Volume 7 Issue 6 (2023) Pages 6959-6968
Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini
ISSN: 2549-8959 (Online) 2356-1327 (Print)

Exploring Counting Processes in Early Childhood: A Study on *Counting All* and *Counting on* Strategies

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DOI: 10.31004/obsesi.v7i6.4954

Abstract
This study aimed to describe the counting processes of counting all and counting in early childhood specifically ages 5-6. To achieve this goal, a qualitative method was employed, and the instrument used consisted of three-word problems read by the examiner. These problems were related to counting all, counting all and counting on, and counting on strategies. The study subjects were six 5-6-year-old students from a kindergarten in Malang. The data collection process began with several students being asked to provide answers and reasons regarding the given instrument. Students who provided appropriate reasons were selected as study subjects. The various results obtained included, students using different strategies, such as counting all, counting on, and a combination of counting all and counting on to solve problems. In counting all, subjects counted the quantity of the first number and proceeded with the second. However, this strategy posed difficulties for students when answering addition problems above 10, leading to the use of toes as an additional counting tool. In counting, students remembered the quantity of the first number and continued counting while extending their fingers according to the quantity of the second number. Furthermore, subjects used both strategies in close succession by transitioning from counting all to counting on when solving addition problems of numbers above 5
Keywords: *counting all, counting on, transition from counting all to counting on.*

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Received 3 July 2023, Accepted 18 December 2023, Published 18 December 2023

Introduction
Mathematics is an essential component of everyday life, and counting is one of its fundamental aspects. According to Delfia & Mayar (2019), counting is a fundamental mathematical skill that can be taught from a basic level up to college, as it is applicable in our daily lives. Snow & Van Hemel (2008) identified three essential skills for early counting, namely 1) understanding number sequence, 2) one-to-one correspondence, and 3) performing addition and subtraction operations. Similarly, Khadijah (2016) stated that counting activities children can engage in include ordering numbers, counting, and performing arithmetic operations.

A recent study conducted by Colin et al. (2021) found that children aged 3-6 years can understand and quantify numbers, but they require additional time to comprehend non-numeric symbols necessary for calculations. Colin also added that children tend to count by reciting numbers in their language while pointing to objects to determine the quantity. Long Thevenot et al. (2016) investigated children aged 5-8 years and discovered that verbal counting involves understanding number symbols and has a close relationship with the

DOI: 10.31004/obsesi.v7i6.4954

development of arithmetic skills. Early counting skills in preschool children entail the conceptual understanding of numbers and counting sequences, as well as manipulating numbers through addition and subtraction. Children are considered to have understood the concept of numbers when they recognize that the last count used to count a set indicates the number of objects in the set (Raghubar & Barnes, 2017). Counting lessons in early childhood education can begin with the use of concrete objects to represent numbers, such as using one candy to denote the number 1, two candies for the number 2, etc (Steffe, 2001).

Chesney, M (2013) found that 5 children aged 2-3 years can utilize advanced counting to solve addition problems. For example, in the addition problem 16 + 8, children counted from 17, 18, ... to 24 while using their fingers. Cheah & Ong (2006) argued that in *counting on* addition, children remember the first number in their minds and continue counting the second number while extending their fingers. According to Chu et al. (2020), their counting skills develop alongside the ability to understand numbers or count sequences. Therefore, children generally use a counting list to determine the quantity of a set.

Basic arithmetic is taught to children after they have grasped the concept of numbers. One of the arithmetic strategies taught in addition, and there are various addition strategies, including *counting all* and *counting on*. *Counting all* is the process of *counting all* objects after combining those that need to be added. For example, in the calculation 2 + 4 = 6, the first step is to determine the quantity of the numbers 2 and 4, then count the total quantity of the two numbers. If expressed verbally, it starts with the number '1, 2, 3, 4, 5, 6' (Maclellan, 2007). Thevenot et al. (2016) stated that the most fundamental strategy in addition is to use objects or fingers to represent the first and the second numbers and then count all the objects.

Counting on strategies is a method used to perform calculations by counting objects without the need to count them all. For example, when solving a calculation such as 2 + 4 = 6, the children will typically start counting from the number 'three', and then continue with 'four, five, six' (Maclellan, 2007). According to Prayitno et al (2018), the main objective of this strategy is to count each item in the second quantity while simultaneously counting each item in the first quantity. In mental addition, procedures of *counting,* Cheah & Ong (2006) suggested that the first number is stored in the brain, and then the second number is counted on the fingers.

When introducing the concept of addition to young children, educators need to use physical aids such as cubes or beads. According to Moeller et al (2011), children learn actively through their senses, by building their knowledge, thinking through concrete objects, and learning from their environment. By using physical aids, children can better understand the quantity of a number. Once they have understood the quantity, educators can gradually phase out the use of physical aids. Carpenter & Moser (1984) emphasized that children can be encouraged to use *counting on* strategies without physical aids, provided they have a good understanding of the number quantity. The use of fingers as a tool for counting is an initial step in introducing the concept of counting to young children because they learn best through concrete objects in their surroundings (Snow & Van Hemel, 2008). Orrantia et al. (2022) showed that finger patterns play an important role in the understanding of cardinality. Therefore, in early numerical development, children often rely on *counting all* procedures using their fingers. The study by Poletti et al. (2022) on children aged 5-6 years old showed that the use of fingers in early numeracy development can facilitate the shift from finger counting to mental strategies (*counting on*) in subsequent educational levels. Although fingers can help solve simple mathematical problems, they can pose difficulties in solving more complex problems and may require additional cues to keep track of the number of steps involved in finger counting (de Chambrier et al., 2018).

To enhance accuracy in the long term, children who use finger-counting strategies tend to obtain less accurate results compared to those using other strategies (Moeller et al., 2011). Barrocas, R, et al. (2020) argued that counting with fingers has limitations, and students often use other body parts such as eyes and shoulders to count. Therefore, it can be concluded that

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counting all with fingers is considered less efficient and difficult when solving addition problems >10 because it is the maximum limit of finger counting.

Ramful & Narod (2014) indicated that children who have a good understanding of the concept of numbers typically utilize *counting on* strategies, while those who have not yet developed a full understanding of numbers tend to use *counting all* strategies. This finding is supported by the discovery of Johansson (2005) on a similar topic. Lannin et al (2013) recommended that counting strategies used by children are influenced by conceptual understanding and the stimuli provided. Therefore, educators need to avoid imposing abstract counting strategies that can confuse students. Study on *counting all* and *counting on'* in Indonesia remains scarce. Although some educators have taught these strategies, they are not familiar with the terms. Children often require different strategies to solve addition problems, such as 7 + 4 = 11 or 9 + 4 = 13, which involve the use of mental *counting on'* strategies to facilitate counting. Napoli (2021) revealed that some preschool-age children have difficulties understanding the concept of addition and continue to struggle with the operations in the first year. Therefore, students need to use basic counting strategies (*counting all*) and then transition to other counting strategies to effectively solve problems (Vanbinst et al., 2020). Educators are expected to support students in transitioning to different counting strategies and guide them in deepening their understanding.

Counting all and *counting on* strategies were observed in children of 4 years old, as well as those with an average age of 6 years (Carpenter & Moser, 1984). According to Aunio et al. (2014), children aged 5-6 years old can understand the number of objects in a set and count without starting from the number one (*counting on*). Therefore, the examiner selected children in this age group as the study subjects. It was observed that these preschool students predominantly employ *counting all* strategies and tend to use their fingers or small objects such as beads. Specifically, they combine the two quantities and start counting from the number one. In some cases, students use their feet to count when their fingers are not enough as a counting tool.

This study aims to describe the process of *counting all* and *counting on* in children aged 5-6 years old. Its expected benefit is to provide educators with feedback to improve the quality of their teaching, especially in teaching counting concepts to children. Additionally, the study can serve as a reference for further investigation into the concepts of *counting all* and *counting on*.

Methods

This study used a qualitative descriptive method to comprehensively understand and explain the behavior and perspectives of the subjects examined (Creswell, 2009). According to El-Nakhel et al (2019), the objective of conducting a qualitative study was to gain an in-depth understanding and explore the activities, models, and processes utilized by the object in the field. Specifically, it aimed to investigate the process of *counting all* and *counting on* among 5-6-year–old children. TK IT Ulil Albab Malang was chosen as the location for this study due to its accessibility and efficiency. Six students from TK B2, aged 5-6 years old, were selected as the subjects. The selection process included (1) All students in class B2 were given addition mathematics problems to solve. (2) Only those who met the topic and study objectives were selected as subjects. (3) The examiner conducted in-depth interviews with the selected subjects to explore the calculation process they used.

The data collection techniques used were observation, documentation, and interviews. The instruments used included the examiner as the main instrument and documentation in the form of video and photos of the counting process of the students. The addition questions consisted of three items in the form of story problems. The first question was solved using *counting all*, the second was solved using both *counting all* and *counting on*, and the third was solved using *counting on*. The additional questions used as study instruments are as follows:

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1. *My younger sibling has 6 bottles of milk, then the teacher gives them 3 more bottles of milk. How many bottles of milk does my younger sibling have now?*
2. *My younger sibling has 7 candies, then the teacher gives them 4 more candies. How many candies does my younger sibling have now?*

When answering the questions, the examiner verbally presented the problems to the students, aiming to further explore their counting process. In the data collection process, concrete counting media, such as beads or small blocks were intentionally withheld by the examiner to gain a deeper understanding and explore counting strategies utilized by students. The data analysis technique employed in this study was Miles and Huberman, which involved data reduction, data display, and verification (Creswell, 2009). Data reduction referred to the process of selecting and focusing on the core data, making it more detailed. After data reduction, the next step was presenting the data and drawing conclusions or verifying the data.

Results and Discussion

The **Table 1** are the addition counting strategies used by students based on the results of the student interview test.

Table 1. Strategies Used by Students in Solving Addition Problems

Student's name	Question 1 (*Counting All*)	Question 2 (*Counting All* and *Counting On*)	Question 3 (*Counting On*)
S I (AR)	Counting On	Counting On	Counting On
S II (RA)	Counting All	Counting On	Counting On
S III (AS)	Counting All	Counting All	Counting All
S IV (BI)	Counting All	Counting All	Counting All
S V (KA)	Counting All	Counting All	Counting All
S VI (AZ)	Counting On	Counting On	Counting On

According to the table above, 2 of the subjects used *counting on*, 3 used *counting all*, and 1 used the combination of *counting all* and *counting on*.

Student Counting Process Using *Counting All*

Counting all is a strategy for adding by counting the total quantity of the first and second numbers. Subjects III, IV, and V used this but subject III had difficulty determining the quantity of numbers with values >5. The distraction resulting from the second number caused the subject to lose track of part of the quantity of the first number. Furthermore, the subject had difficulty representing numbers using concrete objects such as fingers. A picture of subject III solving an addition problem is shown **Figure 1**.

Figure 1. Subject III solving an addition problem

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When adding the numbers 6 + 3 = 9, the subject stretched out only 5 fingers to represent the quantity of the number six and 3 fingers to denote the quantity of the number three, leading to an inaccurate calculation. Initially, the subject stretched out all 6 fingers to indicate the quantity of the number six. After adding the first and second numbers, the subject extended 3 fingers on the left hand and removed 1 finger that was previously used as the number 6. In other words, the subject only added 2 more fingers as the quantity of the number 3. According to Secada et al (1983), students who lacked a proper understanding of counting tended to match numbers while stretching out their fingers. The study conducted by Jacobs et al. (Jacobs et al., 2021) suggested that the cognitive abilities of children had an impact on their counting methodology.

In answering the problem of adding two numbers with a value >10 (the third question), subject V initially counted the quantity of the first number, and then continued counting while matching the numbers with their finger.

Figure 2. subject V initially counted the quantity of the first number, and then continued counting while matching the numbers with their finger

The use of fingers as a counting tool required a good understanding of the concept of numbers (Johansson, 2005) . In preschool, early numeracy skills involved developing a conceptual understanding of numbers, counting sequences, and manipulating numbers through the addition and subtraction of objects. Children were considered to have understood the concept of numbers when they recognized that the final count represented the number of objects in the set (Raghubar & Barnes, 2017). Subject III experienced an error in representing the number of fingers in the finger pattern, which led to an inaccurate answer.

Figure 3. error in representing the number of fingers in the finger pattern, which led to an inaccurate answer

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From the figure above, it was observed that subject III repeated the same mistake. Initially, the subject extended 7 fingers to represent the quantity of the first number. After adding 7 to 4, students suddenly extended 4 fingers on their left hand, despite already using 2 fingers to represent the quantity of the number 7. Based on this explanation, it was concluded that subject III was distracted by the second number and did not pay attention to the quantity of the first number. This lack of synchronization between fingers and counting was due to student's inadequate understanding of the concept of numbers and addition.

When adding numbers >10, children often used their toes to count (Chu et al., 2020). Subject IV faced difficulty when the fingers used for counting were insufficient and hence, resorted to using toes as a counting tool.

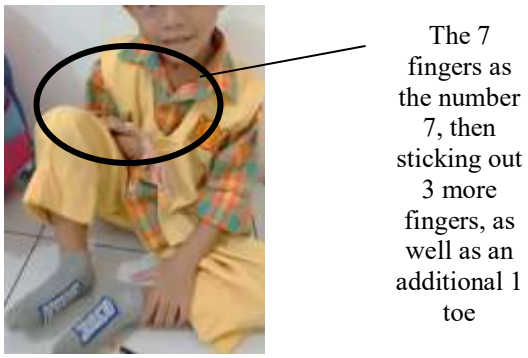

Figure 4. subject to using toes as a counting tool

Based on the figure above, it was concluded that the subject had difficulty counting with the fingers, leading to the use of additional toes to complete the calculation. This aligned with the statement by de Chambrier et al. (2018) that finger patterns helped solve simple math problems. However, it could create problems when solving higher-level mathematics problems that required additional cues to monitor the number of steps needed to be added during finger counting. This implied that the use of fingers as a counting tool required a good understanding of the concept of numbers (Chu et al., 2020). Students who struggled with learning mathematics tended to use the most basic counting strategies, *counting all* (Maclellan, 1995). According to Canobi et al (1998), failure to recognize mathematics problems led to inefficient problem-solving strategies and a lack of conceptual understanding.

Based on the above discussion, it was concluded that *counting all* was the most basic counting strategy when introducing early mathematics learning. In the process, children first counted the quantity of the first number, followed by the quantity of the second number. Children began counting from the number 1 while pointing to objects or extending their fingers.

Student Counting Process Using *Counting On*

Counting on procedure required a good understanding of the concept of numbers. Students who possessed a good mathematical foundation could effortlessly utilize this technique (Hjetland et al., 2020). For example, Subject I was able to recall the quantity of the first number and then counted using the next numbers with their fingers, without any conscious calculation process, while answering the addition problem 5 + 4 = 9. Further investigation revealed that the subject had arrived at the answer by adding 5 + 5 = 10, hence the result of the addition of 5 + 4 = 9. This demonstrated that concepts stored in long-term memory could assist children in solving problems and gaining confidence in their conclusions. According to Thevenot et al. (2016), concepts from long-term memory also influenced the strategies employed by students in counting.

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Figure 5. Subject I employed *counting on* method to solve problems where the values >10.

It was observed from the figure above that Subject I used their fingers as a counting tool. In completing the addition of 6 + 3 = 9, the subject immediately calculated the quantity of the second number from the number sequence "... 7, 8, 9". Initially, they extended 6 fingers to determine the order of counting the first number. The subject then stretched out 3 fingers and started counting from the numbers after 6.

Subject VI attempted to answer the first question three times. For the first and second attempts, they used *counting all,* but the answers were incorrect due to poor understanding of the questions. In the third calculation, the subject switched to *counting on* with some guidance from the examiner.

Figure 7. Subject VI employed the head-saving technique

In *counting on*, subject VI employed the head-saving technique. For example, when adding 7 + 4 = 11, the subject counted to "7 in the head, and 4 in the finger, namely 8, 9, 10, 11". Notably, the subject extended their fingers according to the quantity of the second number while counting. The last number they counted was the answer to the addition problem. This aligned with the statement of Cheah and Ong (2006) that in *counting on*, the first number was stored in the brain, and the second was counted using the fingers.

Students used the head-saving counting method to solve mathematics problems under certain conditions, namely (1) when the first or second number was more than 5. This is because students generally used their fingers as a counting tool, hence, the head-saving method could make counting easier. (2) When the sum of the two numbers >10. In this scenario, students often struggled with the addition of 7 + 4 = 11 because they did not have enough fingers to count. This method was consistent with the discovery of Cheah & Ong (2006) that when using *counting on* method, the first number was stored in the brain, and then the second number was counted on the fingers.

The Process of Counting Students Using *Counting All* And *Counting On*

Orrantia et al (2022) stated that despite understanding *counting on* the procedure, some students still use *counting all* strategies. Therefore, students can switch between using both procedures in quick succession while solving mathematical problems.

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Figure 8. subject employed *counting all* strategies by extending their fingers according to the numbers

In answering the addition of 5 + 4 = 9, the subject employed *counting all* strategies by extending their fingers according to the numbers. However, when solving 6 + 3 = 9 and 7 + 4 = 11, the subject used *counting on* strategies by mentally storing the first quantity and extending their fingers to count the second number. The subjects then started counting from the number after the first number while lowering their fingers one by one. The figure below shows subject II process in answering the addition question 7 + 4 = 11.

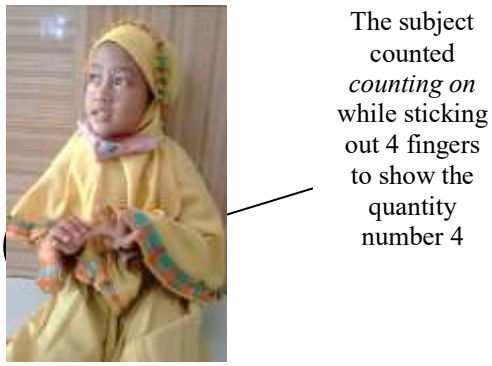

Figure 9. subject II process in answering the addition question 7 + 4 = 11

Subject II used *counting all* procedures in answering the first question and *counting on* for the second and third questions. Based on the observations, subject II employed *counting all* procedures when the first or second number had a value <5 as they could use their fingers to count. This aligned with the opinion of Maclellan (2007) that children can switch from *counting all* to *counting on*, if they had concrete tools such as fingers. Furthermore, subject II changed to *counting on* procedure when the first or second number had a value >5, such as in the sums of 6 + 3 = 9 or 7 + 4 = 11. This was because the fingers of the right or left hand could only count up to the number 5.

Conclusions

Based on the above discussion, the following conclusions could be drawn. In *counting all* processes, students calculated the quantity of the first and second numbers. However, students often struggled to complete additions of numbers >10 and resorted to using their toes as an additional counting tool. While, *counting on* method, students only continued counting after the first number. They did not count the quantity of the first number but rather started counting from the sequence of numbers after the first number. Students used both *counting all* and *counting on* procedures in close succession. This was influenced by the availability of

DOI: 10.31004/obsesi.v7i6.4954

concrete tools that students used in counting. When solving addition problems, students who used *counting all* and *counting on* procedures in solving the addition of numbers have several criteria in choosing a solution strategy including (1) using *counting all* for addition problems where the first or second number was less than or equal to 5, (2) using *counting on* for addition problems where the first or second number was greater than 5.

Acknowledgment

The roles and responsibilities of researchers involved in a study may differ, and their contributions can enhance the perspectives and concepts explored in the research. AP participates in multiple stages, including ideation, data collection, analysis, and result interpretation. On the other hand, LFCF is accountable for conceptualizing the study, devising research methods, interpreting results, and drafting and editing the manuscript.

References

Aunio, P., Heiskari, P., Van Luit, J. E., & Vuorio, J. M. (2014). The development of early numeracy skills in kindergarten in low-, average- and high-performance groups. *Journal of Early Childhood Research*, *13*(1), 3–16. https://doi.org/10.1177/1476718X14538722

Barrocas, R., Roesch, S., Gawrilow, C., & Moeller, K. (2020). Putting a Finger on Numerical Development – Reviewing the Contributions of Kindergarten Finger Gnosis and Fine Motor Skills to Numerical Abilities. *Frontiers in Psychology*, *11*, 1012. https://doi.org/10.3389/fpsyg.2020.01012/bibtex

Canobi, K. H., Reeve, R. A., & Pattison, P. E. (1998). The Role of Conceptual Understanding in Children's Addition Problem Solving. *Developmental Psychology*, *34*(5), 882–891. https://doi.org/10.1037/0012-1649.34.5.882

Carpenter, T. P., & Moser, J. M. (1984). The Acquisition of Addition and Subtraction Concepts in Grades One through Three. *Journal for Research in Mathematics Education*, *15*(3), 179. https://doi.org/10.2307/748348

Cheah, B. L., & Ong, S. L. (2006). Perbandingan Kebolehan Menyelesaikan Masalah Matematik Antara Murid Yang Belajar Abakusaritmetik Mental Dengan Murid Yang Tidak Belajar Abakus-Aritmetik Mental. *Jurnal Pendidik Dan Pendidikan*, *21*, 85–100. Cheah (85-100).pdfhttp://apjee.usm.my/APJEE_21_2006/6

Chesney, M. (2013). Mental Computation Strategies for Addition: There's More than One Way to Skin a Cat. *Australian Primary Mathematics Classroom*, *18*(1), 36–40. https://doi.org/10.3316/informit.395748232567786

Chu, J., Cheung, P., Schneider, R. M., Sullivan, J., & Barner, D. (2020). Counting to Infinity: Does Learning the Syntax of the Count List Predict Knowledge That Numbers Are Infinite? *Cognitive Science*, *44*(8), e12875. https://doi.org/10.1111/cogs.12875

Creswell, J. W. (2009). *Research Design Qualitative, Quantitative, and Mixed Approaches* (3rd ed). SAGE.

de Chambrier, A. F., Thevenot, C., Barrouillet, P., & Zesiger, P. (2018). Frequency of finger looking during finger counting is related to children's working memory capacities. *Journal of Cognitive Psychology*, *30*(5–6), 503–510. https://doi.org/10.1080/20445911.2018.1502190

Delfia, E., & Mayar, F. (2019). Penanaman Konsep Berhitung Anak melalui Permainan Pencocokkan Kepingan Buah. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, *4*(1), 338–350. https://doi.org/10.31004/obsesi.v4i1.350

El-Nakhel, Giordano, Pannico, Carillo, Fusco, Pascale, & Rouphael. (2019). Cultivar-Specific Performance and Qualitative Descriptors for Butterhead Salanova Lettuce Produced in Closed Soilless Cultivation as a Candidate Salad Crop for Human Life Support in Space. *Life*, *9*(3), 61. https://doi.org/10.3390/life9030061

Hjetland, H. N., Brinchmann, E. I., Scherer, R., Hulme, C., & Melby-Lervåg, M. (2020).

DOI: 10.31004/obsesi.v7i6.4954

Preschool pathways to reading comprehension: A systematic meta-analytic review. *Educational Research Review*, *30*. https://doi.org/10.1016/j.edurev.2020.100323

Jacobs, C., Flowers, M., & Jara-Ettinger, J. (2021). Children's understanding of the abstract logic of counting. *Cognition*, *214*, 104790. https://doi.org/10.1016/j.cognition.2021.104790

Johansson, B. S. (2005). Number-word sequence skill and arithmetic performance. *Scandinavian Journal of Psychology*, *46*(2), 157–167. https://doi.org/10.1111/j.1467-9450.2005.00445.x

Lannin, J. K., Webb, M., Chval, K., Arbaugh, F., Hicks, S., Taylor, C., & Bruton, R. (2013). The development of beginning mathematics teacher pedagogical content knowledge. *Journal of Mathematics Teacher Education*, *16*(6), 403–426. https://doi.org/10.1007/s10857-013-9244-5

Maclellan, E. (2007). Counting all, counting on, counting up, counting down. *International Journal of Primary, Elementary and Early Years Education*, *23*(3), 17–21. https://doi.org/10.1080/03004279585200261

Moeller, K., Martignon, L., Wessolowski, S., Engel, J., & Nuerk, H. C. (2011). Effects of finger counting on numerical development the opposing views of neurocognition and mathematics education. *Frontiers in Psychology*, *2*(NOV), 328. https://doi.org/10.3389/fpsyg.2011.00328/bibtex

Napoli, A. R. (2021). Characteristics Related to Parent-Child Literacy and Numeracy Practices in Preschool. *Frontiers in Education*, *6*. https://doi.org/10.3389/feduc.2021.535832

Orrantia, J., Muñez, D., Sanchez, R., & Matilla, L. (2022). Supporting the understanding of cardinal number knowledge in preschoolers: Evidence from instructional practices based on finger patterns. *Early Childhood Research Quarterly*, *61*, 81–89. https://doi.org/10.1016/j.ecresq.2022.05.009

Poletti, C., Krenger, M., Dupont-Boime, J., & Thevenot, C. (2022). The Evolution of Finger Counting between Kindergarten and Grade 2. *Children*, *9*(2). https://doi.org/10.3390/children9020132

Prayitno, A., Setyowati, V. L., Damayanti, N. W., Khasanah, F., Mayangsari, S. N., Mahardika, L. T., Yuniarto, E., Octavianti, C. T., Wulandari, Y. O., & Pertiwi, R. I. (2018). Performance of Understanding Students' Construction in the Naming Fraction of the Three Representation. *Journal of Physics: Conference Series*, *1114*(1). https://doi.org/10.1088/1742-6596/1114/1/012022

Raghubar, K. P., & Barnes, M. A. (2017). Early numeracy skills in preschool-aged children: a review of neurocognitive findings and implications for assessment and intervention. *The Clinical Neuropsychologist*, *31*(2), 329–351. https://doi.org/10.1080/13854046.2016.1259387

Ramful, A., & Narod, F. B. (2014). Proportional reasoning in the learning of chemistry: Levels of complexity. *Mathematics Education Research Journal*. https://doi.org/10.1007/s13394-013-0110-7

Secada, W. G., Fuson, K. C., & Hall, J. W. (1983). The Transition from Counting-All to Counting-on in Addition. *Journal for Research in Mathematics Education*, *14*(1), 47. https://doi.org/10.2307/748796

Snow, C. E., & Van Hemel, S. B. (2008). Early Childhood Assessment: Why, What, and How. *Early Childhood Assessment: Why, What, and How*, 1–484. https://doi.org/10.17226/12446

Steffe, L. P. (2001). A new hypothesis concerning children's fractional knowledge. *Journal of Mathematical Behavior*, *20*(3), 267–307. https://doi.org/10.1016/S0732-3123(02)00075-5

Thevenot, C., Barrouillet, P., Castel, C., & Uittenhove, K. (2016). Ten-year-old children strategies in mental addition: A counting model account. *Cognition*, *146*, 48–57. https://doi.org/10.1016/j.cognition.2015.09.003

Vanbinst, K., Van Bergen, E., Ghesquière, P., & De Smedt, B. (2020). Cross-domain associations of key cognitive correlates of early reading and early arithmetic in 5-year-olds. *Early Childhood Research Quarterly*, *51*, 144–152. https://doi.org/10.1016/j.ecresq.2019.10.009