatial, graphical, & algebraic; systematical mathematical thinking and strategies; the ability to interpret data, make projections across the range of context. Accordingly, children would be curious, confident to investigate ideas and solve problems (ACARA, 2010). Children of different age, gender, and background performed differently in daily activities. I will describe the activities that I observed in detail, illustrate how these activities reflect the numeracy concept.

2.2 Number sense game---Sudoku, number missing game

When I came to the classroom, I noticed that two children were playing Sudoku respectively. This is a number-placement puzzle game that requires no calculations and provides a wide variety of logic situations. Rilla was playing a 3X3 grids board (appendix 1). Number 1, 2, and 3 were randomly placed on the board. She quickly put 1 to the block where neither row nor column has the same number. She finished the first board in one minute without mistake. I complimented her and said you did it so quickly. She replied: "I play it every day at home." When she finished, she found the boy Henry who was her classmate, was playing 9X9 grids board. Not to be outdone, she wanted to play the hardest one in the set which was a 12X12 grids board. She asked for the hardest one from her mother, her mother said: "dear, you do not know how to play this level." But she insisted on the hardest board. Her mother gave it to her. She did well in the first 4 blocks. When she picked number 5, she put it in a faraway place, her mother reminded her there was a number 5 in the same row, then she tried another place near number, there was a number 5 in the same column though. She tried four times, but all incorrect, then she asked her mother to do it. She ran away, played with other classmates. I communicated with her mother, she said Rilla only played 4X4 grids at home, she was competitive. This was an act of sheer bravado.

The 6-year-old boy Henry was still playing on his 9X9 grids board. I asked him: "Do you think this is hard?" He replied: "yes, it is hard, but I know how to figure it out." Then he put the number 6 to a grid where a 6 already exist on the same row. He found the mistake by himself. Then put 6 to the right place. Sometimes, he cannot find a proper place for the number he held, he would put it down, and pick up another number. He asked me for help twice, I did not provide the right answer directly, instead I provided a range of numbers or gave him some clues. Finally, he finished the board proudly. In this game, their mathematical thinking and strategies were practised. they also recognize their mistakes and make progress.

The second game called "which one is missing?" The teacher put the cards from 1 to 10 on the table in order (appendix 2). She asked children to close their eyes, then take one or two cards away, then asked which one is missing? All the children could give the right answer immediately. However, when put the cards in a disordered state, they had to count from 1 to the missing number. Then the teacher put three cards on the table and asked: "how many cards on the table?" Most students could answer it without counting. When the number of cards increased to five, the younger children below 4 years old, tended to count. As children examine each aspect of early counting, their understanding of number sequence is continually refined.

2.3 Spatial sense game---memory chess, building blocks, Lego

This game was memory thinking played in the childcare centre. Children were divided into two groups, each group had 2 children. Two wooden boxed memory chess were put in front of each group. When the teacher put the hourglass down, two groups would start together (appendix 3).

The teacher placed the card in the slot and cover the pattern with the pieces. Children opened any piece and memorized the pattern and position inside. If they turned

to the same mode, removed the pieces, and if they're different, covered them again, until all the pieces have been removed and the game is over. Within the allotted time, the group which removes all the pieces first wins. Cultivate children's memory and observation skills. Those kids could not understand the rules, they could not wait to open these pieces one by one. Hence the teacher demonstrated the game herself and said what the shape she saw. In the first round, both two teams did as the teacher demonstrated. They cannot remove all the pieces when the hourglass ran out. In the next few rounds, they could remember a certain shape's position, so keep the one open, kept looking for another shape that matches it. In the end, all of them could finish before the hourglass ran out.

While the older children were playing the game. The 2-year-old girl Anna was playing the Hanoi tower with her mother. Anna aims to move the disks to another empty rod, with no consideration for size (appendix 4). When Rilla came by, she put all the disks in order from largest to smallest, even if she did not follow the original rule that Only one disk can be moved at a time.

The next day, I came to Rilla's home, played with Rilla and Henry. At first, Rilla's mother placed two colours of blocks at intervals, both of them could follow the rules to place the next blocks. When Rilla's mother gradually increased the colours and placement of the blocks, and when the colours increased to more than 5, they needed to think for a while before placing (appendix 5). Then they played Lego to build their dream home. Rilla built a small apartment as large as her hand size. While Henry built a large house (Appendix 6). He separated different areas for different functions. When his mother asked him, how many rooms do you have in his house? He began to count one by one. These activities are of great help to their graphic cognition and spatial construction.

3. CRITIQUE OF THESE ACTIVITIES

All these activities were happened in real life, in these activities, children's mathematical ability is improved and exercised to varying degrees. I will discuss from these aspects: counting strategies, subitizing and special arrangement, problem-solving and relational understanding.

3.1 Counting strategies

When children played sudoku, missing game, and count the cards, they all tended to count one by one, as the difficulty increased. In their familiar context, such as 3X3 grids board, or put the card in order, they can easily find out the right answer immediately. Before group ideas develop, counting by ones is the popular way that children could adapt rapidly. Most of the games I observed with visual and concrete objects, like cards and other toys. This was a beneficial environment for kids to get the correct answers. Through a variety of experience, children's understanding of counting is continually refined (Van de Walle et al., 2018). To be specific, children would learn how to count---matching counting words with the cards. It reinforced the idea that the last count word indicates the amount of the set or the cardinality of the set.

However, when more elements and variables are involved in the activity, children had to count step by step. From the constructivism perspective, knowledge is actively constructed rather than passively received, children can construct new knowledge through reflection on their physical and mental actions (Doig et al., 2003). The order of the number was the child's current knowledge, counting strategies as their action. This is their way to construct the relationship between numbers and daily life. When given appropriate materials and activities, children are able to mentally combine and divide numbers so that they can identify the whole number and its related parts (Bobis, 2008). These activities were consistent with the curriculum frameworks' principles---high expectations and equity, respect for diversity, ongoing learning and reflective practice (Department of Education & Council of Australian Governments, 2009). As children construct new relationship and begin to use a more powerful new idea, like subitizing, counting by ones will become less and less necessary (Van de Walle et al., 2018).

3.2 Subitizing and special arrangement

In the card game, the teacher showed three cards, most children were able to answer the exact number. They could quickly recognize and name how many objects are in a small group without counting, this is so-called subitizing (Van de Walle et al., 2018). Children could "see" a set of items in an almost innate way, their ability to solve and understand challenging mathematical problems increases with the development of understanding strategies (Ferris, 2018). In this activity, children recognized the collection of three cards, even four cards. They regarded these cards as a whole. When cards number increased to five, subitizing is replaced by sequential counting when the amount becomes four or more (Kroesbergen et al., 2009). Kroesbergen et al. (2009) claimed that the subitizing test explained 22% of the variance in counting skills. subitizing played a significant part in invariance in children's counting skills, we need to see the importance of subitizing.

Children were able to subitize some sample collections by recognizing the particular spatial arrangements of different colour blocks. When the adult placed a series of blocks on the ground, by observation, Rilla was able to identify underlying patterns in the building blocks. With less than 5 regular variables, they can still find the pattern and continue to place the blocks according to the pattern. Even if Rilla's mother added vertical and parallel placement as more variables, they could also complete successfully. Advantages of presenting different groups of

blocks for the young ages, children developed the ability to summarize and generalize shapes and colours. Spatial arrangements also happened in the Hanoi tower playing, different ages performed various, the 2-year-old girl Anna would place the disks randomly without disturb. But following the previous pattern, she knew she needed to place the disks vertically on the rod (appendix 4). When Rilla came by, she noticed the size of the disks were also an important variable, so she reorganized the order of the disks.

As for the Lego play, Rilla tended to decorate her house with delicate and small space thinking, while for the boy Henry inclined to decorate his house with a diffuse and extended mind. When appropriate materials and activities were given to children, they had the freedom to reorganize the blocks, thus enabling them to recognise the wholes and their related parts (Bobis, 2008).

According to Piaget's classification, early childhood covered the first two stages of cognitive development --- the sensorimotor stage and the pre-operational stage (Piaget, 1999). Children develop symbolic representational schemata through language, imitation, imagination, symbolic play, and symbolic drawing. Thus, numeracy development happened in these activities. In these games, children were confident and involved learners, they had a chance to develop a range of skills such as inquiry, problem-solving. This coincides with curriculum frameworks' learning outcomes---children are connected with contribute to their world (Department of Education & Council of Australian Governments, 2009).

3.3 problem solving and relational understanding

In terms of memory thinking games and 9X9 grids board Sudoku. Both of these games are relatively difficult for children, and this difficulty is neither so difficult that they wanted to give up, nor so easy that they immediately came up with the answer. In 3X3 and 12X12 grids board Sudoku games, these two examples and the child's performance can be summarized as the two extremes of being too difficult or too easy. Participating in problem-based activities would engage children to use existing mathematical knowledge to solve problems.

In order to make sense of problems, children need to know how to identify or analyse the given information, patterns or relationships so that they could know how to solve the problem (Van de Walle et al., 2018). In the first round of memory chess, without understanding the rules, children cannot complete the task. After the teacher's demonstration, they knew when removing the piece combined with pattern cognition in mind. Understanding these relationships makes learning mathematics much easier 9 (Smith et al., 2018). It is noteworthy that NCTM (2000) identified the means by which children acquire and use mathematical knowledge included problem-solving, reasoning and proof, representations, communication and connections. As the curriculum frameworks stated the outcome of children are confident and involved learners, the play process was the problem-solving process (Department of Education & Council of Australian Governments, 2009).

4. DIRECTIONS FOR EARLY CHILDHOOD NUMERACY DEVELOPMENT

There are many participants in the process of early childhood numeracy development, I will discuss from home practice, school practice, and learning from mistakes.

4.1 Home practice

The application of mathematics to contextual problem confronts children throughout their day in different settings, home, school, shopping centre, or even in a car. Home and school are the places where they spend the most time. To solve the problem or meet the challenges, young children need not only to develop their numeracy skills but also are willing to apply these skills in novel situations (Perry, 2000). From previous activities I observed, the young child who had a better number sense had a lot of experience with number games at home. Like Rilla, she could finish 3X3 Sudoku independently, this was closely related to her previous experience. Family numeracy experiences are associated with early numeracy and make a unique contribution in predicting early numeracy after controlling for child cognitive and language factors (Kleemans et al., 2012). Children bring a new understanding of math through engaging with problem-solving. It is vital that mathematical thinking interacts with younger children to be relevant and meaningful in the context of their current lives (Van de Walle et al., 2018). What should parents do to create a good learning atmosphere?

As for the parents, they could adopt the "ask-before-tell" approach in mathematics learning (Van de Walle et al., 2018). How to support their children when she or he got stuck or gotten the wrong answer? Before the parents provide the correct answer, they cloud ask children how she or he did it. Children may self-correct.

Alternatively, providing some hints instead of explaining the correct answer directly when they were stuck. In the 9X9 Sudoku play, the teacher did not give the right answer but provided a range of number as hints. Henry could find out the right number under the teacher's guide. Besides, parents should be able to find resources to create opportunities to practice mathematics at a young age. They could lead a child to count objects during household chores, such as counting chopsticks, bowls. Or in the car, they could have fun mathematics explorations. For example, family members can try to point the car plate number, ask the child to read the number or create a true mathematic equation. Number sequence, one-to-

one correspondence, cardinality and subitizing makeup to the interrelated aspects of early numerical knowledge (Clements et al., 2014). It would be enhanced when children constant exposure to the number of names used to describe daily things.

4.2 School practice

4.2.1 Individual difference

As the basis of individual difference in numeracy skills is possibly also related to variations in teaching methods at school. Early childhood teachers play an important role in providing young children with exploratory and experimental opportunities for numeracy learning, thus laying the foundation for future learning (Scull et al., 2016). The different children have different characteristics, some child may be very competitive, like Rilla. We need to protected child's self-esteem during mathematical activities. Such as Rilla's mother, she did not force Rilla to learn how to play the 12X12 Sudoku. Differences in context may lead to significant differences in early literacy and numeracy development patterns through different opportunities for mediated interaction with resources (Fleer & Raban, 2010). As educators, we need to protect children's curiosity, keep them passionate about mathematics, and make them feel happy in the process of learning. Set up various play-based activities of different for different ages. As sociocultural theories claimed that the teacher is a facilitator in the learning process, the teacher's guidance should provide according to the proximal development zone (Kleemans et al., 2012). This is a range of new knowledge for young children that may be out of reach independently but is accessible under the teacher's assistance (Vygotsky, 1978)

4.2.2 Relational understanding

Young children are not passive recipients of learning, they should take the initiative in learning. Understanding must be a fundamental premise in mathematics teaching. However, understanding goes beyond knowing, it is more than a collection of information or being able to follow steps in a procedure (Van de Walle et al., 2018). In a numeracy game, understanding indicates knowing what to do and why. In the memory chess game, students cannot totally understand the rules at first, even if the teacher has explained the rules verbally, they don't fully understand until the teacher demonstrates herself. Children ought to solve problems in ways that make sense to them. Understanding relationships of numeracy concepts makes learning easier. In the chess game, the teacher could modify some variables to make the activity more interesting, and she can reduce the repetition of a single rule. For example, "please find four pictures contain red circles." A question like this could provide a chance for young children to develop spatial and number sense in the same activity. Young children are able to explain, provide evidence or justification, find examples, apply concepts, generalize, representing ideas in various ways (Van de Walle et al., 2018). Hence, they develop a robust understanding of numeracy.

4.2.3 Using pedagogy flexibly

Pedagogy is regarded as the approach of teaching which is the guidance of teaching. There are many ways to achieve teaching objectives. Educators not only require a rich mathematical vocabulary to describe and explain children's numerical idea but also require adjusting teaching method to match children's knowledge (Perry, 2000). Notably, activities designed to stimulate interest were carried out for children to expand their numeracy experience. Only when it is highly relevant to children's life experiences can children fully understand and participate in these activities. In the Lego game, we saw two totally different style houses children made. In this situation, the teacher can lead the child to explain why and how they made this house. How many members in your family? Is it suitable for your family?

Meanwhile, the teacher may encourage children to pay attention to their peers when they are sharing ideas. Then a productive discussion about the similarities and differences of their Lego will carry out. Thus, there is no one-size-fits-all teaching method. We should listen to children about what they are thinking and doing as they engage in a mathematical task. If they respond in an unexpected way, do not imposing your ideas onto theirs (Van de Walle et al., 2018). Children use processes such as exploration, collaboration and problem-solving across all aspects of the curriculum.

4.3 Learning from mistakes

It is inevitable that children make mistakes or exhibit misconceptions, particularly when we pose challenging tasks (Van de Walle et al., 2018). In previous activities, Rilla chose to run away in the face of mistakes when she was playing the challenging 12X12 Sudoku. Her mother did not force her to finish it. This educational approach is desirable because the activity is far more difficult than the child's current mathematical ability. Conversely, when Henry got stuck in the same game, he tends to seek help and insist on completing the task. On one hand, Rilla may not perceive the difficult task as opportunities to learn, but rather as the chance to highlight her inadequacies. On the other hand, Henry may view these difficulties as a chance to reconsider, revise, and improve their understanding. In this case, the teacher could offer some helpful suggestions for ensuring that the error maker is respected (Bray, 2013). Then, encourage Anna to join Henry's work, watch what he is doing. She may learn how peers face difficulties and solve problems by discovering the connection between numbers.

Making mistakes should be regarded as a normal component of learning (Smith et al., 2012). Concern has been raised that when the children make mistakes they

may develop a negative feeling about mathematics. Whereas the child will act in an opposite way when the educator gives the child some praise appropriately and acknowledges their efforts in the learning process (Smith et al., 2012). Such as "well done! I can see your effort to think about that." Thus, we can use mistakes as a vital resource in our approach to finding out what mathematics children know and extend the foundation mathematics curriculum to supporting children's learning process.

5.CONCLUSION

In conclusion, through the observation of children's activities, I get more profound understanding of young children's mathematical development. Every child is full of potential in numeracy learning when given appropriate materials and activities. The above activities have their own characteristics in children's observation, memory, test the children's reaction to develop their both spatial and number sense. At the same time, the different activities still have room for further development to stimulate children's interest in numeracy learning. Home and school should take collaborative efforts to build home-school links considering individual difference and relational understanding. More factors need to be taken into account in further research, such as gender, age, and environment. Significantly, effective numeracy activities for young children were highly related to later mathematical achievement.

REFERENCES

ACARA. (2010). *ACARA - National report on schooling in Australia 2010*. https://www.acara.edu.au/reporting/national-report-on-schooling-in-australia/national-report-on-schooling-in-australia-2010

Bobis, J. (2008). Early spatial thinking and the development of number sense. *Australian Primary Mathematics Classroom, 13*(3), 4-9.

Bray, W. S. (2013). How to leverage the potential of mathematical errors. *Teaching Children Mathematics, 19*(7), 424-431. https://doi.org/10.5951/teacchilmath.19.7.0424

Clements, D. H., Baroody, A. J., & Sarama, J. (2014). *Background research on early mathematics: Background research for the National Governor's Association (NGA) center project on early mathematics*. Washington, DC: National Governor's Association.

Department of Education, Employment and Workplace Relations & Council of Australian Governments. (2009). *Belonging, being & becoming: The early years learning framework for Australia*. Department of Education, Employment and Workplace Relations for the Council of Australian Governments. http://www.deewr.gov.au/EarlyChildhood/Policy_Agenda/Quality/Documents/Final%20EYLF%20Framework%20Report%20-%20WEB.pdf

Doig, B., McCrae, B., Rowe, K., Australia, & Department of Education, Science, and Training. (2003). *A good start to numeracy: Effective numeracy strategies from research and practice in early childhood*. ACER.

Ferris, M. (2018). Using subitizing as a math lesson warm-up to improve automaticity scores. *Dissertations, Theses, and Projects*. https://red.mnstate.edu/thesis/60

Fleer, M., & Raban, B. (2010). Literacies in early childhood: The preschool period. In *International Encyclopedia of Education* (pp. 75-80). Elsevier. https://doi.org/10.1016/B978-0-08-044894-7.01185-4

Kleemans, T., Peeters, M., Segers, E., & Verhoeven, L. (2012). Child and home predictors of early numeracy skills in kindergarten. *Early Childhood Research Quarterly, 27*(3), 471-477. https://doi.org/10.1016/j.ecresq.2011.12.004

Kroesbergen, E. H., Van Luit, J. E. H., Van Lieshout, E., Van Loosbroek, E., & Van de Rijt, B. A. M. (2009). Individual differences in early numeracy: The role of executive functions and subitizing. *Journal of Psychoeducational Assessment, 27*(3), 226-236.

Perry, B. (2000). *Early childhood numeracy*. https://eric.ed.gov/?id=ED462286

Piaget, J. (1999). *Judgement and reasoning in the child*. Taylor & Francis Group. http://ebookcentral.proquest.com/lib/monash/detail.action?docID=179827

Scull, J., Nolan, A., & Raban, B. (2016). Young learners: Educators' conceptualisation and practice of literacy in preschool contexts. *7*.

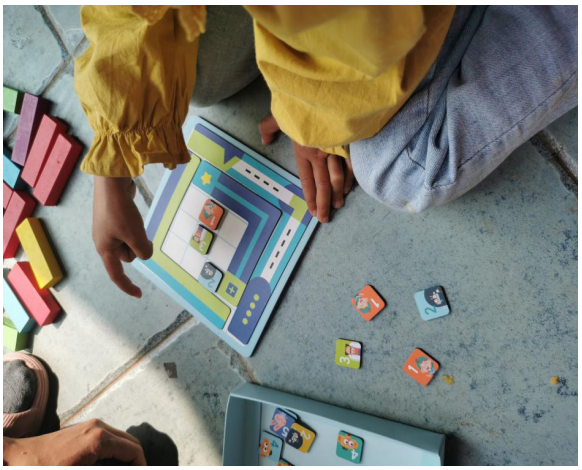
Smith, A., Allison, & Ann. (2012). *Mathematics in early years education*. Routledge.

Van de Walle, J. A., Lovin, L. H., Karp, K. S., & Bay-Williams, J. M. (2018). *Teaching student-centered mathematics: Developmentally appropriate instruction for grades pre-K-2* (3rd ed.). Pearson.

Vygotsky, L. (1978). Interaction between learning and development. In *Readings on the development of children, 23*(3), 34-41.

APPENDIX

1. Sudoku play



2. Number missing game

3. Memory chess

4. Hanoi tower

5. Block placement

6.. Lego