OBJECT COUNTING

Construct Progression

DOMAIN: Cognitive Development

CLAIM: Students can use content-independent abilities and strategies as well as content-specific skills, processes, and approaches to solve problems and acquire information.

This document was developed under a grant from the U.S. Department of Education. However, the contents do not necessarily represent the policy of the Department and you should not assume endorsement by the U.S. Federal Government or the North Carolina State Board of Education.

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Background

Some important concepts regarding the development of early counting skills are reviewed here to help teachers know what to look for so they can determine a child's learning status on the progression. Let's use 10 pennies as our example. Being able to correctly count 10 pennies requires that a child have three skills: (1) knowledge of the number words to 10 and their order; (2) the ability to apply one and only one number word to each penny; and (3) a way to keep track of which pennies have and have not been counted. These three skills can develop somewhat independently; children count correctly when they have integrated all three. Conversely, a child who has not yet developed one or more of the three skills will count incorrectly. When children are learning to count, they typically count out loud which makes it easy to observe the sophistication of their counting skills if the teacher knows what to look for. It also makes it easy to identify which of the three necessary counting skills children do not yet have when they do not count objects correctly.

A counting-related skill that children develop early is called *subitizing*. For small sets of objects such as 2 or 3, the child learns to "see" the number without needing to count the objects. When teachers are observing early counting behavior, they might see children subitizing which is an important early skill and is to be encouraged because it reinforces counting as a way to get the same number. For larger sets of objects, especially those that are not arranged in a pattern, the child will need to count.

Related to the three skills are some of the features that will make counting harder or easier for children including:

- Counting small sets of objects is easier than larger sets. Fewer objects require knowledge of fewer number words and it is easier to keep track of which object has been counted.
- Objects arranged in a line are easier to count than randomly arranged objects. The line provides a structure for helping the child keep track of which objects have and have not been counted.
- Objects that are very similar to one another (that is, same shape or even same color) may be easier to count than objects that do not share attributes such as color or shape. For example, counting five red Legos is easier than counting a pencil, a cup, a block, a fork, and a small car.
- Objects that can be moved are easier to count than objects that are fixed. A common strategy that children (and adults) use for keeping track of which objects have been counted is to move the objects as each one is counted. A different strategy is required when the objects don't move especially if they are scattered and close together (for example, marking each one that has been counted).
- Counting the total number in a small set of objects is easier than *counting out* that same number from a larger set. When counting out, the child also has to remember to stop at the requested number.

Two important concepts in early counting are cardinality and conservation. *Cardinality* is the knowledge that the last number counted is the number of objects in the set. The number of objects in the set is referred to as the *cardinal number*. The child who knows to stop counting at 5 when asked to count out 5 objects from a larger set is demonstrating cardinality. *Conservation* is the knowledge that the number in the set stays the same unless something is added or subtracted. After counting a set of objects once, early counters will need to recount to find out how many objects there are if the objects are rearranged because they do not yet understand that the number in the set stays the same.

As children become more sophisticated counters, they also learn how to find a new total when an object is added to a set. Let's say the child has counted 7 objects, and the teacher places one more in the set and asks the child how many are there now. An early strategy that children will use involves counting the entire set again starting at "1." A more sophisticated strategy is to count on from the cardinal number in the first set, for example, "7-8.". Eventually, when children understand more about numbers, they quickly will say "8" without any indication of counting.

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Rationale
Children need to develop foundational concepts, such as knowledge of numbers, in order to build future math and reading skills. The ability to understand number names, the counting sequence, and that counting tells the number of objects, are essential understandings needed in the early years. Understanding counting is more than being able to count to 100. Counting is a complex concept. Children move through progressive mathematical stages in order to understand that quantities remain the same when they are rearranged; they learn to be consistent and accurate and to see relationships between numbers. Research shows that general math achievement measured around kindergarten entry has been found to be highly predictive of subsequent mathematics achievement, measured around third grade (Duncan et al., 2007; Claessens, Duncan, & Engel, 2009; Claessens & Engel, 2013). Key advocacy groups, such as the National Association for the Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics (NCTM), have issued position statements on the importance of early mathematics, arguing that mathematics education for 3- to 6-year-olds is essential to promoting future mathematics achievement. (NAEYC & NCTM, 2002). Children's ability in mathematics has also been found to affect reading ability. "Most surprising is that it also predicts later reading achievement even better than early reading skills. In fact, research shows that doing more mathematics increases oral language abilities, even when measured during the following school year. These include vocabulary, inference, independence, and grammatical complexity." (Clements & Sarama, 2013)

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Understanding	**Skills**	**Performance Descriptors**	**Example**
Children understand that counting tells the number of objects and that strategies are needed to determine the number of objects in a set.	A. Displays early counting behavior with 4-6 objects arranged in a line (i.e., says or indicates some number words while pointing to the objects but does not count all of the objects correctly).	When attempting to count 4-6 objects arranged in a line, the child displays at least one of three errors: 1. Using number words incorrectly; 2. Using one-to-one correspondence incorrectly; 3. Not keeping track of objects that have and have not been counted.	*Karen is counting her five crayons before she begins her art project. She touches each crayon as she says the number words out loud, "1, 3, 2, 5, 6."* (**Error**: Using number words incorrectly) *During snack time, the teacher notices that Zahir has lined up four crackers in front of him. The teacher asks Zahir, "How many crackers do you have?" Zahir moves the first cracker over and says, "1." He moves the second cracker over and says, "2.". He then moves the third and fourth crackers over and says, "3."* (**Error:** Using one-to-one correspondence incorrectly) *Shiloh is playing with a set of five Counting Bears. She lines up the five bears and begins counting. She touches the first bear and says "1". She touches the second bear and says "2". She touches the fourth bear (skipping the third bear) and says, "3". She touches the fifth bear and says "4." (***Error**: Not keeping track of objects that have and have not been counted). *Justin is playing with a set of five Counting Bears. He lines up the five bears and begins counting. He touches the first bear and says "1". He touches the second bear and says "2". He touches the second bear again and says, "3". He touches the third bear and says "4". He touches the fourth bear and says "5". He touches the fifth bear and says "6". (***Error**: Not keeping track of objects that have and have not been counted).
	B. Consistently counts 4-6 objects in a line correctly.	When counting 4-6 objects in a line, the child correctly uses only one number for	*Tameka begins exploring the acorns at the science center. When counting objects, she lines them up,*

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		each object, uses the appropriate number words in the correct order, and keeps track of objects that have and have not been counted NOTE: The child could visually track the objects without pointing. If the child correctly counts all of the objects presented, his/her ability to keep track may be inferred.	*touches each one and says, "1-2-3-4-5".*
	C. Consistently counts 4-6 randomly arranged objects correctly.	When counting 4-6 randomly arranged objects, the child correctly uses only one number for each object, uses the appropriate number words in the correct order, and keeps track of objects that have and have not been counted NOTE: The child could visually track the objects without pointing. If the child correctly counts all of the objects presented, his/her ability to keep track may be inferred.	*Teisha is on the playground counting six leaves that have fallen to the ground in a scattered arrangement. She points to each leaf and says "1-2-3-4-5-6."* *When Taran's mobility specialist lines up his paints and art supplies on the table, Taran counts each one "1, 2, 3, 4, 5, 6."*
	D. Knows the last number word used while counting is the total quantity and that the total number of objects in a collection of objects does not change unless objects are added or removed.	When counting objects, the child knows the last number counted is the total quantity (cardinality). AND The child indicates that the value of a collection of objects does not change if the objects are rearranged or hidden (i.e., unless objects are added or removed, the number stays the same) (conservation)	<u>Cardinality Examples:</u> *When counting objects, Erik says, "1-2-3-4-5. I have 5 blocks";* *During recess, the teacher observes Tyson and Abby playing a game. Abby asks Tyson, "How many of my pieces did you get so far?" Tyson counts the pieces he captured and says, "1-2-3-4-5. I have 5 of your pieces."* <u>Conservation examples:</u> *Benjamin and Davion playing a game with cards.*

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			Benjamin asks Davion, "How many cards do you have left?" Davion responds by counting the cards, "1-2-3-4-5-6. I have six cards left." After counting the cards, Davion drops the six cards on the floor. He picks up all of the dropped cards and says, "I still have 6 cards left." *A teacher observes Michael playing with some Unifix cubes. He lines up five of the cubes and counts them aloud indicating a total quantity. The teacher asks Michael if she can play, too. The teacher then mixes up the cubes and asks Michael, "How many cubes are there?" He responds with the same total quantity as before without recounting the objects.*
	E. Consistently counts out 4-6 objects from a set of more than 10 objects.	When observed counting objects, the child produces a set of 5 objects from a larger set of 10 objects by counting out the correct number of objects.	*The teacher observes two children playing marbles. Anna says to Elijah, "Can you give me five marbles from the bag?" Elijah pulls five marbles one at a time from a large clear bag of marbles (i.e., a bag with more than 10 marbles) and correctly counts each one as it is pulled out of the bag - "1, 2, 3, 4, 5". Elijah gives the five marbles to Anna.*
	F. Consistently counts out 8-10 objects from a set of more than 10 objects.	When counting objects, the child produces a set of 10 objects from a set of more than 10 objects by counting out the correct number of objects.	*The teacher observes Demetrius and Lola coloring. The teacher asks Demetrius to give her 10 crayons from the crayon bin that is between him and Lola. Demetrius correctly counts 10 crayons from the bin and gives the 10 crayons to the teacher.*
	G. Correctly counts 18-20 objects arranged randomly.	Child correctly counts 18-20 objects arranged randomly.	*When counting objects, the teacher observes Angelica playing with Legos. The teacher sits down with her and pulls 20 Legos from the bin (without counting them aloud). The teacher places the 20 Legos randomly in front of Angelica. The teacher asks her to count the Legos. Angelica correctly counts the randomly arranged Legos using only one*

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			number for each object, using the appropriate number words in the correct order, and keeping track of objects that have and have not been counted.
Children understand that counting can be used to find the new total when objects have been added to a set.	H. Uses beginning strategies (i.e., counting again from one or by repeating the cardinal number in the original set and then counting on) to find the new total when one object is added to a set of 6-10 objects.	The child uses beginning strategies (i.e., counting again from one or by repeating the cardinal number in the original set and then counting on) to correctly find the new total when one object is added to a set of 6-10 objects.	*The teacher observes Roberto playing a card game with Leia. He counts out six cards aloud from the deck. Then he takes one more card. Roberto then counts all of the cards aloud again and says, "Now, I have seven cards."* *Leia is playing cards with Roberto. Roberto pulls seven cards from the deck for her as she counts them aloud. Leia's aide asks Roberto to pull one more card from the deck and place it on the table in front of Leia. Leia then says, "7, 8; I have 8 cards now".* *A teacher is playing a card game with Asia. The teacher gives six cards to Asia and says, "Here are six cards." The teacher gives her another card and asks, "How many cards do you have now?" Asia looks at the six cards and says, "Six" then looks at the additional card and says, "Seven."*
	I. Produces the correct number automatically (without pause) when one object is added to a set of 6-10 objects.	The child is able to produce the correct number automatically (without pause) when one object is added to a set of 6-10 objects (i.e., without counting any of the objects again or repeating the cardinal number in the original set).	*Brittany and Mario have jobs as cashiers in their class market. Brittany accurately counts the pennies in the cash register and tells Mario, "We have nine pennies." Mario sees an extra penny on the floor, picks it up, hands it to Brittany and says, "Now we have ten pennies!"* *The teacher holds up the Compliment Jar filled with cubes, one cube for every compliment the class has*

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			received. She reminds the class that yesterday they counted eight cubes in the jar. She then holds up one more cube, puts it in the jar and asks, "Chloe, how many cubes do you think are in the jar?" Chloe says, "Nine."
	J. Produces the correct number automatically (without pause) when two objects are added to a set of 6-10 objects.	The child is able to produce the correct number automatically (without pause) when two objects are added to a set of 6-10 objects (i.e., without counting any of the objects again or repeating the cardinal number in the original set.)	*Sarah and Zola are playing in their class market. Sarah counts out eight coins and then says to Zola, "Can you give me some more coins?" Zola gives her two additional coins and Sarah says, "Now, I have ten."* *Isidor and Lucy are playing a game they made up. Isidor rolls an eight-sided die and gets an eight. He then counts out eight chips and places them on table. Lucy then rolls a two. She picks up two more chips and places them with the others on the table and says, "ten".*

Resources

Baroody, A. J. (1987a). Children's mathematical thinking: A developmental framework for preschool, primary, and special education teachers. New York: Teachers College Press. Claessens, A., Duncan G., & Engel, M. (2009). Kindergarten skills and fifth-grade achievement: Evidence from the ECLS-K. *Economics of Education Review, 28*, 415-427.

Baroody, A. J. (1987b). The development of counting strategies for single-digit addition. Journal for Research in Mathematics Education, 18(2), 141–157.

Baroody, A. J. (1989). Kindergartners' mental addition with single-digit combinations. Journal for Research in Mathematics Education, 20(2), 159–172.

Baroody, A. J. (1992a). The development of kindergartners' mental-addition strategies. Learning and Individual Differences, 4(3), 215–235.

Baroody, A. J. (1992b). Remedying common counting difficulties. In J. Bideaud, C. Meljac, & J. P. Fischer (Eds.), Pathways to number (pp. 307–323). Hillsdale, NJ: Lawrence Erlbaum Associates.

Baroody, A. J. (2004). The developmental bases for early childhood number and operations standards. In D. Clements & J. Sarama (Eds.), Engaging young children in mathematics: Standards for early childhood mathematics education (pp. 173–219). Mahwah, NJ: Lawrence Erlbaum Associates.

Baroody, A. J., Eiland, M. D., Purpura, D. J., & Reid, E. E. (2012). Fostering kindergarten children's number sense. Cognition and Instruction, 30(4), 435–470. doi: 10.1080/07370008.2012.720152

Baroody, A. J., Purpura, D. J., Eiland, M. D., & Reid, E. E. (2015). The impact of highly and minimally guided discovery instruction on promoting the learning of reasoning strategies for basic add-1 and doubles combinations. Early Childhood Research Quarterly, 30, 93–105. doi: 10.1016/j.ecresq.2014.09.003

Claessens, A., & Engel, M. (2013). How important is where you start? Early mathematics knowledge and later school success. *Teachers College Record, 115*, 1-29.

Clements, D. & Sarama, J. (2009). *Learning and teaching early math: The learning trajectories approach*. New York, NY: Routledge.

Clements, D., & Sarama, J. (2013). *Math in the Early Years: The Progress of Education Reform*. Retrieved from http://www.ecs.org/clearinghouse/01/09/46/10946.pdf

Confrey, J., Nguyen, K.H., Lee, K., Panorkou, N., Corley, A.K., & Maloney, A P. (2012). *Turn-on common core math: Learning trajectories for the common core state standards for mathematics*. Retrieved from http:www.turnonccmath.net

Copley, J., Jones, C., & Dighe, J. (2010). *The creative curriculum for preschool* (5th ed.). Bethesda, MD: Teaching Strategies, Inc.

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Daro, P., Mosher, F.A., & Corcoran, T. (2011). *Learning trajectories in mathematics*. Retrieved from http://www.cpre.org/ccii/images/stories/ccii_pdfs/learning%20trajectories%20in%20math_ccii%20report.pdf

De Smedt, B., Verschaffel, L., Ansari, D., Grabner, R., Schneider, M., & Hannula, M. (2010). Cognitive neuroscience meets mathematics education. *Educational Research Review, 5*(1), 97-105.

Duncan, G.J., Dowsett, C.J., Claessens, A., Magnuson, K., Huston, A.C., Klebanov, P., & Japel, C. (2007). School readiness and later achievement. *Developmental Psychology*, *43*(6), 1428–1446.

Edens, K.M., & Potter, E.F. (2012). An exploratory look at relationships among math skills, motivational factors and activity choice. *Early Childhood Education Journal, 41*, 235-243. doi:10.1007/s10643-012-0540-y

Frye, D., Baroody, A. J., Burchinal, M., Carver, S. M., Jordan, N. C., & McDowell, J. (2013). Teaching math to young children: A practice guide. Washington, DC: National Center for Education Evaluation and Regional Assistance (NCEE), Institute of Education Sciences, U.S. Department of Education. <http://i+R16es.ed.gov/ncee/wwc/practiceguide.aspx?sid=18>.

Fuson, K. C. (1988). Children's counting and concepts of number. New York, NY: Springer-Verlag.

Fuson, Karen C. & Grouws, Douglas A. (Eds.), (1992). *Handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics.* New York, NY: Macmillan Publishing Co, Inc.

Fosnot, C.T. (2007). *Investigating number sense, addition, and subtraction*. Portsmouth, NH: Heinemann.

Gelman, R., & Gallistel, C. (1986). *Child's understanding of number*. Boston, MA: Harvard College.

Joyner, J., & Muri, M. (2011). *INFORMative assessment: Formative assessment to improve math achievement.* CA: Scholastic, Inc.

K – 3 North Carolina Think Tank. (2013). *Assessment for learning and development in K – 3: A report by the K – 3 North Carolina think tank.* Raleigh, NC: Author.

Maclellan, E. (2012). Number sense: The underpinning understanding for early quantitative literacy. *Numeracy, 5*(2). doi: http://dx.doi.org/10.5038/1936-4660.5.2.3.

Myoungwhon, J., Hartman, P., Smith, T., & Wallace, S. (2013). The effectiveness of teaching number relationships in preschool. *International Journal of Instruction, 6*(1), 165-178.

National Association for the Education of Young Children and National Council of Teachers of Mathematics. (2002). *Early childhood mathematics: Promoting good beginnings* (Position Statement). Retrieved from http://www.naeyc.org/files/naeyc/file/positions/psmath.pdf

National Research Council. (2009). *Mathematics learning in early childhood: Paths toward excellence and equity*. Washington, DC: National Academies Press.

North Carolina Department of Public Instruction. (2013). Unpacking Guides http://www.ncpublicschools.org/acre/standards/common-core-tools/#unmath

North Carolina Department of Public Instruction. (2013). Quick Reference Guides http://www.ncpublicschools.org/curriculum/links/reference-guides/

North Carolina Foundations Task Force. (2013). *North Carolina foundations for early learning and development*. Raleigh, NC: Author.

Olive, J., & Caglayan, G. (2008). Learners' difficulties with quantitative units in algebraic word problems and the teacher's interpretation of those difficulties. *International Journal of Science and Mathematics Education, 6*(2), 269-292.

Richardson, K. (2012). *How children learn number concept*. Rowley, MA: Didax, Inc.

Sarama, J., & Clements, D. (2009). Teaching math in the primary grades: The learning trajectories approach. *Young children, 64*(2), 63-65.

State of New South Wales Department of Education and Communities. (2013). *The numeracy continuum*. Retrieved from

http://www.numeracycontinuum.com/aspects-of-the-continuum/aspect1/8-aspect-1/27-backward-number-word-sequences

Thomas, G., Tagg, A., & Ward, J. (2003). *Exploring issues in mathematics education: An evaluation of the early numeracy project 2002.* Wellington, New Zealand: Ministry of Education.

Van De Rijt, B., Godfrey, R., Van Luit, J. E., Ghesquiere, P., Torbeyns, J., Hasemann, K., & Tzquriadou, M. (2003). The development of early numeracy in Europe. *Journal of Early Childhood Research, 1*(2), 155-180. doi:10.1177/1476718X030012002.

Willey, R., Holliday, A., & Martland, J. (2003). Achieving new heights in Cumbria: Raising standards in early numeracy through mathematics recovery. *Educational and Child Psychology, 24*(2), 108-118.

Wright, R., Ellemor-Collins, D., & Tabor, P. (2012). *Developing number knowledge: Assessment, teaching & intervention with 7-11-year-olds.* Thousand Oaks, CA: SAGE Publications, Ltd.

Wright, R., Staner, G., Stafford, A., & Martland, J. (2006). *Teaching number in the classroom with 4-8-year-olds.* Thousand Oaks, CA: SAGE Publications, Ltd.