The Development of Children's Early Numeracy Skills in The Piaget's Preoperational Stage

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Abstract
Early numeracy skills are crucial for young children's cognitive and mathematical development, particularly during the preoperational stage (ages 2-7), when they begin to develop symbolic thinking and foundational mathematical concepts. This study investigates the progression of early numeracy skills in two preschool-aged children (Child H and Child K), focusing on their ability to engage with numeracy concepts such as counting, cardinality, numeral identification, and number combination. Using a qualitative case study approach, the research observes the children's numeracy behaviors through assessments and direct observation during play-based learning activities. Findings reveal notable differences in the children's numeracy development: Child H demonstrates stronger skills in one-to-one counting, subitizing, number ordering, and problem-solving, while Child K shows emerging abilities but struggles with tasks such as number comparison and number combination. These differences highlight the variability in the development of numeracy skills, with confident children progressing more rapidly in their understanding of numbers and relationships. The study emphasizes the importance of concrete, hands-on learning experiences in developing mathematical thinking, mainly through physical manipulatives and interactive, game-based activities. The results underscore the need for tailored learning experiences to support children in the preoperational stage, which has implications for early childhood educators in fostering a strong mathematical foundation.
Keywords: Early Numeracy Skills, Preoperational Stage

Introduction

Early numeracy skills play a crucial role in fostering the development of mathematical abilities during the formative years of childhood. The significance of this proficiency is underscored by its status as an essential variable, alongside reading abilities, in determining a child's success in subsequent phases of education (Claesens & Engel, 2013, p. 1). Research indicates that children who exhibit advanced numeracy skills at an early age are more likely to excel in formal education compared to their counterparts who may not have received the same level of support and exposure to numerical concepts (Van Luit & Toll, 2015, p. 1). The impact of early numeracy proficiency extends beyond mere arithmetic; it shapes how a child approaches problem-solving, comprehends contextual information, and establishes connections between various mathematical concepts within the classroom setting. These indicators of maturity reflect a child's current academic performance and lay the foundation for their ongoing mathematical journey.

Early numeracy skills encompass various cognitive abilities essential for mathematical development. These skills include verbal counting, quantity recognition, comprehension of numerical symbols, numerical pattern recognition, numerical comparison, and manipulating quantities by adding and subtracting objects from a set (Raghubar & Barnes, 2017, p. 2). Assessing children's progress in these skills involves gauging competencies such as one-to-one counting, cardinality, numeral comparison, and story problem-solving (Purpura & Lonigan, 2015, p. 9). During the initial stages of learning, children actively participate in oral counting sequences, directly compare small quantities, assign values to number words while counting sets (one-to-one counting, cardinality), and solve story problems involving manipulating numbers. Concurrently, children begin to grasp the concept of number names, with some demonstrating the ability to identify early numerals like 1 and 2 as early as 18 months old (Clement dalam Purpura & Lonigan, 2015, p. 6). This early phase of numerical development establishes the groundwork for acquiring more advanced mathematical skills as children progress in their educational journey.

In its developmental process, early numeracy skills pose their own challenges. Parents' belief is one key to understanding how to support a child's numeracy skills (Douglas et al., 2021, p. 1). Early numeracy development highly depends on how the child is treated by those closest to them. Parents are a kid's first teacher before formal schooling, especially when helping the youngster develop early numeracy abilities at home. To effectively boost mathematical dialogue with their children, parents can use a variety of strategies, including storytelling, game playing, reading illustrated books, and other activities that are rich in numeracy (Crystallography, 2016, p. 128).

One element influencing a child's ability to use numbers is their age (Ransdell & Hecht, 2003, p. 1). From the pre-conceptual phase, which lasts from ages 2 to 4, efforts are made to improve numeracy skills. Games and other activities are used to promote sensory and motor skills. Nevertheless, children are still egocentric and unable to see things from other people's viewpoints at this age. Jean Piaget classified this period as the preoperational stage, which lasts until the child is 4 to 7 years old (intuitive phase), when they can utilize their imagination and make primary connections (Lowenthal, 1975, p. 1).

The preoperational stage is where symbolic abilities, such as using pictures and symbols to represent real objects, have developed in children (Bjorklund & Blasi, 2012 dalam Babakr, Z. et al., 2019, p.2). They tend to be able to train their mathematical skills, although in a limited capacity (Rabillas & Cañete, 2023). Learning that supports children at this stage includes game-

based learning and using real objects in their activities. In this phase, children exhibit characteristics such as difficulty controlling ego (egocentricity), inability to focus on multiple objects or events (centration), difficulty establishing relationships between objects (conservation), and the ability to control their limitations (locus of control) (Kanwal, 2023, pp. 17–19).

Early numeracy skills in the preoperational stage impact how children learn mathematical concepts and ideas (Ojose, 2008, p.1). Mathematical ideas are more easily understood when applied to children's daily activities. Therefore, educational institutions should establish preschool education as an integral part of preparing children to adapt socially and cognitively when entering elementary school (Girard et al., 2021). Hence, this research aims to examine the process of developing early numeracy skills in the preoperational stage and how to build these skills in the family environment. This study is crucial as early numeracy development is an integral part of developing a child's mathematical abilities, an area that has not been extensively studied.

Method

Descriptive qualitative research using a case study technique was the research methodology employed in this study. This methodology is utilized to direct the investigator in investigating and/or documenting the occurrences to be thoroughly, extensively, and in-depth examined. Field notes, interviews, and observations are among the tools employed. The information gathered consists of observations of the numeracy abilities of two preschoolers and the outcomes of parent interviews. Researchers can actively observe the educational dynamics within a family setting by engaging in participant observation. The research involves recording participants' activities during the learning process, specifically noting the involvement of parents in facilitating activities and observing the children's responses and engagement during play and learning. The interview was conducted to learn about the children’s daily numeracy activities and how the parent’s role is involved. Research questions are the following:

1. What activities do children do to enhance their numeracy skills?
2. To what extent are the children's numeracy skills exposed daily?
3. What is the parent’s role in managing children's numeracy skills?

The characteristics of the selected subjects in this study are two children with different backgrounds in abilities and behaviors. The children were observed responding to the tasks given by their parents that the researcher had prepared. The subjects were selected based on

specific considerations and goals. The research findings will not be generalized to the population because the sampling was not done randomly.

The final method of data collection involves photography. Pictures were captured while the research was being carried out. Researchers can facilitate learning assessment by showcasing these images during the teaching and learning process. Moreover, the photographs function as educational tools, enabling researchers to reflect on the action's process and outcomes.

Ultimately, the study findings will undergo examination through triangulation analysis, incorporating insights derived from parent interviews, observational notes, and a comprehensive review of literature about the context. This approach enabled the researcher to consider perspectives from various angles and prevent biased conclusions.

A child's proficiency in oral counting, one-to-one counting, cardinality, subset computation, subitizing, numerical comparison, number sequencing, number grouping, and number combining is observed using the Child Math Assessment (CMA) (Purpura & Lonigan, 2015, p. 292), as shown in Table 1.

Table 1. Tasks Description of Child Math Assessment (CMA)

No.	Skill	Description
1	One-to-one counting	Children are given a set of objects with a specific quantity, and they can count them (one by one)
2	Cardinality	After counting the total number of objects in the set, the children understand that the last number mentioned in the counting represents the total quantity of those objects.
3	Subitizing	The children are provided with a set of objects, and it is observed whether they can directly state the total number of objects without counting them one by one.
4	Numeral comparison	The children are given two numerical symbols in the form of pictures and are then asked to distinguish which of the two numerical symbols is larger.
5	Set comparison	The children are given two quantities of objects, and it is requested to differentiate which of the two quantity numbers of the given objects is larger.
6	Numeral identification	The children can randomly mention a number's name when shown a numerical symbol.
7	Number Order	The children can randomly state the missing numbers from a sequence of numbers.
8	Number combination	The children are asked to combine two quantity of the objects and see the new quantity of those objects
9	Story problems	The children are capable of answering story problems presented verbally.

Result and Discussion

Children's profiles on the early numeracy skills

Based on the findings from interviews and observations conducted with the parents of Child H on November 21, 2023, and Child K on December 12, 2023, it was found that Child H strongly likes counting activities. This is evident in the child's ability to count sequentially verbally and apply it to numerical concepts. Meanwhile, Child K did not seem to engage in the numeracy activities, showing refusal during the process.

In terms of one-to-one counting and cardinality, both children exhibit proficiency. However, Child H has acquired subitizing skills, whereas Child K has not yet developed this ability. Neither child has mastered numeral comparison. Both Child H and Child K demonstrate the capability to compare sets with the limit quantities, identify numeral symbols, and solve story problems. Child H excels in number ordering and number combination, while Child K has not fully grasped these skills. Table 2 provides a comprehensive overview of the differences in mathematical skill development between the two children, highlighting areas of strength and areas that may require further attention.

Table 2. Early numeracy skills overview of children H and K

No.	Skill	Child H	Child K
1	One-to-one counting	✓	✓
2	Cardinality	✓	✓
3	Subitizing	✓	×
4	Numeral comparison	×	×
5	Set comparison	✓	✓
6	Numeral identification	✓	✓
7	Number Order	✓	×
8	Number combination	✓	✓
9	Story problems	✓	✓

H can already do so in the concept of one-to-one counting, demonstrated by the ability to recite numbers from 1 to 99. Furthermore, H can do this in both English and Indonesian. On the other hand, child K can also recite number sequences but is limited to numbers 1 to 30. Both children are within the normal range of abilities for their age, as typically, children in the 5-6 age range can only perform counting up to 1-10 (Kesicioğlu, 2021, p.269).

Regarding cardinality skills, both H and K can determine that the last number mentioned in their one-to-one counting represents the number of given objects. However, H excels over

K in verbally stating the quantity of objects without counting them individually. Furthermore, H can also compare the quantities of numbers using manipulatives but not symbolically, as illustrated in Figure 1.

Figure 1. H compares the quantity of numbers using number blocks.

When comparing the two children, it becomes evident that both Child H and Child K can illustrate their understanding through the utilization of manipulatives in their immediate environment. For instance, Child H employed number blocks to convey his comprehension, while Child K opted for the use of his toys for the same purpose. Notably, these young learners have not yet fully grasped the concept of comparison when expressed through numeral symbols; as such, abstract representations remain somewhat challenging for them at this age.

Children H and K were proficient in recognizing numeral symbols during the assessment. They were presented with random numeral symbols like 12 or 15 and both confidently and accurately articulated the corresponding number names. However, an interesting observation emerged when assessing K's abilities further. Specifically, K encountered challenges in identifying the missing number within a given set of numeral symbols. This aspect of the evaluation shed light on a nuanced aspect of K's numerical comprehension, providing valuable insights into areas that may benefit from additional support and guidance.

Regarding number combination skills and tackling the story problems, both children have a similar understanding but with different limitations. In Figure 2, H has demonstrated the ability to independently combine two different numerical quantities into a new quantity using number blocks. Child K is also able to construct a similar case, but it has been done with the parent’s guidance to dictate the steps. Similar to the story problem’s condition, children H and K are given the story problems in the contexts of simple addition and subtraction. Child H

is able to do it confidently despite his limitation in the size of quantity, while Child K still lacks the courage to solve it independently.

Figure 2. H combines two quantities of numbers

The early numeracy abilities of H are significantly demonstrated, especially when with their parents at home or in other situations. This is based on the role of parents in providing numeracy-rich experiences for H in various situations, given that the number of counting interactions in reading and playing significantly correlates with the number of parent initiations in reading and playing (Vandermaas-Peeler et al., 2009, p. 12). H's parents often engage H in mathematical dialogue, such as counting mosque pillars during prayer, grouping objects by their colors, and providing manipulative games rich in numeracy.

In Figure 3, K is seen with ten aligned toys. Then, K is asked to count the number of toys in front of them one by one. However, as demonstrated by H, K does not show enthusiasm for this activity.

Figure 3. K able to identify the quantity of objects

This happens because K is not accustomed to engaging in numeracy-rich activities with parental guidance at home, even though parental expectations and activities can be seen as two main components of the home environment that influence a child's abilities (Segers et al., 2015, p.221). Parents' methods are too formal, involving activities such as counting with K, using math posters, and formal scheduled learning sessions.

Early numeracy skills on the Preoperational stage

The development of the characteristic abilities of H and K in the preoperational phase has many similarities. At their age, both H and K belong to the intuitive phase characterized by a lack of conservation, where they cannot yet make connections between events or provide reasons for the occurrences (Kanwal, 2023, p. 18). H and K also share a reluctance to sit passively, requiring activities that can encourage their active movement. Large-sized toys can help accommodate learning and other physical activities, such as running, jumping, and climbing, as they fundamentally solve problems through movement and perception, explore the environment, and gradually develop cognitive patterns and ways of thinking about the world (Yu & Wang, 2023, p. 69). Play also contributes a significant role for children in cognitive development in multiple of ways. It helps children with their imagination and memory, which are important in their thinking (Ahmad et al., 2016, p. 73).

In line with his preoperational phase, where a child can develop symbolic play and manipulate symbols (Ghazi & Ullah, 2016, p.81), H can optimize the concrete object to demonstrate his ability to count and compare numbers. K, on the other hand, can compare two different quantities in the form of objects but cannot yet compare the quantities of two different number symbols. Additionally, K has been unable to combine two quantities into a new quantity. This also indicates that K lacks concrete knowledge, logic, and the ability to work with information wisely (Ghazi & Ullah, 2016, p.81). Operations at this concrete level include classification (categorization), ordering (seriation), the construction of numerical ideas, spatial and temporal operations (sequential), as well as all fundamental operations of basic logic (basic and simple) of class and basic mathematical relationships, basic geometry, and even basic physics (Ghazi & Ullah, 2016, p.81; Piaget, 1964, p.177).

One of the misconceptions that most people might think of at this preoperational stage is that children must be provided with merely an enriched physical environment to study mathematics. Children indeed pick up some mathematics independently through unstructured play. But it doesn't allow for the thorough and detailed analysis of mathematical concepts that can only be given under the supervision of an adult (Lee & Ginsburg, 2009, p. 40). Parents must watch over their children, guide them, and join in when they explore and learn about math (Elliott & Bachman, 2018, p. 16). When parents get involved like this, they create a good learning environment. It helps the kids feel supported and improves their cognitive growth and understanding. This active role from parents ensures that children have a strong base for understanding mathematics.

Parents can also provide other numeracy activities offering direct experiences, such as planting, watering, and observing their growth over time. These activities focus on the child's sensory experiences through creative design and appropriate material selection to provide diverse sensory stimulation, allowing the child to sense and perceive the surrounding environment through touch, hearing, sight, smell, and taste (Yu & Wang, 2023, p. 69). Direct experiences involving the child can provide more meaningful learning experiences, making the learning process more relevant and lasting for the child.

When observing child K in his numeracy activity, the researcher found K intensely interested in using mobile phones. This interest is seen in how K always looks back at his mobile phone. Digital devices, for instance, computer and mobile phones, could, be a useful teaching tool for young children, giving them relevant or tangible experiences (Lee & Ginsburg, 2009, p. 43). It can be optimized to help children learn numeracy, while the other activities have their own limitations. The study found that children socially interacted more in the computer area than in other areas and did not isolate children but supported their social interaction with peers (Mantilla & Edwards, 2019, p. 7). However, there must be a support and hinder factor for children in terms of digital use, such as (1) connecting digital use with real-life themes; (2) using friendly software with simple design, instruction, pictures, and audio; (3) state the time limit when using the digital device; (4) technology set-up that did not allow children to share their screens.

Conclusion dan Suggestion

To support the development of early numeracy skills in preschool-aged children, this research reveals the significant role of parents in shaping a child's early numeracy. Findings indicate that children who receive rich numeracy experiences in the family environment tend to demonstrate better early numeracy abilities. Parents are responsible for providing stimuli that support their child's learning process through games, storytelling, and other activities involving mathematical concepts. Interview results with one parent highlight that counting interactions in the context of reading and play positively correlates with a child's numeracy development. Therefore, supporting parents in understanding and implementing creative approaches to early numeracy development is a key step in establishing a solid mathematical foundation.

This research also emphasizes the importance of understanding a child's numeracy development stages, particularly during the preoperational phase. This phase is a vital period

in which children use symbols and images to represent mathematical concepts. Although numeracy skills during this phase are still limited, using concrete objects and game-based learning proves effective in building a numeracy foundation. Consequently, future research can focus on developing more specific and phase-appropriate learning strategies and analyzing their impact on children's numeracy abilities.

Further research recommendations may include a more in-depth analysis of other factors influencing children's numeracy development, such as the school environment and peer influence. A deeper understanding of the interaction between these factors can provide a more holistic picture of numeracy development in children. Moreover, the research could integrate broader measurement methods to depict numeracy abilities comprehensively. By involving various aspects of numeracy development, future research can make a more substantial contribution to enhancing mathematical education approaches at the preschool level.

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