Unit 1 Research

As young children learn to describe and represent quantities, shapes, space, and patterns, they gain insights and ideas for understanding the world. Evidence shows that learning mathematics is vital for children's early years and for later success in mathematics, as well as increased overall academic success in such areas as literacy, science, and technology.[1] Starfall Math is designed to help children see relationships and interconnections in mathematics. Each unit is a building block for future units.

In 2006, NCTM (National Council of Teachers of Mathematics) released Curriculum Focal Points for pre-kindergarten through grade 8 mathematics. At the kindergarten level, the three focal points include numbers and operations, geometry, and measurement.[2] It is crucial that sufficient time is devoted to mathematics instruction in kindergarten so that children develop the foundational mathematical skills and understanding described here. Time must be allocated not only for the more formal parts of mathematics instruction and discussions that occur in the whole group or small groups, but also for children to elaborate and extend their mathematical thinking by exploring, creating, playing in learning centers, and completing computer activities.[3] Effective whole group interactions include brief demonstrations and discussions, problem solving in which children partner to talk and work together, and physically active activities such as marching around the room while counting, acting out nursery rhymes that include counting, and acting out patterns and graphs.

Children in a Starfall Math classroom learn that with the combination of only 10 numerals (0 through 9), they can write any number, no matter how large. They begin to understand that the meaning of a numeral in a written number depends in a very specific way on its placement. They actively participate in creating larger and larger units of numbers by bundling them together to create groups of 10.

Research reveals that the use of open-ended questions increases math talk in the classroom. Effective teachers ask children "Why"? and "How do you know?"[4] Starfall's Magic Math Moment and math lessons provide experiences that allow children to share strategies, explain their thinking, work together, and listen to each other to solve problems.

Morning math routines, in which students gather together on a rug or carpet to interact, help enhance math instruction.[5] The activities are designed to build number sense in students, therefore it is important that students are in control and have the opportunity to demonstrate their understanding and proficiency in number operations. Posting the date on the calendar, adding a craft stick to count school days, predicting the day's weather, and other similar activities help children develop real-life math skills and reinforce the base ten number system throughout the 180 days of the school year.

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(2) National Council of Teachers of Mathematics (2006). *Curriculum Focal Points for Pre-Kindergarten through Grade 8 Mathematics: A Quest for Coherence*. Reston, VA.

(3) Committee on Early Childhood Mathematics (2009). *Mathematics Learning in Early Childhood: Paths toward Excellence and Equity.* Washington, D.C.: National Academies Press.

(4) Clements, D.H., and Sarama, J. (2007). Early childhood mathematics learning. In F.K. Lester, Jr. (Ed.), *Second Handbook of Research on Mathematics Teaching and Learning* (pp. 461-555). New York, NY: Information Age.

(5) McCoy, A., Barnett, J., and Combs, E., (2013). *High-Yield Routines for Grades K-8*. National Council of Teachers of Mathematics.

Unit 1 Frequently Asked Questions

What is the primary focus of the Starfall math curriculum?

Number sense is the primary focus of the Starfall Math curriculum. Number sense is the foundation for children's later mathematical achievement. Many preschool children can mechanically count, or even add and subtract as a result of practice and drill, yet they hardly understand the meaning of numbers or their relationships. In other words, children "do" math without understanding numbers. The Starfall Math curriculum focuses on number sense, involving the understanding of whole numbers, number operations, and number relations. In order to navigate formal mathematics, children must be able to link their basic understanding of numbers to symbolic representations. Early number competencies influence future success in mathematics. As number sense is being developed, geometry, algebraic reasoning, and measurement are integrated and spiraled throughout the curriculum.

Why is the Daily Morning Routine so important?

The Daily Morning Routine includes the following five components, which demonstrate the use of numbers in everyday life and provide daily exposure to cardinality.

1. ***Calendar Routine*** — The Calendar Routine provides practice in ordering numbers, reading a graph, adding "one more," creating equivalent sets, ordinal numbers, coin values, and the list goes on!
2. ***Weather Routine*** — The Weather Routine provides experience with a different way to graph numbers through the use of tally marks. Children learn and practice predicting, estimating, greater than, less than, equal, and probability as they chart the daily weather.
3. ***Number Line Routine*** — The Number Line Routine establishes, at an early age, that numbers do not begin at zero but are infinite in both directions (positive and negative). The premise is that children will use the number line as one way to chart how many days they have been in school. Its uses are unlimited: counting forward from a given number; counting backward from a given number; skip counting by 2s, 5s, 10s, 25s, 50s; ordering numbers; and adding one more.
4. ***Place Value Routine*** — The Place Value Routine is linked to the Number Line Routine, and is probably the single most important routine in which children learn from a very young age that our number system contains only the digits 0 through 9 and that regrouping is necessary to form additional numbers. Children "bundle" every ten days, which helps to set the stage for understanding place value.
5. ***Hundreds Chart*** — The Hundreds Chart also reinforces number order and intuitively creates a visual that demonstrates how numbers are organized by groups. It provides another experience in charting numbers.

Unit 2 Research

Developing an understanding of numbers and how to represent them is a major mathematical task for kindergarten children. Numbers are abstractions that apply to a broad range of situations (Example: five children, five fingers, five years old, five apples, five o'clock). It is necessary for children to memorize the number sequence in order to count objects. Children in Starfall Math classrooms have many opportunities to count in unison by ones, fives, and tens, to sing counting songs and nursery rhymes, to count items in a set, and to count on from a given number.

In learning about numbers, the key connection children must make is the one-to-one correspondence between numbers and the number of objects in a set.[1] Children begin to understand and create sets in relation to more than, less than, and equal to. They gradually develop strategies for matching the objects in sets to determine which has leftover objects, or they count both sets and use their understanding of more/less than to compare the sets.

Engaging kindergarten children in number activities and simple games (such as board games) that emphasize one-to-one correspondence, counting, and moving along a number path are important for strengthening foundations and building conventional number knowledge.[2] Many activities on Starfall.com directly reinforce classroom math lessons.

Another crucial mathematical process is pattern. Recognizing and using patterns is a valuable problem solving and mathematical thinking skill for young children. They need to experience patterns visually, auditorily, and physically.[3] Starfall Math's pattern activities focus on repeated patterns such as *abab, aabbaabb,* and *abcabc* using colors, sounds, and body movement. Children learn to analyze, duplicate, extend, and describe many different patterns.

Patterns are not taught as a unit, but integrated throughout the Starfall curriculum across many units.

(1) Committee on Early Childhood Mathematics (2009). *Mathematics Learning in Early Childhood: Paths toward Excellence and Equity.* Washington, D.C.: National Academies Press.

(2) Klibanoff, R.S., Levine, S.C., Huttenlocher, J., Visilyeva, M., and Hedges, L.V. (2006). Preschool children's mathematical knowledge: The effect of teacher "Math Talk". *Developmental Psychology*, 42(1), 59-69.

(3) Clements, D.H., and Sarama, J. (2007). Early childhood mathematics learning. In F.K. Lester, Jr. (ed.), Second Handbook of Research on Mathematics Teaching and Learning (pp. 461-555). New York: Information Age.

Unit 2 Frequently Asked Questions

Why does Starfall Math include patterns in its curriculum? Patterns are not a Common Core Standard.

Patterns serve as the cornerstone of algebraic thinking. Children watch the sun setting every day. They listen to stories, songs, and verses that follow patterns. They notice how a kitten alternates between play and sleep. They jump rope to patterned chants, and skip over sidewalk bricks laid in patterns. Recognizing, describing, extending, and translating patterns encourages children to think in terms of algebraic problem solving. Working with patterns requires young children to identify relationships and form generalizations.

By comparing objects to one another and understanding the relationship between pairs of objects, children demonstrate the ability for transitive thinking. (Example: If Lucas is taller than Olivia, and Olivia is taller than Emma, then Lucas is also taller than Emma.)

Children's understanding of mathematical relationships develops over time. By describing and working with patterns in the world around them, they are using ideas that are foundational to algebraic thinking.

Why does Starfall include so many lessons dealing with more than and less than?

Children learn to count by rote. Educators (and others) often mistakenly assume that because children can count to 20 easily that they understand the sequence of numbers. Throughout the curriculum Starfall provides opportunities for children to practice the meaning of counting and to recognize the quantity the numbers represent.

The fact that children are usually more successful at determining which number is "one more" than which number is "one less" is an indication that they do not fully comprehend the meaning of numbers. Therefore, Starfall integrates opportunities throughout the math curriculum for children to demonstrate understanding of the number system by requiring them to determine which number is one less than another. These opportunities occur primarily during the Magic Math Moments.

Unit 3 Research

Research supports the importance of incorporating learning centers into the curriculum for successful mathematics achievement.[1] Integrating math into other parts of the day, especially during learning center time, makes math meaningful and provides opportunities for children to practice what they have learned in a purposeful manner. When teachers coordinate their current math objectives with activities in the classroom, children reinforce their skills.[2] For instance, math games for learning centers in the Starfall classroom have been created to match current math objectives. These games build on children's math knowledge, provide a reason for learning skills and concepts, and supply repeated practice that is fun. Math games were found to have a positive influence on young children and their learning. A group of studies found that children who played number-based board games performed better in the domain of basic number concepts than those who played other types of board games or no board games.[3]

Math learning centers give children and teachers an opportunity to discuss strategies and ideas and generate excitement. The arrangement of construction materials (connect cubes, dice, dominoes, tiles, play dough, etc.) in learning centers encourages children to match and sort by color, shape, size, and other features, to count, and to practice one-to-one correspondence. They identify and reproduce shapes and patterns, form arrays, compose and decompose numbers, measure, estimate, and much more.

Active, appropriate use of computers in kindergarten supports and extends traditional learning materials.[4] The use of Starfall.com in the classroom computer centers is one of the tools children use to acquire knowledge and skills and solve math problems in interactive, open-ended learning activities. For example, research supports the use of computers to allow children to manipulate shapes with greater dexterity than they can manage by hand and to promote problem- solving.[5]

(1) National Research Council (2009). *Mathematics Learning in Early Childhood: Paths toward Excellence and Equity.* Washington, DC: National Academies Press.

(2) Curtis, R., Okamoto, Y. & Weckbacher, L. M. (2009). Preschoolers' use of count information to judge relative quantity. *Early Childhood Research Quarterly*, 24 (3), 325-336.

(3) Siegler, R.S., and Ramani, G. B. (2008). "Playing Linear Numerical Board Games promotes Low-income Children's Numerical Development," *Developmental Science,* 11:5, pp 655-661.

(4) National Association for the Education of Young Children and Fred Rogers Center for Early Learning and Children's Media (2012). Technology and interactive media as tools in early childhood programs serving children from birth through age 8: A joint position statement.

(5) Clements, D. H. (2002). Computers in early childhood mathematics. Contemporary Issues in Early Childhood, 3(2), 160–181.

Unit 3 Frequently Asked Questions

Why does Starfall Math include Learning Centers only one day a week?

Kindergarten teachers spend nearly twice as much instructional time on reading compared with mathematics. This pattern continues in the typical school through at least fourth grade. The average math time allotment is between 45 and 60 minutes per day. Scheduling three or four learning centers per day, and allowing a minimum of ten minutes per center, results in 40 minutes for a class of 20 children or less not including transitional time, set up, and clean up. This leaves only ten minutes for group instruction and/or partner learning each day.

Starfall's remedy is to schedule four days of group and partner learning, including formative assessment activities, and to devote the fifth day to practicing skills learned each week, thereby providing enough time for the children to engage in their center activities while also providing the teacher with an opportunity to conduct formal summative assessments.

What does a Learning Center rotation entail?

The Learning Centers are designed to review and practice skills taught in the previous four daily sessions. They include two activities or games, a Teacher's Choice activity or game, a computer assignment from Starfall.com, and a teacher-directed activity that is combined with a summative assessment. The children rotate approximately every twelve to fifteen minutes. The Summative Assessment Center provides an opportunity to not only assess the children, but also to ask questions and determine on which developmental level each child is functioning for that particular skill. Checklists are provided to record results, observations, and anecdotal notes.

What kind of partner learning takes place during instructional time?

Instructional time begins with a whole group presentation. The children practice the concepts introduced and/or reviewed through activities using their Starfall Math Bags (which contain math manipulatives), whiteboards, and/or other hands-on math materials. The children often partner using a cooperative learning technique outlined in the lesson plans. Daily instructional time also includes formative assessments. Formative assessments are the key to creating the learning environment needed to meet individual children's needs and improve learning outcomes. During this formative assessment teachers observe children and ask open-ended questions, such as "Why?" or "How did you know?" questions. This information then informs any remediation that might need to take place either as a group or for individuals.

Unit 4 Research

Money concepts should be taught at home and in kindergarten because the learned knowledge and skills are not only relevant, but practiced in daily life. According to Mary Brenner at the University of CA, Santa Barbara, "One of the many prescriptions for making mathematics more meaningful to children is to include mathematical tasks that relate to children's everyday lives." (1)

The introduction of coins in kindergarten should begin with activities designed to acquaint children with the identification and value of coins, using real money. The learning objectives are recognizing coins, knowing the value of the penny, nickel and dime, simple addition of coins, and problem solving using money. Counting, addition, and subtraction in terms of money make it easier for many children to gain math confidence.

Children learn to identify coins and their values by experiencing numerous hands-on activities. Coins are introduced one at a time as children participate in various activities to create understanding of that coin before another coin is introduced.(2) They then work on the questions, "How many pennies (or cents) are in a nickel? A dime?" Children become aware of the differences in color, shape, and feel as well as value. In Starfall kindergarten classrooms, children learn about coins through classroom games, rhymes, and Learning Center activities. They pretend to buy items using actual coins, play "Toss the Coin" to learn about head and tails, identify presidents on coins, and play "Coin Town," "Coin Concentration," and various coin games on Starfall.com. Children learn the value of a set of coins, create a set of coins with a given value, and compare the values of sets of coins.(3) Children demonstrate their understanding in a variety of ways. These types of activities enable students to become proficient problem solvers.(4)

Some kindergarten children struggle to advance from the concrete to the abstract. It is important to reinforce these developmental concepts throughout the year with coin games and activities that reinforce their learning, such as practice in solving problems involving addition and subtraction using coins, showing different combinations of coins that equal the same value, and solving problems using combinations of coins.

(1) Brenner, Mary. Meaning and Money. *Educational Studies in Mathematics*, July, 1998, Vol. 36, Issue 2, pp 123-155.

(2) Martin-Kniep, Gisselle O. *Becoming a Better Teacher: Eight Innovations That Work*, Alexandria, VA: Association for Supervision and Curriculum Development, 2000.

(3) Randell L. Drum and Wesley G Petty, Jr. Teaching Children Mathematics, Vol. 5, No. 5, (January 1999), pp 265-268.

(4) National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA.

Unit 4 Frequently Asked Questions

Why does the Starfall Math curriculum include money even though many state standards do not?

Using money is a real-life skill that requires math knowledge. Kindergarten children do not become experts at using money, nor do they need to for tests or state standards, but they like coins, in part because they are "real" objects.

Coins make excellent counters even if children don't recognize their values, and they provide a perfect opportunity to practice "counting on." When children see a nickel and two pennies, they learn it isn't necessary to count 1-2-3-4-5 and then add 2 more. Instead they learn to recognize the value of the nickel as five, thus starting at five and counting on two more, 5,6,7.

Including money in the curriculum also provides children with the opportunity to practice addition and subtraction skills by using coins as they play store and pretend to "purchase" items.

Kindergarten children invariably express interest in handling and distinguishing coins. Even learning their values proves interesting. While the children aren't expected to be able to correctly count change, they do take pride in knowing the coins' names and their values.

Kindergarten children who have rich and varied math experiences have been found to perform at higher levels in later years. Previewing coins and their values will help children become more successful later on, when money is more formally introduced.

Unit 5 Research

Once kindergarten children have basic number sense, they soon begin to understand 10 as the foundation for place value. They are then able to distinguish that teen numbers consist of a set of ten and some ones, and that ten ones create one group of ten.

Children must understand that each cardinal teen number consists of two groups; one group of ten, and a group of ones. Therefore they should realize, for example, that 16 consists of one group of ten and 6 ones. The ability to visualize ten ones as one set of ten is crucial to future understanding of math concepts.

To aid in the development of this sense of awareness, it is helpful to provide experiences in which the children observe 16 objects, for example, separated into a group of ten and a group of six, and relate these quantities using both the number words "sixteen is ten and six" and the written number symbol, 16.

It is also helpful to illustrate the written equation 16 = 10 + 6. Repeated experiences in considering these relationships will assist the children in overcoming the typical error of reversal, or writing the number they say first, when writing teen numerals. Children will eventually hear sixteen and recognize that when writing teen numerals, they write 1 first, even though they may not yet think of this one as a representation of ten, so they write 61.[1]

Having learned that ten is the building block of our base 10 numeration system, young children can usually "read" two-digit numbers long before they understand the effect the placement of each digit has on its numerical value. A kindergartner might be able to correctly read 41 as forty-one and 14 as fourteen, without understanding why the numbers are of different values. Ten-frames were developed by researchers Van de Walle (1988) and Bobis (1988) to help develop numbers sense within the context of ten.[2][3]

The simultaneous use of two ten-frames can provide an important first step to understanding teen numbers. In a Starfall classroom, the teacher articulates a teen number, for example, 14. The children then place the Number Card 1 beneath the first ten-frame and fill the ten-frame with 10 counters. They then place the Number Card 4 beneath the second ten-frame and add 4 counters to total 14. Activities such as this are included in the Starfall Math Curriculum because research shows that children develop mental images of numbers based on their experiences with ten-frames.[4]

(1) Committee on Early Childhood Mathematics, (2009). *Mathematics Learning in Early Childhood: Paths toward Excellence and Equity.* Cross, C.T., Woods, T. A., and Schweingruber, H. (Eds). Washington, D.C.: National Academies Press.

(2) Bobis, J. (1996). "Visualization and the development of number sense with kindergarten children." In Mulligan, J. & Mitchelmore, M. (Eds.) *Children's Number Learning: A Research Monograph of the Mathematics Education Group of Australasia and the Australian Association of Mathematics Teachers.* Adelaide: AAMT.

(3) Van de Walle, J. A. (1988). Elementary School Mathematics: Teaching Developmentally. London: Longman.

(4) Back, J. (2014). "Place Value: The Ten-ness of Ten", NRICH: Enriching Mathematics, University of Cambridge, UK.

Unit 5 Frequently Asked Questions

Do children need to have a solid understanding of place value before introducing teens?

It is very common for children to experience some difficulty with the numbers 11-19, since their names do not follow the common rules, and numerals now take on very different meaning depending on their placement.

The key to understanding numbers beyond ten is to understand place value; however, children do not need to have a full understanding of place value prior to introducing the teen numbers.

Children are exposed to numbers beyond ten daily during the calendar, number line, and hundreds chart routines, and most importantly through the place value routine, in which they are bundling sets of tens with ones left over. Activities involving counting on from a given number and the use of ten frames also assist children in their understanding of the "tricky teens," which provides a foundation for formally introducing the numbers 11 through 19.

What types of intervention do you suggest for children who struggle with teens?

As with learning to read the numerals 0 through 9, there are many everyday situations that provide purposeful opportunities to practice recognizing numerals and numeral writing. For example, recording the score of a game between the teachers and children, counting crayons in a container and then recording the number, lining children up and having them "count off" as you indicate them in line, assigning a "teen" number to each child (they can write their teen number on their whiteboards or paper), and playing games calling up different teen numbers are all excellent opportunities in which the children can receive needed daily practice. Repeated exposure to the numbers and experiences that involve recording numbers will help those who are struggling while also providing reinforcement for the others.

Unit 6 Research

Shape is a fundamental idea in mathematics and in early childhood development. Beyond mathematics, shape is the basic way children learn the names of objects, and attending to the objects' shapes facilitates that learning.[1] Through the study of geometric shapes, children can begin to develop ways to mentally structure the spaces and objects around them and develop mathematical reasoning ability. Every 2-D shape or 3-D object has multiple aspects: the overall shape, the particular parts and features of the object or shape, and the relationships among these parts and the whole object or shape. Young children need time to observe and analyze the parts and features of geometric shapes, the "inside region" and the "outer boundary," the number and length of sides, and the nature of these sides and their relationships to each other. The study of geometric shapes is not only about seeing shapes as wholes, it's about finding and analyzing their properties and features.[2]

Children first identify shapes at the visual level on the basis of their appearance, then represent shapes at the "descriptive" level on the basis of their properties. They tend to regard squares as a distinct category and not as a special kind of rectangle with four sides that are equal in length. Children should learn that a square is a special type of rectangle (a square-rectangle). This approach has been shown to be successful with kindergartners.[3]

Children need to experience various examples of shapes and understand their attributes. Examples of triangles and rectangles should include a wide variety of shapes, including "long," "skinny," and "fat" examples.[4] As children move beyond perceiving and naming shapes, they build mathematical concepts as they discuss the parts and attributes of shapes. Well-designed activities using hands-on manipulatives can effectively build geometric and special skills and general reasoning abilities. Extensive mathematics research conducted by Douglas H. Clements, a leading teacher, researcher, and writer in early childhood mathematics at the State University of New York at Buffalo, has shown that the use of manipulatives helps young children develop geometric and spatial thinking. Manipulatives, either physical or using a computer, assist children in constructing mathematical meaning. Computers can be used to carry out mathematical processes that are difficult or impossible to perform with physical manipulatives.[5] In a Starfall Math classroom, children build squares and other polygons with toothpicks and marshmallows; they form shapes with play dough or with their bodies, either singly or with their classmates. They gather rectangles and describe in their own words why their shapes are rectangles. Children are shown a variety of shapes and have to decide whether they are or are not rectangles and why. Children work online at Starfall.com on the Geometry and Measurement section of the Math Index.

In summary, key findings from broad research in mathematics in early childhood education tells us that children are better prepared for all school tasks when they gain the thinking tools and representational competence of geometric and spatial sense.[6]

(1) Jones, SS., and Smith, L.B. (2002). How children know the relevant properties for generalizing object names. *Developmental Science,* 2, 210-232.

(2) Committee on Early Childhood Mathematics, (2009). *Mathematics Learning in Early Childhood: Paths toward Excellence and Equity.* Cross, C.T., Woods, T. A., and Schweingruber, H. (Eds). Washington, D.C.: National Academies Press.

(3) Clements, D.H., and Sarama, J. (2007). Early childhood mathematics learning. In F.K. Lester, Jr. (ed.), *Second Handbook of Research on Mathematics Teaching and Learning* (pp. 461-555). New York: Information Age.

(4) Seo, K.H., and Ginsburg, H.P. (2004). What is developmentally appropriate in early childhood mathematics education? In Clements, D.H., Sarama, J., and DiBaise, A.M. (Eds.), *Engaging Young Children in Mathematics: Standards for Early Childhood Mathematics Education* (pp. 91-104). Mahwah, NJ: Erlbaum.

(5) Clements, D. H. (1999). Concrete manipulatives, concrete ideas. *Contemporary Issues in Early Childhood*, 1 (2, 45-60).

(6) Ginsburg, H.P., Greenes, C., and Balfanz, R. (2003). *Big Math for Little Kids.* Parsippany, NJ: Dale Seymour.

Unit 6 Frequently Asked Questions

Why does the Starfall Math curriculum spend so much time teaching shapes?

Most children have many ideas about shapes upon entering kindergarten. However, teachers often do not question children appropriately in order to extend their ideas. Many times the questions teachers ask are closed-ended and require simple recall to answer correctly.

Research shows that young children's concepts about shapes stabilize by six years of age, but that these concepts are not necessarily accurate. Starfall Kindergarten Math builds on children's prior knowledge and generates new content. The children learn and practice awareness of shape properties, identify individual shapes in a variety of positions, and experiment with combining smaller shapes to create larger ones. Children are asked to complete statements such as "I know this is a (name of shape), because (shape's properties)." Doing so provides them the opportunity to identify shapes using their attributes or properties. Learning the accurate properties of two-dimensional shapes lays the foundation for future understanding of three-dimensional shapes.

Starfall Kindergarten Math introduces math nets. Isn't working with math nets a 5th-grade skill?

A math net is simply a two-dimensional paper shape that can be folded to create a three-dimensional shape. When a math net is laid flat, it shows the pattern of a three-dimensional shape, including each of its faces. By introducing math nets in kindergarten, the children see more concretely the relationship between two-dimensional and three-dimensional shapes.

Spatial thinking plays a fundamental role in our lives, ranging from the everyday activities we take for granted (e.g., navigating a new city, assembling furniture, remembering the location of objects, etc.) to the more specialized skills required for higher education and various professions (e.g., architecture, dentistry, medicine, art and design). Recent research shows that spatial thinking is strongly related to entrance and success in science, technology, engineering, and math (STEM) disciplines.

Learning two-dimensional shapes is key for further math learning. If children don't recognize two-dimensional shapes, they most likely will not be able to recognize three-dimensional shapes. Using math nets is a way to help the children see the relationship between them.

Unit 7 Research

Subitizing, a fundamental skill in the development of children's understanding of numbers, is the process of instantly recognizing how many objects are in a group without actually counting them. The importance of teaching subitizing to young children has been underscored by a series of studies, which found that doing so helps children mathematize their environment and stimulates their interest in numerical skills.(1)

How is it that children see an eight-dot domino and "just know" the total number? Mathematics researchers Steffe and Cobb found that children recognize the number pattern as a composite of parts and as a whole. They see each side of the domino as composed of four individual dots and as "one four." They see the domino as composed of two groups of four and also as "one eight." Children are capable of viewing number and number patterns as units of units.(2)

The author of "Subitizing: What is it? Why teach it?," Douglas Clements, says that children can use pattern recognition to discover essential properties of numbers such as conservation.(3) Subitizing also helps children develop skills such as counting on, composing and decomposing numbers, as well as place value.

Many number activities can promote subitizing. One particularly valuable activity is known as "quick images." Starfall classrooms utilize this technique through the use of ten-frames. The children are shown a ten-frame with magnets placed in varying numbers of sections, then it is quickly hidden. The children respond by articulating how many magnets are on the ten-frame. Other variations of the quick image activity are matching games such as Concentration, and using dominoes or dice to help children develop pattern recognition by visualizing combinations of objects.

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(2) Steffe, Leslie P., and Paul Cobb. (1988). Construction of Arithmetical Meanings and Strategies. New York: Springer-Verlag.

(3) Clements, Douglas H. (1999). "Subitizing: What is it? Why teach it?" *Teaching Children Mathematics*. National Council of Teachers of Mathematics.

Unit 7 Frequently Asked Questions

What is subitizing?

To be able to subitize is to have the ability to quickly identify numbers of objects in relatively small sets, without the need to count. It is recognizing a number without relying on other mathematical processes. Subitizing plays an important role in the development of basic math skills, especially addition and subtraction skills.

Why does the Starfall Math Curriculum introduce subitizing before addition and subtraction?

Subitizing is initially presented as the rapid recognition of images of the dots on dice and dominoes. Children quickly learn these patterns, and without really trying, commit the patterns to their visual memories. The children then extend this skill to the ability to add on from a given number. For example, if a domino has 3 dots on one side and 6 dots on the other side, the children learn to identify the larger number (6) then count on (3) from that number (6, 7, 8, 9). Repeated recognition of patterns of dots and use of tally marks help children learn number combinations, so eventually when a child looks at the same domino with 3 dots on one side and 6 on the other, he or she instantly realizes that 6 plus 3 is equal to 9. Therefore, subitizing provides an early basis for composing and decomposing numbers.

Unit 8 Research

Counting is adding. Each counting number adds one more to the previous number. This observation is essential for children's early methods of solving addition problems. Also, each step in the counting process can be thought of as describing the total number of objects that have been counted so far.[1] Children first learn the comparing terms "equal to" and "more than" for two groups of things or two numbers. They find out which one is bigger and which one is smaller or if they are equal by matching and by counting. Addition is used to relate amounts before and after combining, to relate amounts in parts and totals, or to say precisely how two amounts compare. Situations that can be formulated with addition occur in a wide variety of story problems.

Once children recognize that the sum of a given number plus one is simply the number after the given number, they use this knowledge as a scaffold for inventing a counting-on strategy for starting with a cardinal value of a number (e.g., four and three more: four, five is one more, six is two more, seven is three more – so the answer is seven). In other words, given a problem such as "four and three more," children seem to recognize that "four and one more" would be the next number in the number-word sequence (five) and reason that "four and three more", then, must be three numbers past four (five, six, seven).[2] This shortcut allows them to compute sums without having to start their count from one each time.

Math instruction for young children should begin with informal representations of math ideas. Initially, teachers should link math ideas to familiar experiences and terms, resisting the urge to use more formal methods until children have a conceptual foundation for understanding.[3] Once children are comfortable using informal methods and representations to describe math ideas, such as "more" and "all together," teachers can help them link formal math vocabulary, symbols, and procedures to their informal knowledge or experiences. They should explicitly teach children math words so they have the vocabulary needed to connect their informal knowledge to formal terms. Teachers can use this math vocabulary when speaking to children throughout the day, not just during math instruction. Math conversations can happen spontaneously as teachers comment about natural occurrences that involve number or other math concepts. Linking formal representations to informal concepts and representations enables children to understand and more readily learn formal terms, symbols (+ or =), definitions, or procedures.[4]

It is often assumed that solving real-life or story problems is a relatively difficult task and that problem solving should be introduced after formal addition skills (e.g., after they have memorized the basic facts or at least after more concrete experiences). However, children can often solve simple real-life problems before they comprehend formal expressions such as 5 +2 = ?.[5] Research indicates that many children can also use their informal arithmetic knowledge to analyze and solve simple addition word problems before they receive formal arithmetic instruction.

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Unit 8 Frequently Asked Questions

Why does Starfall introduce addition so early in the curriculum?

Addition is introduced after the children have had the opportunity to develop number sense. To allow for this, the first semester focuses on the prerequisites necessary to successfully perform the operation of addition. These prerequisites, which are then spiraled throughout the Starfall math curriculum include:

- Counting to 20 or beyond
- Recognizing numerals 0 through 9
- Correctly counting a given number of objects
- Understanding the concepts of more than and less than (greater than and less than)
- Counting on from a given number
- Matching a number of objects with the corresponding numeral symbol
- Writing the numerals 0 through 10
- Recognizing coins and their values
- The ability to see patterns
- Subitizing

Teaching addition earlier in the school year rather than later provides more time for the children to practice their skills and helps them master the relationships between numbers and understand how quantities relate to each other.

Why does the Starfall math curriculum focus so much on story problems when so many children seem to struggle with this concept?

Story problems help bring math to life and give numbers a purpose. For these reasons, the Starfall curriculum introduces story problems long before formally introducing the concept of addition.

The keys to understanding and solving story problems are vocabulary and number sense. Early in the school year math terms such as greater than, one more than, altogether, and how much are introduced. However, relying solely on certain key words that signal specific operations is not enough!

Children are also introduced to eight different strategies for solving addition problems. Many of these strategies are then applied to solving addition story problems. Providing these strategies helps children visualize a problem.

Children need repeated practice applying math concepts to solve real life problems. Providing real-life situations that children can relate to, inserting their names into the story problems, and then moving on to more difficult components such as adding numbers to problems that do not affect the outcome, can lead to future success.

Unit 9 Research

Research indicates that the fundamental understanding of subtraction evolves from children's early counting experiences. [1] By playing with sets of items, children can recognize that taking something away from a set makes it smaller. From their numerous experiences that involve removing items from a set to make it smaller, children construct an informal conceptual basis for understanding subtraction as taking away. They use this view of subtraction to comprehend and to solve simple arithmetic tasks or word problems.

Various early math content areas should be taught according to a developmental progression of skills and concepts that build on one another. These developmental progressions show the order in which young children typically learn math concepts and skills. Educators should ensure that children are comfortable with earlier steps in the progression before being introduced to more complex steps. Understanding developmental progressions is also necessary to employ progress monitoring that tracks each individual child's success along the steps in the progression. [2] Children should be provided many opportunities to practice recognizing the total number of objects in small sets. Next, teachers should promote accurate one-to-one counting as a means of identifying the total number of items in a set. Once children can recognize or count sets, they need many occasions to use number words and counting to compare quantities. When children have developed these fundamental number skills, they are ready to begin solving basic problems.

Using their number knowledge to solve arithmetic problems gives children a context to apply and expand this knowledge and gain confidence in their math ability. Once children can determine the total number of items in a set by using number recognition or counting and can understand the concepts of "fewer," they can explore the effects of subtracting items from a set. Children can change small sets of objects by combining or removing objects (e.g., taking away two blocks from a set of five blocks) and then count to determine "how many" they have in the new set.

As children become more adept, teachers should present more difficult problems with slightly larger numbers. Children should begin posing word problems as well as solving them. It is important for children to retell a word problem in their own words as a powerful general teaching strategy to extend their knowledge.[3] Problem solving challenges children to use their math knowledge to answer and explain math-related questions. Teachers can use problem-solving tasks across classroom situations so children can see how to apply counting to solve everyday challenges, such as taking attendance to see how many children are present or absent. Once children have experience with combining or separating items in a set they can see, they can do the same with collections of objects (e.g., pennies) when the final outcome is hidden from view. The children see the initial group of objects and the objects being taken away, but they do not see the final set of objects. The children must then determine how many are hiding. Children may solve this problem by counting on their fingers or in their heads. After the children give their answer, the teacher can take the cover away, and the children can count to check the answer. Snack time can provide children with authentic comparisons of adding and subtracting or "more" and "fewer." As children receive or eat their snacks, they can count how many items they have, or "How many will you have after you eat one?"

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(3) National Research Council. (2009) *Mathematics Learning in Early Childhood: Paths toward Excellence and Equity.* Washington, DC: National Academies Press.

Unit 9 Frequently Asked Questions

Subtraction traditionally seems more difficult for young children than addition. With that in mind, how does Starfall ensure that children meet with success when they are introduced to this concept?

The Starfall math curriculum begins preparing children for subtraction early in the year through the morning Daily Routines, in which the children practice counting backward and identifying numbers that are less than other numbers. Because subtraction is practiced in these and other real-life situations throughout the program, the children develop a basic understanding of the concept before it is formally introduced, making them much more likely to meet with success later on.

The concept of subtraction is introduced and reviewed through:

- Subtraction story songs (*Starfall.com* and *Starfall Math Melodies*)
- Subtraction strategies (*Backpack Bear's Big Math Book*)
- Illustrating subtraction word problems
- Learning center games and activities
- *Starfall.com* subtraction activities
- Dramatizations
- Board games
- Story maps

Children often try to use their fingers to subtract but end up adding the numbers rather than subtracting. What are some ways to help children use this strategy correctly?

The key to helping children understand the concept of subtraction is to be sure they understand the concept of less than. Additionally, practice with estimation, teaching number sense, and working with money help the children understand that the outcome of a subtraction problem will be less than the original number.

Children are introduced to eight different subtraction strategies, so they have others on which they may also rely. These strategies are practiced repeatedly and help to reinforce the concept of subtraction.

The online subtraction activities at *Starfall.com* concretize subtraction in a fun way. The children hear and see the concept being played out in games and activities. Providing opportunities for children to explore subtraction activities online provides the much-needed practice children require in order to become proficient in subtraction.

Unit 10 Research

Estimation is a pervasive process in the lives of children. "How many steps from the classroom to the cafeteria?" "How long is one minute? Close your eyes and open them when you think one minute is up.""How many jellybeans are in the jar?""How many cups of water will it take to fill the bucket?" Without the ability to estimate reasonably accurately, life would be difficult. The most consistent conclusion reached by investigators of the development of estimation is that young children are not very skillful estimators. This conclusion was reached by researchers studying estimations of various properties, including distance, money, number of objects, and answers to math problems.[1] The difficulty young children have with estimation has been ascribed to various causes: mindless symbol manipulation, lack of number sense, and lack of relevant conceptual structures.

Little is known about the ability of children in early childhood to estimate the size of collections. Unlike their sense of small numbers, children's sense of "large" numbers is not well defined. With small numbers—numbers they can relate to concrete examples and experiences—children have a well-developed sense of number size. For example, one is clearly distinct from, and clearly smaller than, two. With large numbers—numbers that they cannot relate to concrete examples and experiences—children have little or no sense of number size. As a result, they do not clearly distinguish among such numbers and may have great difficulty ordering them.[2] Fuson and Hall hypothesized that younger children may have difficulty estimating the size of collections larger than five because they have not constructed numerical benchmarks. In their research, they found that many kindergartners appear to have an over-exaggerated mental image of ten and twenty, and some even had an over-exaggerated view of five.[3] Through everyday experiences of counting collections of five, ten, and so forth, children gradually construct mental benchmarks that allow them to better gauge the size of collections of five and larger. Constructing a sense of number size is a gradual process that comes from using and thinking about numbers in everyday situations. In other words, it comes from relating numbers to personally meaningful experiences.

Research on using a number line from the 0 to 100 range with young children indicates a correlation between number-line estimation and math achievement. In Siegler and Booth's 2004 research, children were given sheets of paper showing a blank number line with only 0 at one end and 100 at the other end. They were asked to show where they thought different numbers (random numbers such as 17, 52, 6, 81, 96, 12, etc.) would fall on the line by marking the right location with a pencil. Construction of a linear representation of numbers seems crucial to mathematical development.[4] Reliance on a linear representation with a given number range is related to the ability to learn answers to unfamiliar math problems in that range. Young children whose number-line estimation indicates a linear representation produce errors that are closer to the correct answer. Young children's estimates become more accurate and linear with age and experience.

Starfall Math instruction is written in harmony with the children's ways of learning. This requires sensitive observation and thoughtful questions at critical junctures ("How many pages do you think are in this book?""Are there more boys than girls in our class?" "Which will take more time: walking to the gym or to the library?") Children's interests, ideas, and strategies should remain at the center of early childhood mathematics education.[5] We encourage teachers to foster the development of children's number sense in everyday situations and where appropriate (when an exact amount is not needed or in situations where only a quick look is possible), by encouraging children to estimate the size of collections. Look for opportunities to have children compare the relative sizes and differences in collections. "Your new neighbors have an eight-year-old boy and a six-year-old girl. Who do you think is older?"

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Unit 10 Frequently Asked Questions

Why is teaching estimation in kindergarten important?

For many children, estimation is a difficult concept. Kindergarten children want to be right, so if there are 18 objects, saying there are about 20 is not good enough! Although children are usually encouraged to calculate the correct answer, being able to estimate is a valuable skill. The ability to estimate shows that a child has good number sense. Children who have good number sense are able to use that skill to determine whether their answer to a math question is reasonable.

It is important for children to understand that estimation does not replace the need to produce accurate answers. However, teaching children to estimate helps them become critical thinkers and better understand expectations. Children also learn early on to use mental math in order to arrive at reasonable answers to problems.

In real life, estimation is part of our everyday experience. When shopping in the grocery store and trying to stay within a budget, for example, we estimate the cost of the items we place in our carts to keep a running total in our heads. For young children the ability to estimate helps them to determine how much they might accomplish in a given period of time, for example when the teacher informs children that they have only five more minutes to work or play before clean up time.

How do you prepare children to estimate?

The Common Core Standards require estimation skills at every grade level. In kindergarten, Starfall uses language with children that includes such words and phrases as *about, close, just about, a little more* (or *less*) *than,* and *between*. These concepts are introduced and reinforced throughout the Starfall Math Curriculum before the concept of estimation is introduced.

The intention of *Estimate with Backpack Bear*, a book included in the program, is to provide the children with many opportunities to practice their estimation skills in a variety of settings, and reinforce the fact that estimation is making smart guesses to find numbers that are close to the right answers.

Unit 11 Research

In addition to learning about number and shape, early childhood also includes development of measurement, which is a fundamental aspect of mathematics that connects geometry and number.

In its most basic form, measurement is the process of determining the size of an object. To measure a quantity (with respect to a given measurable attribute, such as length, area, or volume) a unit must be chosen. Children begin with nonstandard units: craft sticks to measure the length of a classroom rug; square 1" tiles to measure the area of a table; cube-shaped blocks to measure a book. So when a unit is chosen, a measurement is the number of those units. An important idea about units which children learn gradually is that when measuring a given object, the larger the unit used to measure, the smaller the total number of units. Because the concept of units underlies core ideas in number, geometry and measurement, it has been recommended as a central focus for early childhood mathematics education.(1)

The development of measurement skills usually starts with directly comparing objects along one dimension. Thus children generally succeed in measuring length prior to area and volume.(2) Starfall Math introduces children to nonstandard measures to determine the length and height of classroom objects, and offers many activities for practice in ordering objects by length.

An important feature of their learning during this period is that children have difficulty understanding units of measure. Young children can be successful at measurement when given appropriate instruction. Both research with children and interviews with teachers support claims that (a) the principles of measurement are difficult for children, (b) they require more attention in school than is usually given, (c) time needs to first be spent in informal measurement, in which the use of measurement principles is evident, and (d) transition from informal to formal measurement needs much more time and care.(3)

Children's early competency in measurement is facilitated by play with structured materials, such as unit blocks, pattern blocks, and measuring tiles, and strengthened through opportunities to reflect on and discuss their experiences. Research on the learning of shapes and certain aspects of visual literacy suggests the inclusion of these topics in the early years can be powerful.(4) Starfall Math affords children many opportunities to describe measurable attributes of objects and compare two objects with a common measurable attribute.

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(2) Hart, K. (1984). Which comes first – length, area, or volume? *Arithmetic Teacher,* 31. 66-18, 26 – 27.

(3) Irvin, K.D., Vistro-Yu, C.P., and Ell, F.R. (2004). Understanding linear measurement: A comparison of Filipino and New Zealand children. *Mathematics Education Research Journal*, 16(2), 3-24.

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Unit 11 Frequently Asked Questions

The Starfall Math Curriculum seems to spend a great deal of time on measurement activities. How can this fit into the schedule and still allow time to achieve all of the other standards?

Unfortunately, with the shift from the concept of Kindergarten as a developmentally appropriate setting that included a housekeeping area, sandbox, and large and small block centers, to a much more academic setting, young children do not have as much opportunity to practice measurement skills in a play environment as they once did. Experimenting with measurement takes time because it must be hands-on, so measurement activities are included throughout the curriculum, with a focus on measurement in Unit 11. Children need to manipulate and experiment with measurement concepts in order for real understanding to occur.

Only nonstandard measurement is included in the program. Wouldn't it be better to introduce children to a ruler and other standard measurement tools?

It is important for children to understand the concept of measurement in a developmentally-appropriate way. It is also important to teach the underlying concepts before introducing more difficult units of measure such as measuring tapes and rulers, etc. Concepts such as always measuring from the baseline, or always measuring with the same-sized unit of measurement (paper clip, craft stick, cube, etc), and estimating length and height are emphasized and practiced throughout all of the measurement activities.

Later in the program children are introduced to standard units of measurement, but they are not required to use them to measure.

Unit 12 Research

The development of young children's number sense and understanding of the base ten system is essential for the acquisition of more complex number skills in later years. Once children have developed a basic sense of numbers up to ten, they need to develop a strong "sense of ten" as a foundation for both place value and mental calculations. Students need many instructional experiences to develop their understanding of numerical systems including how numbers are written. Research indicates that students' experience using physical models to represent tens and ones can be effective in dealing with place value issues early in the curriculum. The materials should help them think about how to combine quantities and eventually how this process connects with written procedure. Children, therefore, often need extra help in understanding the base ten organization underlying number names and in seeing quantities organized into hundreds, tens, and ones. Conceptual supports, such as manipulatives, show the magnitude of the quantities and connect them to the number names and written numerals, and have been found to help children acquire insight into the base ten number system. That insight is important to learning and understanding numerals and also to developing strategies for solving math problems.[1] However, "merely having manipulatives available does not ensure that students will think about how to group the quantities and express them symbolically", states The National Council of Teachers of Mathematics. Rather, students must construct meaning for themselves by using manipulatives to represent groups of tens in classroom discussions and in authentic, cooperative activities.[2]

Research findings suggest that in two-digit numeral representations, children's understanding of the ones place develops before knowledge of the tens place. These findings directly relate to mathematics contexts, with implications for early childhood mathematics instruction. Arthur J. Baroody at the University of Illinois argues that exposure to foundational place value concepts (e.g., exposure to multiunit meanings, working with two-digit numbers) should be introduced much earlier than first grade, and can begin as soon as children begin working with two-digit numbers. Baroody's rationale for early exposure rests on the assertion that young children have the ability to make basic connections and establish foundational understanding for later mathematics. He suggests, "By introducing multiunit meanings concretely as soon as children begin using two-digit numbers in school and discussing them throughout the primary grades, children may develop a more secure basis for understanding multiunit concepts."[3]

Students need opportunities to practice the fundamentally important "exchange principle", e.g., ten ones is the same as one group of ten and explore the concept of leftovers.[4] In Starfall Math, children learn that the meaning of a digit in a written number is determined by its placement within the number. Activities are designed to provide opportunities to create and count groups of 10 with connect cubes, providing students with a physical representation of how two-digit numbers are created, and emphasizes the place value concepts of groups of ten and leftover ones.

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(3) Baroody, A. (1990). How and when should place value concepts and skills be taught? *Journal for Research in Mathematics Education*, 21(4), 281-286.

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Unit 12 Frequently Asked Questions

The Starfall Math Curriculum includes place value concepts from day one. Why is so much emphasis placed on this concept?

It is absolutely essential that children develop a solid understanding of the base ten numeration system and place value concepts. Starfall introduces place value through real-life experiences every day during the Gathering Routine in which the children chart the number of days they have been in school then group them by ones, tens, and one hundred. This daily exposure to place value helps children understand that our base ten number system only includes the numbers 0 through 9. Being introduced to the concept of regrouping from an early age helps children develop the concepts they will later need to successfully learn to regroup in addition and subtraction.

In which other types of lessons do children use their knowledge of place value?

Children use their individual ten-frames and manipulatives to construct number representations above 9. When the concept of teens is introduced, the children learn them by understanding the value of each number's placement. The children construct meaning for themselves by using manipulatives to represent groups of tens in classroom discussions and in authentic cooperative activities.

Unit 13 Research

In a kindergarten classroom, many activities revolve around time. How long do we have before gym? When is snack? What day do we have music? Time is a difficult concept for young children to grasp. Introducing the concepts of clocks, seconds, minutes, and hours will help prepare them for future lessons of telling time. By participating in meaningful calendar activities, young children begin to understand that time is sequential. The sequences include yesterday, today, and tomorrow; morning, afternoon, and evening; the seasons; Sunday, Monday, Tuesday, and so on. Children also need to be able to conceptualize before and after, and think about future and past events, such as planning for the hundredth day of school or writing a class story about yesterday's field trip.[1] It is useful to occasionally time events such as "5 minutes until clean-up time", "Let's see if anyone can finish up before the 10 minute timer rings". Much of clock knowledge comes from everyday activities through informal experiences. Teachers can support these experiences by posting visual models of important times during the day that children can match to the real clock. Books can be read that include time concepts and time sequence.[2] In the Starfall Math Curriculum, children are provided blank calendars each month that they can fill with important dates (holidays, birthdays, etc.).

Linear representations help children begin to understand and conceptualize that a day is a unit of time and to talk about it with increasing clarity. For example, to count the number of days they have been in kindergarten, children can add a link to a paper chain each day, or number a pattern of colored Post-it notes and place them on the classroom number line, or add a connect cube to a stack of cubes. The teacher can emphasize time-linked vocabulary, such as before, after, later, earlier, as the children add the new link. Picture schedules illustrating the schedule of class activities are often used, or a poster with photos of the day's activities in sequence can be helpful to young children. Displaying documentation of shared class events, such as field trips or class science projects of planting beans or measuring the growth of a sweet potato vine, can lead to meaningful discussions that involve time-linked vocabulary (first day, third day, last week, etc.).[3]

Kindergarten children should also be introduced to standard units of measure to compare temperatures and to learn how to use a thermometer to measure temperature.[4] They need to have experiences with hot, warm and cold things and hot, comfortable and cold weather. Children can examine thermometers and discuss their experiences with them (going to the doctor for a check-up, measuring outdoor and indoor air temperatures, controlling the thermostat on their furnaces and air conditioners, etc.). They can experiment with measuring the temperatures of the water after adding ice cubes and/or warm water to the water table or science center. Children can also record results as they continue to add ice or warm water. Teachers can place outdoor thermometers outside the classroom and have children record the temperature each day in the morning, noon, and end of the day.

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(3) NAEYC & NCTM (National Council of Teachers of Mathematics). (2002). Early childhood mathematics: Promoting good beginnings. A joint position statement of NAEYC and NCTM. www. naeyc.org/about/positions/mathematics.asp

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Unit 13 Frequently Asked Questions

Why does the Starfall Math Program introduce time and temperature, since these are not included in the Common Core standards?

The Common Core standards are just that, a core of standards, or a baseline. Every state and district is encouraged to add standards to the Common Core list in order to ensure a well-rounded curriculum. Since the concepts of time and temperature appear in many state standards, Starfall has chosen to include them in its effort to produce the best possible kindergarten math curriculum.