Standard 1: Number and Computation – The student uses numerical and computational concepts and procedures in a variety of situations.

Benchmark 1: Number Sense – The student demonstrates number sense for rational numbers and simple algebraic expressions in one variable in a variety of situations.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. knows, explains, and uses equivalent representations for rational numbers expressed as fractions, terminating decimals, and percents; positive rational number bases with whole number exponents; time; and money (2.4.K1a-c) **($)**. 2. ▲ compares and orders (2.4.K1a-c) **($)**: a. integers; b. fractions greater than or equal to zero, c. decimals greater than or equal to zero through thousandths place. 3. explains the relative magnitude between whole numbers, fractions greater than or equal to zero, and decimals greater than or equal to zero (2.4.K1a-c). 4. ▲ **N** knows and explains numerical relationships between percents, decimals, and fractions between 0 and 1 (2.4.K1a,c), e.g., recognizing that percent means out of a 100, so 60% means 60 out of 100, 60% as a decimal is .60, and 60% as a fraction is 60/100. 5. uses equivalent representations for the same simple algebraic expression with understood coefficients of 1 (2.4.K1a), e.g., when students are developing their own formula for the perimeter of a square, they combine s + s + s + s to make 4s.	The student… 1. generates and/or solves real-world problems using equivalent representations of (2.4.A1a-c) **($)**: a. integers, e.g., the basketball team made 15 out of 25 free throws this season. Express their free throw shooting as a fraction and as a decimal. b. fractions greater than or equal to zero, e.g., the basketball team made 15 out of 25 free throws this season, express their free throw shooting as a fraction. c. decimals greater than or equal to zero through thousandths place (2.4.1a), e.g., the basketball team made 15 out of 25 free throws this season, express their free throw shooting as a decimal. 2. determines whether or not solutions to real-world problems that involve the following are reasonable **($)**. a. integers (2.4.A1a), e.g., the football is placed on your own 10-yard line with 90 yards to go for a touchdown. After the first down, your team gains 7 yards. On the second down, your team loses 4 yards; and on the third down your team gains 2 yards. Is it reasonable for the football to be placed on the 5 yard line for the beginning of the fourth down? Why or why not? b. fractions greater than or equal to zero (2.4.A1c), e.g., Gary, Tom, and their parents are selling greeting cards. Gary receives 1/3 of the profit and Tom receives 1/4 of the profit. Is it reasonable that together they received 2/7 of the profits? Why or why not?

▲– Assessed Indicator on the Objective Assessment
■ – Assessed Indicator on the Optional Constructed Response Assessment
N – Noncalculator
($) – Financial Literacy

	c. decimals greater than or equal to zero through thousandths place (2.4.A1c), e.g., the beginning bank balance is $250.40 A deposit of $175, a withdrawal of $198, and a $2 service charge are made. The checkbook balance reads $127.40. Is this a reasonable balance? Why or why not?

Teacher Notes: Number sense refers to one's ability to reason with numbers and to work with numbers in a flexible way. The ability to compute mentally, to estimate based on understanding of number relationships and magnitudes, and to judge reasonableness of answers are all involved in number sense.

When we say that someone has good number sense, we mean that he or she possesses a variety of abilities and understandings that include an awareness of the relationships between numbers, an ability to represent numbers in a variety of ways, a knowledge of the effects of operations, and an ability to interpret and use numbers in real-world counting and measurement situations. Such a person predicts with some accuracy the result of an operation and consistently chooses appropriate measurement units. This "friendliness with numbers" goes far beyond mere memorization of computational algorithms and number facts; it implies an ability to use numbers flexibly, to choose the most appropriate representation of a number for a given circumstance, and to recognize when operations have been correctly performed. (Number Sense and Operations: Addenda Series, Grades K-6, NCTM, 1993)

At this grade level, rational numbers include positive and negative numbers, large numbers (one million), and small numbers (one-thousandth). **Relative magnitude** refers to the size relationship one number has with another – is it much larger, much smaller, close, or about the same? For example, using the numbers 219, 264, and 457, answer questions such as –

- Which two are closest? Why?
- Which is closest to 300? To 250?
- About how far apart are 219 and 500? 5,000?
- If these are 'big numbers,' what are small numbers? Numbers about the same? Numbers that make these seem small?

(Elementary and Middle School Mathematics, John A. Van de Walle, Addison Wesley Longman, Inc., 1998)

Mathematical models such as concrete objects, pictures, diagrams, Venn diagrams, number lines, hundred charts, base ten blocks, or factor trees are necessary for conceptual understanding and should be used to explain computational procedures. If a mathematical model can be used to represent the concept, the indicator in the Models benchmark is identified in the parentheses. For example, (2.4.K1a) refers to Standard 2 (Algebra), Benchmark 4 (Models), and Knowledge Indicator 1a (process models). Then, the indicator in the Models benchmark lists some of the mathematical models that could be used to teach the concept. In addition, each indicator in the Models benchmark is linked back to the other indicators. Those indicators are identified in the parentheses. For example, *process models* are linked to 1.1.K3, 1.2.K6, 1.3.K1, … with 1.1.K3 referring to Standard 1 (Number and Computation), Benchmark 1 (Number Sense), and Knowledge Indicator 3.

The National Standards in **Personal Finance** identify what K-12 students should know and be able to do in personal finance; benchmarks are provided at three grade levels (grades 4, 8, and 12) and are grouped into four major categories) Income, Spending and Credit, Saving and Investing, and Money Management. Although the National Standards in Personal Finance are benchmarked at three grade levels, the indicators in the Kansas Curricular Standards for Mathematics that correlate with the National Standards in Personal Finance are indicated at each grade level with a **($)**. The National Standards in Personal Finance are included in the Appendix.

Standard 1: Number and Computation – The student uses numerical and computational concepts and procedures in a variety of situations.

Benchmark 2: Number Systems and Their Properties – The student demonstrates an understanding of the rational number system and the irrational number pi; recognizes, uses, and describes their properties; and extends these properties to algebraic expressions in one variable.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. classifies subsets of the rational number system as counting (natural) numbers, whole numbers, integers, fractions (including mixed numbers), or decimals (2.4.K1a,c,k). 2. identifies prime and composite numbers and explains their meaning (2.4.K1d). 3. uses and describes these properties with the rational number system and demonstrates their meaning including the use of concrete objects (2.4.K1a) **($)**: a. commutative and associative properties of addition and multiplication (commutative – changing the order of the numbers does not change the solution; associative – changing the grouping of the numbers does not change the solution); b. identity properties for addition and multiplication (additive identity – zero added to any number is equal to that number; multiplicative identity – one multiplied by any number is equal to that number); c. symmetric property of equality, e.g., 24 x 72 = 1,728 is the same as 1,728 = 24 x 72; d. zero property of multiplication (any number multiplied by zero is zero); e. distributive property (distributing multiplication or division over addition or subtraction), e.g., 26(9 + 15) = 26(9) + 26(15); f. substitution property (one name of a number can be substituted for another name of the same number), e.g., if a = 3 and a + 2 = b, then 3 + 2 = b; g. addition property of equality (adding the same number to each side of an equation results in an equivalent equation – an equation with the same solution), e.g., if a = b, then a + 3 = b + 3;	The student… 1. generates and/or solves real-world problems with rational numbers using the concepts of these properties to explain reasoning (2.4.A1a-c,e) **($)**: a. commutative and associative properties for addition and multiplication, e.g., at a delivery stop, Sylvia pulls out a flat of eggs. The flat has 5 columns and 6 rows of eggs. Show two ways to find the number of eggs: 5 • 6 = 30 or 6 • 5 = 30. b. additive and multiplicative identities, e.g., the outside temperature was T degrees during the day. The temperature rose 5 degrees and by the next morning it had dropped 5 degrees. c. symmetric property of equality, e.g., Sam took a $15 check to the bank and received a $10 bill and a $5 bill. Later Sam took a $10 bill and a $5 bill to the bank and received a check for $15. $15 = $10 + $5 is the same as $10 + $5 = $15 d. distributive property, e.g., trim is used around the outside edges of a bulletin board with dimensions 3 ft by 5 ft. Show two different ways to solve this problem: 2(3 + 5) = 16 or 2 • 3 + 2 • 5 = 6 + 10 = 16. Then explain why the answers are the same. e. substitution property, e.g., V = IR [Ohm's Law: voltage (V) = current (I) x resistance (R)] If the current is 5 amps (I = 5) and the resistance is 4 ohms (R = 4), what is the voltage? f. addition property of equality, e.g., Bob and Sue each read the same number of books. During the week, they each read 5 more books. Compare the number of books each read: b= number of books Bob read, s= number of books Sue read, so b + 5 = s + 5..

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■ – Assessed Indicator on the Optional Constructed Response Assessment
N – Noncalculator
($) – Financial Literacy **THESE STANDARDS ARE ALIGNED <u>ONLY</u> TO THE ASSESSMENTS THAT WILL BEGIN DURING THE 2005-06 SCHOOL YEAR.**

h. multiplication property of equality (for any equation, if the same number is multiplied to each side of that equation, then the new statement describes an equation equivalent to the original), e.g., if a= b, then a x 7 = b x 7; i. additive inverse property (every number has a value known as its additive inverse and when the original number is added to that additive inverse, the answer is zero), e.g., $^{+}5 + (^{-}5) = 0$. 4. recognizes and explains the need for integers, e.g., with temperature, below zero is negative and above zero is positive; in finances, money in your pocket is positive and money owed someone is negative. 5. recognizes that the irrational number pi can be represented by an approximate rational value, e.g., 22/7 or 3.14.	g. multiplication property of equality, e.g., Jane watches television half as much as Tom. Jane watches T.V. for 3 hours. How long does Tom watch television? Let T = number of hours Tom watches TV. 3 = ½T, so 2•3 + 2•½T. h. additive inverse property, e.g., at the shopping mall, you are at ground level when you take the elevator down 5 floors. Describe how to get to ground level. 2. analyzes and evaluates the advantages and disadvantages of using integers, whole numbers, fractions (including mixed numbers), decimals, or the irrational number pi and its rational approximations in solving a given real-world problem (2.4.A1a-c) **($)**, e.g., in the store everything is 50% off. When calculating the discount, which representation of 50% would you use and why?

Teacher Notes: From the Mathematics Dictionary and Handbook (Nichols Schwartz Publishing, 1999), **property** as a mathematical term means a characteristic (an attribute) of a number, geometric shape, mathematical operation, equation, or inequality. To give an example:

- Property of a number: 8 is divisible by 2.
- Property of a geometric shape: Each of the four sides of a square is of the same length.
- Property of an operation: Addition is commutative. For all numbers x and y, x + y = y + x.
- Property of an equation: For all numbers a, b, and c, if a = b, then a + c = b + c.
- Property of an inequality: For all numbers a, b, and c, if a > b, then a – c > b – c.

Mathematical models such as concrete objects, pictures, diagrams, Venn diagrams, number lines, hundred charts, base ten blocks, or factor trees are necessary for conceptual understanding and should be used to explain computational procedures. If a mathematical model can be used to represent the concept, the indicator in the Models benchmark is identified in the parentheses. For example, (2.4.K1a) refers to Standard 2 (Algebra), Benchmark 4 (Models), and Knowledge Indicator 1a (process models). Then, the indicator in the Models benchmark lists some of the mathematical models that could be used to teach the concept. In addition, each indicator in the Models benchmark is linked back to the other indicators. Those indicators are identified in the parentheses. For example, *process models* are linked to 1.1.K3, 1.2.K6, 1.3.K1, … with 1.1.K3 referring to Standard 1 (Number and Computation), Benchmark 1 (Number Sense), and Knowledge Indicator 3.

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Standard 1: Number and Computation – The student uses numerical and computational concepts and procedures in a variety of situations.

Benchmark 3: Estimation – The student uses computational estimation with rational numbers and the irrational number pi in a variety of situations.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. estimates quantities with combinations of rational numbers and/or the irrational number pi using various computational methods including mental math, paper and pencil, concrete objects, and/or appropriate technology (2.4.K1a-c) **($)**. 2. uses various estimation strategies and explains how they were used to estimate rational number quantities or the irrational number pi (2.4.K1a-c) **($)** 3. recognizes and explains the difference between an exact and an approximate answer (2.4.K1a-c). 4. determines the appropriateness of an estimation strategy used and whether the estimate is greater than (overestimate) or less than (underestimate) the exact answer and its potential impact on the result (2.4.K1a).	The student… 1. adjusts original rational number estimate of a real-world problem based on additional information (a frame of reference) (2.4.A1a) **($)**, e.g., given a large container of marbles, estimate the quantity of marbles. Then, using a smaller container filled with marbles, count the number of marbles in the smaller container and adjust your original estimate. 2. **▲N** estimates to check whether or not the result of a real-world problem using rational numbers is reasonable and makes predictions based on the information (2.4.A1a) **($)**, e.g., a class of 28 students has a goal of reading 1,000 books during the school year. If each student reads 13 books each month, will the class reach their goal? 3. selects a reasonable magnitude from given quantities based on a real-world problem and explains the reasonableness of the selection (2.4.A1a), e.g., length of a classroom in meters – 1-3 meters, 5-8 meters, 10-15 meters. 4. determines if a real-world problem calls for an exact or approximate answer and performs the appropriate computation using various computational methods including mental math, paper and pencil, concrete objects, or appropriate technology (2.4.A1a) **($)**, e.g., Kathy buys items at the grocery store priced at: $32.56, $12.83, $6.99, 5 for $12.49 each. She has $120 with her to pay for the groceries. To decide if she can pay for her items, does she need an exact or an approximate answer?

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Teacher Notes: Estimate, as a verb, means to make an educated guess based on information in a problem or to give an answer close to the exact number. Estimation is used when an exact answer is not needed, as in many real-life situations for which "ballpark" computations are acceptable. Good number sense enables one to estimate a quantity, estimate a measure, or estimate an answer.

Estimation serves as an important companion to computation. It provides a tool for judging the reasonableness of computational methods including mental math, paper and pencil, concrete objects, and appropriate technology. However, being able to compute does not automatically lead to an ability to estimate or judge reasonableness of answers. Frequent modeling by the teacher helps students develop a range of estimation strategies. Students should be encouraged to frequently explain their thinking as they estimate. As with exact computation, sharing estimation strategies allows students access to others' thinking and provides opportunities for class discussion. Identifying the estimation strategy by name is not critical; however, explaining the thinking behind the strategy to make a valid estimation is important. (Principles and Standards for School Mathematics, NCTM, 2000)

Mental math and **estimation** are distinct but related mathematical skills. Proficiency in mental math contributes to increased skill in estimation. In order for students to become more familiar with estimation, teachers should introduce estimation with examples where rounded or estimated numbers are used. Emphasis should be placed on real-world examples where only estimation is required, e.g., About how many hours do you sleep a night? Using the language of estimation is important, so students begin to realize that a variety of estimates (answers) are possible.
In addition, when students are taught specific estimation strategies, they develop mental math and estimation skills easier. Estimation strategies include front-end with adjustment, compatible "nice" (friendly) numbers, clustering, special numbers, or truncation.

Mathematical models such as concrete objects, pictures, diagrams, Venn diagrams, number lines, hundred charts, base ten blocks, or factor trees are necessary for conceptual understanding and should be used to explain computational procedures. If a mathematical model can be used to represent the concept, the indicator in the Models benchmark is identified in the parentheses. For example, (2.4.K1a) refers to Standard 2 (Algebra), Benchmark 4 (Models), and Knowledge Indicator 1a (process models). Then, the indicator in the Models benchmark lists some of the mathematical models that could be used to teach the concept. In addition, each indicator in the Models benchmark is linked back to the other indicators. Those indicators are identified in the parentheses. For example, *process models* are linked to 1.1.K3, 1.2.K6, 1.3.K1, … with 1.1.K3 referring to Standard 1 (Number and Computation), Benchmark 1 (Number Sense), and Knowledge Indicator 3.

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Standard 1: Number and Computation – The student uses numerical and computational concepts and procedures in a variety of situations.

Benchmark 4: Computation – The student models, performs, and explains computation with positive rational numbers and integers in a variety of situations.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. computes with efficiency and accuracy using various computational methods including mental math, paper and pencil, concrete objects, and appropriate technology (2.4.K1a). 2. performs and explains these computational procedures: a. ▲**N** divides whole numbers through a two-digit divisor and a four-digit dividend and expresses the remainder as a whole number, fraction, or decimal (2.4.K1a-b), e.g., 7452 ÷ 24 = 310 r 12, 310 12/24, 310 ½, or 310.5; b. **N** adds and subtracts decimals from millions place through thousandths place (2.4.K1c); c. **N** multiplies and divides a four-digit number by a two-digit number using numbers from thousands place through hundredths place (2.4.K1a-b), e.g., 4,350 ÷ 1.2 = 3,625; d. **N** multiplies and divides using numbers from thousands place through thousandths place by 10; 100; 1,000; .1; .01; .001; or single-digit multiples of each (2.4.K1a-c); e.g., 54.2 ÷ .002 or 54.3 x 300; e. **N** adds integers (2.4.K1a); e.g., $^{+}6 + ^{-}7 = ^{-}1$ f. ▲**N** adds, subtracts, and multiplies fractions (including mixed numbers) expressing answers in simplest form (2.4.K1c); e.g., 5¼ • 1/3 = 21/4 • 1/3 = 7/4 or 1¾ g. **N** finds the root of perfect whole number squares (2.4.K1a); h. **N** uses basic order of operations (multiplication and division in order from left to right, then addition and subtraction in order from left to right) with whole numbers; i. adds, subtracts multiplies, and divides rational numbers using concrete objects. 3. recognizes, describes, and uses different representations to express	The student… 1. generates and/or solves one- and two-step real-world problems with rational numbers using these computational procedures **($)**: a. division with whole numbers (2.4.A1b), e.g., the perimeter of a square is 128 feet. What is the length of its side? b. ▲ ■ addition, subtraction, multiplication, and division of decimals through hundredths place (2.4.A1a-c), e.g., on a recent trip, Marion drove 25.8 miles from Allen to Barber, then 15.2 miles from Barber to Chase, then 14.9 miles from Chase to Douglas. When Marion had completed half of her drive from Allen to Douglas how many miles did she drive? c. addition, subtraction, and multiplication of fractions (including mixed numbers) (2.4.A1c), e.g., the student council is having a contest between classes. On the average, each student takes 3 1/3 minutes for the relay. How much time is needed for a class of 24 to run the relay?

▲– Assessed Indicator on the Objective Assessment
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($) – Financial Literacy

the same computational procedures, e.g., 3/4 = 3 ÷ 4 = $4\overline{)3}$. 4. identifies, explains, and finds the prime factorization of whole numbers (2.4.K1d). 5. finds prime factors, greatest common factor, multiples, and the least common multiple (2.4.K1d). 6. finds a whole number percent (between 0 and 100) of a whole number (2.4.K1a,c) **($)**, e.g., 12% of 40 is what number?	

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Teacher Notes: Efficiency and accuracy means that students are able to compute single-digit numbers with fluency. Students increase their understanding and skill in single-digit addition and subtraction by developing relationships within addition and subtraction combinations [and by developing relationships with multiplication and division combinations]. Students learn basic number combinations and develop strategies for computing that makes sense to them. Through class discussions, students can compare the ease of use and ease of explanation of various strategies. In some cases, their strategies for computing will be close to conventional algorithms; in other cases, they will be quite different. Many times, students' invented approaches are based on a sound understanding of numbers and operations, and these invented approaches often can be used with efficiency and accuracy. (Principles and Standards for School Mathematics, NCTM, 2000)

The definition of computation is finding the standard representation for a number. For example, 6 + 6, 4 x 3, 17 – 5, and 24 ÷ 2 are all representations for the standard representation of 12. **Mental math** is mentally finding the standard representation for a number – calculating in your head instead of calculating using paper and pencil or technology. One of the main reasons for teaching mental math is to help students determine if a computed/calculated answer is reasonable; in other words, using mental math to estimate to see if the answer makes sense. Students develop mental math skills easier when they are taught specific strategies. Mental math strategies include counting on, doubling, repeated doubling, halving, making tens, multiplying by powers of tens, dividing with tens, thinking money, and using compatible "nice" numbers.

Mathematical models such as concrete objects, pictures, diagrams, Venn diagrams, number lines, hundred charts, base ten blocks, or factor trees are necessary for conceptual understanding and should be used to explain computational procedures. If a mathematical model can be used to represent the concept, the indicator in the Models benchmark is identified in the parentheses. For example, (2.4.K1a) refers to Standard 2 (Algebra), Benchmark 4 (Models), and Knowledge Indicator 1a (process models). Then, the indicator in the Models benchmark lists some of the mathematical models that could be used to teach the concept. In addition, each indicator in the Models benchmark is linked back to the other indicators. Those indicators are identified in the parentheses. For example, *process models* are linked to 1.1.K3, 1.2.K6, 1.3.K1, … with 1.1.K3 referring to Standard 1 (Number and Computation), Benchmark 1 (Number Sense), and Knowledge Indicator 3.

Technology is changing mathematics and its uses. The use of technology including calculators and computers is an important part of growing up in a complex society. It is not only necessary to estimate appropriate answers accurately when required, but also it is also important to have a good understanding of the underlying concepts in order to know when to apply the appropriate procedure. Technology does not replace the need to learn basic facts, to compute mentally, or to do reasonable paper-and-pencil computation. However, dividing a 5-digit number by a 2-digit number is appropriate with the exception of dividing by 10, 100, or 1,000 and simple multiples of each.

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Standard 2: Algebra – The student uses algebraic concepts and procedures in a variety of situations.

Benchmark 1: Patterns – The student recognizes, describes, extends, develops, and explains the general rule of a pattern in variety of situations.

Sixth Grade Knowledge Base Indicators

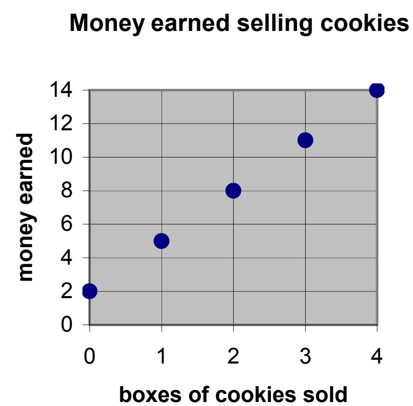
The student…

1. identifies, states, and continues a pattern presented in various formats including numeric (list or table), visual (picture, table, or graph), verbal (oral description), kinesthetic (action), and written using these **attributes** include:
   a. counting numbers including perfect squares, and factors and multiples (number theory) (2.4.K1a);
   b. positive rational numbers limited to two operations (addition, subtraction, multiplication, division) including arithmetic sequences (a sequence of numbers in which the difference of two consecutive numbers is the same) (2.4.K1a);
   c. geometric figures through two attribute changes (2.4.K1g);
   d. measurements (2.4.K1a);
   e. things related to daily life (2.4.K1a) **($)**, e.g., time (a full moon every 28 days), tide, calendar, traffic, or appropriate topics across the curriculum.
2. generates a pattern (repeating, growing) (2.4.K1a).
3. extends a pattern when given a rule of one or two simultaneous operational changes (addition, subtraction, multiplication, division) between consecutive terms (2.4.K1a), e.g., find the next three numbers in a pattern that starts with 3, where you double and add 1 to get the next number; the next three numbers are 7, 15, and 31.
4. ▲ states the rule to find the next number of a pattern with one operational change (addition, subtraction, multiplication, division) to move between consecutive terms (2.4.K1a), e.g., given 4, 8, and 16, double the number to get the next term, multiply the term by 2 to get the next term, or add the number to itself for the next term.

Sixth Grade Application Indicators

The student…

1. recognizes the same general pattern presented in different representations [numeric (list or table), visual (picture, table, or graph), and written] (2.4.A1a,k), e.g., you are selling cookies by the box. Each box costs $3. You have $2 to begin your sales. This can be written as a pattern that begins with 2 and adds three each time, as a table or graph.



X	Y
0	2
2	8
3	11
4	14

2. recognizes multiple representations of the same pattern (2.4.A1a) **($)**, e.g., 1, 10; 100; 1,000; 10,000…
   – represented as 1; 10; 10 x 10; 10 x 10 x 10; 10 x 10 x 10 x 10; …;
   – represented as $10^{0;}$ 10^1; 10^2; 10^3; 10^4; …;
   – represented as a unit; a rod; a flat; a cube; … using base ten blocks; or
   – represented as a $1 bill; a $10 bill; a $100 bill ; a $1,000 bill; ….

▲– Assessed Indicator on the Objective Assessment
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THESE STANDARDS ARE ALIGNED ONLY TO THE ASSESSMENTS THAT WILL BEGIN DURING THE 2005-06 SCHOOL YEAR.

Teacher Notes: A fundamental component in the development of classification, number, and problem solving skills is inventing, discovering, and describing patterns. Patterns pervade all of mathematics and much of nature. All **patterns** are either repeating or growing or a variation of either or both. Translating a pattern from one medium to another to find two patterns that are alike, even though they are made with different materials, is important so students can see the relationships that are critical to repeating patterns. With growing patterns, students not only extend patterns, but also look for a generalization or an algebraic relationship that will tell them what the pattern will be at any point along the way.

Working with **patterns** is an important process in the development of mathematical thinking. Patterns can be based on geometric attributes (shapes, regions, angles); measurement attributes (color, texture, length, weight, volume, number); relational attributes (proportion, sequence, functions); and affective attributes (values, likes, dislikes, familiarity, heritage, culture). (Learning to Teach Mathematics, Randall J. Souviney, Macmillan Publishing Company, 1994)

This process (working with patterns) can be used to develop or deepen understandings of important concepts in number theory, rational numbers, measurement, geometry, probability, and functions. Working with patterns provides opportunities for students to recognize, describe, extend, develop, and explain.

Number theory is the study of the properties of the counting numbers (positive integers), their relationships, ways to represent them, and patterns among them. Number theory includes the concepts of odd and even numbers, factors and multiples, primes and composites, greatest common factor and least common multiple, and sequences.

Mathematical models such as concrete objects, pictures, diagrams, number lines, unifix cubes, hundred charts, or base ten blocks are necessary for conceptual understanding and should be used to explain computational procedures. If a mathematical model can be used to represent the concept, the indicator in the Models benchmark is identified in the parentheses. For example, (2.4.K1a) refers to Standard 2 (Algebra), Benchmark 4 (Models), and Knowledge Indicator 1a (process models). Then, the indicator in the Models benchmark lists some of the mathematical models that could be used to teach the concept. In addition, each indicator in the Models benchmark is linked back to the other indicators. Those indicators are identified in the parentheses. For example, *process models* are linked to 1.1.K3, 1.2.K6, 1.3.K1, … with 1.1.K3 referring to Standard 1 (Number and Computation), Benchmark 1 (Number Sense), and Knowledge Indicator 3.

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Standard 2: Algebra – The student uses algebraic concepts and procedures in a variety of situations.

Benchmark 2: Variables, Equations, and Inequalities – The student uses variables, symbols, positive rational numbers, and algebraic expressions in one variable to solve linear equations and inequalities in a variety of situations.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. explains and uses variables and/or symbols to represent unknown quantities and variable relationships (2.4.K1a), e.g., x < 2. 2. uses equivalent representations for the same simple algebraic expression with understood coefficients of 1 (2.4.K1a), e.g., when students are developing their own formula for the perimeter of a square they combine s + s + s + s to make 4s. 3. solves (2.4.K1a,e) **($)**: a. one-step linear equations (addition, subtraction, multiplication, division) with one variable and whole number solutions, e.g., 2 x = 8 or x + 7 = 12 b. one-step linear inequalities(addition, subtraction) in one variable with whole numbers, e.g., x – 5 < 12; 4. explains and uses equality and inequality symbols (=, ≠, <, ≤, >, ≥) and corresponding meanings (is equal to, is not equal to, is less than, is less than or equal to, is greater than, is greater than or equal to) to represent mathematical relationships with positive rational numbers (2.4.K1a-b) **($)**. 5. knows and uses the relationship between ratios, proportions, and percents and finds the missing term in simple proportions where the missing term is a whole number (2.4.K1a,c), e.g., $\frac{1}{2} = \frac{x}{4}$, $\frac{2}{3} = \frac{4}{x}$, $\frac{1}{4} = \frac{x}{100}$. 6. finds the value of algebraic expressions using whole numbers (2.4.Ka), e.g., If x =3, then 5x = 5(3).	The student… 1. represents real-world problems using variables and symbols to (2.4.A1a,e) **($)**: a. write algebraic or numerical expressions or one-step equations (addition, subtraction, multiplication, division) with whole number solutions, e.g., John has three times as much money as his sister. If M is the amount of money his sister has, what is the expression that represents the amount of money that John has? The expression would be written as 3M. b. ▲ ■ write and/or solve one-step equations (addition, subtraction, multiplication, and division), e.g., a player scored three more points today than yesterday. Today, the player scored 17 points. How many points were scored yesterday? Write an equation to represent this problem. Let Y = number of points scored yesterday. The equation would be written as y + 3 = 17. The answer is y = 14. 2. generates real-world problems that represent simple expressions or one-step linear equations (addition, subtraction, multiplication, division) with whole number solutions (2.2.A1a,e), **($)** e.g., write a problem situation that represents the expression x + 10. The problem could be: How old will a person be ten years from now if x represents the person's current age? 3. explains the mathematical reasoning that was used to solve a real-world problem using a one-step equation (addition, subtraction, multiplication, division) (2.2.A1a,e) **($)**, e.g., use the equation form y + 3 = 17. Solve by subtracting 3 from both sides to get y = 14.

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Teacher Notes: Understanding the **concept of variable** is fundamental to algebra. Students use various symbols, including letters and geometric shapes to represent unknown quantities that both do and do not vary. Quantities that are not given and do not vary are often referred to as unknowns or missing elements when they appear in equations, e.g., 2 + 4 = Δ or 3 • s = 15 where a triangle and s are used as variables. Various symbols or letters should be used interchangeably in equations.

Mathematical models such as concrete objects, pictures, diagrams, number lines, unifix cubes, hundred charts, or base ten blocks are necessary for conceptual understanding and should be used to explain computational procedures. If a mathematical model can be used to represent the concept, the indicator in the Models benchmark is identified in the parentheses. For example, (2.4.K1a) refers to Standard 2 (Algebra), Benchmark 4 (Models), and Knowledge Indicator 1a (process models). Then, the indicator in the Models benchmark lists some of the mathematical models that could be used to teach the concept. In addition, each indicator in the Models benchmark is linked back to the other indicators. Those indicators are identified in the parentheses. For example, *process models* are linked to 1.1.K3, 1.2.K6, 1.3.K1, … with 1.1.K3 referring to Standard 1 (Number and Computation), Benchmark 1 (Number Sense), and Knowledge Indicator 3.

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Standard 2: Algebra – The student uses algebraic concepts and procedures in a variety of situations.

Benchmark 3: Functions – The student recognizes, describes, and analyzes linear relationships in a variety of situations.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. recognizes linear relationships using various methods including mental math, paper and pencil, concrete objects, and graphing utilities or appropriate technology (2.4.K1a). 2. finds the values and determines the rule with one operation using a function table (input/output machine, T-table) (2.4.K1f). 3. generalizes numerical patterns up to two operations by stating the rule using words (2.4.K1a), e.g., If the sequence is 2400, 1200, 600, 300, 150, …, what is the rule? In words, the rule could be split the previous number in half or divide the previous number before by 2. 4. uses a given function table (input/output machine, T-table) to identify, plot, and label the ordered pairs using the four quadrants of a coordinate plane (2.4.K1a,f).	The student… 1. represents a variety of mathematical relationships using written and oral descriptions of the rule, tables, graphs, and when possible, symbolic notation (2.4.A1f,k) **($)**, e.g., linear patterns and graphs can be used to represent time and distance situations. Pretend you are in a car traveling from home at 50 miles per hour. Then, represent the n[th] term. 50n meaning 50 times the number of hours traveling equals the distance away from home. **<u>Time | Distance</u>** 0 | 0 1 | 50 2 | 100 . | . . | . . | . n | 50n 2. interprets and describes the mathematical relationships of numerical, tabular, and graphical representations (2.4.Alf,k).

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Teacher Notes: Functions are relationships or rules in which each member of one set is paired with one, and only one, member of another set (an ordered pair). The concept of function can be introduced using function machines. Any number put in the machine will be changed according to some rule. A record of inputs and corresponding outputs can be maintained in a two-column format. Function tables, input/output machines, and T-tables may be used interchangeably and serve the same purpose.

Function concepts should be developed from **growing patterns**. Each term in a number sequence is related to its position in the sequence – the functional relationship. The pattern – 4, 7, 10, 13, 16, 19, and so on – is an arithmetic sequence *with a difference of 3*. The pattern could be described as *add 3* meaning that 3 must be added to the previous term to find the next. This pattern is explained by using the recursive definition for a sequence. The recursive definition for a sequence is a statement or a set of statements that explains how each successive term in the sequence is obtained from the previous term(s).

In the pattern 1, 4, 9, 16, 25,.., 225; there is *no common difference.* This sequence is not arithmetic or geometric (no common ratio between geometric terms). Neither is it a combination of the two; however, there is a pattern and the missing terms between 25 and 225 can be found. To find the term value, square the number of the term. The next missing terms would be 36, 49, 64, 81, 100, 121, and 144. This pattern is explained by using the explicit formula for a sequence. The explicit formula for a sequence defines a rule for finding each term in the number sequence related to its position in the sequence. In other words, to find the term value, square the number of the term – the 5^{th} term is 5^2, the 8^{th} term is 8^2, …

Patterns themselves are not explicit or recursive. The *RULE* for the pattern can be expressed explicitly or recursively and *MOST* patterns can be explained using either format especially *IF* that pattern reflects either an arithmetic sequence or geometric sequence.

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Standard 2: Algebra – The student uses algebraic concepts and procedures in a variety of situations.

Benchmark 4: Models – The student generates and uses mathematical models to represent and justify mathematical relationships in a variety of situations.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. knows, explains, and uses mathematical models to represent mathematical concepts, procedures, and relationships. Mathematical models include: a. process models (concrete objects, pictures, diagrams, number lines, hundred charts, measurement tools, multiplication arrays, division sets, or coordinate planes/grids) to model computational procedures and mathematical relationships and to solve equations (1.1.K1-5, 1.2.K1, 1.3.K1-4, 1.4.K1, 1.4.K2a, 1.4.K2c-e, 1.4.K2g, 1.4.K2i, 1.4.K6, 2.1.K1a-b, 2.1.K1d-e, 2.1.K2-4, 2.2.K1-6, 2.3.K1, 2.3.K3-4, 3.2.K1-4, 3.2.K8, 3.3.K1-4, 3.4.K1-3, 4.2.K4) **($)**; b. place value models (place value mats, hundred charts, base ten blocks, or unifix cubes) to compare, order, and represent numerical quantities and to model computational procedures (1.1.K1-4, 1.2.K1, 1.3.K1-3, 1.4.K2b, 1.4.K2c-d, 2.2K4) **($)**; c. fraction and mixed number models (fraction strips or pattern blocks) and decimal and money models (base ten blocks or coins) to compare, order, and represent numerical quantities (1.1.K1-4, 1.2.K1, 1.3.K1-3, 1.4.K2b, 1.4.K2d, 1.4.K2f, 1.4.K6, 2.2.K5, 4.1.K4, 4.2.K4) **($)**: d. factor trees to find least common multiple and greatest common factor (1.4.K4-5); e. equations and inequalities to model numerical relationships (2.2.K3,) **($)**; f. function tables (input/output machines, T-tables) to model numerical and algebraic relationships (2.3.K2, 2.3.K4) **($)**;	The student… 1. recognizes that various mathematical models can be used to represent the same problem situation. Mathematical models include: a. process models (concrete objects, pictures, diagrams, number lines, hundred charts, measurement tools, multiplication arrays, division sets, or coordinate planes/grids) to model computational procedures and mathematical relationships, to represent problem situations, and to solve equations (1.1.A1, 1.1.A1a, 1.2.A1-2, 1.3.A1-4, 1.4.A1a-b, 2.1.A1-2, 2.1.A1-3, 3.2.A1a, 3.2.A1c, 3.2.A2, 3.3.A1-2, 3.4.A1-2, 4.2.A1) **($)**; b. place value models (place value mats, hundred charts, base ten blocks, or unifix cubes) to model problem situations (1.1.A1, 1.2.A1-2, 2.2.A3) **($)**; c. fraction and mixed number models (fraction strips or pattern blocks) and decimal and money models (base ten blocks or coins) to compare, order, and represent numerical quantities (1.1.A1, 1.1.A2b-c, 1.2.A1-2, 1.4.A1b-c) **($)**; d. factor trees to find least common multiple and greatest common factor; e. equations and inequalities to model numerical relationships (2.2.A1-3) **($)**; f. function tables (input/output machines, T-tables) to model numerical and algebraic relationships (2.3.A1-2) **($)**; g. two-dimensional geometric models (geoboards or dot paper) to model perimeter, area, and properties of geometric shapes and three-dimensional geometric models (nets or solids) and real-world objects to model volume and to identify attributes (faces, edges, vertices, bases) of geometric shapes (3.1.A1-3. 3.2.A1b, 3.4.A2);

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g. two-dimensional geometric models (geoboards or dot paper) to model perimeter, area, and properties of geometric shapes and three-dimensional geometric models (nets or solids) and real-world objects to model volume and to identify attributes (faces, edges, vertices, bases) of geometric shapes (2.1.K1c, 3.1.K1-5, 3.1.K7-10, 3.2.K7, 3.3.K1-4); h. tree diagrams to organize attributes and determine the number of possible combinations (4.1.K2); i. graphs using concrete objects, two- and three-dimensional geometric models (spinners or number cubes) and process models (concrete objects, pictures, diagrams, or coins) to model probability (4.1.K1-4) **($)**. j. frequency tables, bar graphs, line graphs, circle graphs, Venn diagrams, line plots, charts, tables, single stem-and-leaf plots, and scatter plots to organize and display data (4.2.K1-3) **($)**; k. Venn diagrams to sort data and to show relationships (1.2.K1). 2. uses one or more mathematical models to show the relationship between two or more things.	h. scale drawings to model large and small real-world objects (3.4.A2); i. tree diagrams to organize attributes and determine the number of possible combinations; j. two- and three-dimensional geometric models (spinners or number cubes) and process models (concrete objects, pictures, diagrams, or coins) to model probability (4.1.A1-3) **($)**; k. graphs using concrete objects, frequency tables, bar graphs, line graphs, circle graphs, Venn diagrams, line plots, charts, tables, and single stem-and-leaf plots to organize, display, explain, and interpret data (2.1.A1, 2.3.A1-2, 4.1.A1-2, 4.2.A1-3) **($)**; l. Venn diagrams to sort data and to show relationships. 2. selects a mathematical model and justifies why some mathematical models are more accurate than other mathematical models in certain situations.

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Teacher Notes: For assessment purposes, the mathematical modeling process appropriate to the indicator may be included as part of the item being assessed.

The **mathematical modeling** process involves:

a. selecting key features and relationships within the real-world situation and representing these concepts in mathematical terms through some sort of mathematical model,
b. performing manipulations and mathematical procedures within the mathematical model,
c. interpreting the results of the manipulations within the mathematical model,
d. using these results to make inferences about the original real-world situation.

The use of **mathematical models** is necessary for conceptual understanding. The ways in which mathematical ideas are represented is fundamental to how students understand and use those ideas. As students begin to use multiple representations of the same situation, they begin to develop an understanding of the advantages and disadvantages of various representations/models.

Many **mathematical models** are listed in this benchmark. The indicator lists some of the mathematical models that could be used to teach a concept. Each indicator in this benchmark is linked to other indicators in other benchmarks; those indicators are identified in the parentheses. For example, *process models* are linked to 1.1.K3, 1.2.K6, 1.3.K1, … with 1.1.K3 referring to Standard 1 (Number and Computation), Benchmark 1 (Number Sense), and Knowledge Indicator 3. In addition, the indicator in the other benchmarks identifies, in parentheses, the Models' indicator. For example, (2.4.K1a) refers to Standard 2 (Algebra), Benchmark 4 (Models), and Knowledge Indicator 1a (process models).

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Standard 3: Geometry – The student uses geometric concepts and procedures in a variety of situations.

Benchmark 1: Geometric Figures and Their Properties – The student recognizes geometric figures and compares their properties in a variety of situations.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. recognizes and compares properties of plane figures and solids using concrete objects, constructions, drawings, and appropriate technology (2.4.K1g). 2. recognizes and names regular and irregular polygons through 10 sides including all special types of quadrilaterals: squares, rectangles, parallelograms, rhombi, trapezoids, kites (2.4.K1g). 3. names and describes the solids [prisms (rectangular and triangular), cylinders, cones, spheres, and pyramids (rectangular and triangular)] using the terms faces, edges, vertices, and bases (2.4.K1g). 4. recognizes all existing lines of symmetry in two-dimensional figures (2.4.K1g). 5. recognizes and describes the attributes of similar and congruent figures (2.4.K1g). 6. recognizes and uses symbols for angle (find symbol for), line(↔), line segment (—), ray (→), parallel (||), and perpendicular (⊥). 7. ▲ classifies (2.4.K1g): a. angles as right, obtuse, acute, or straight; b. triangles as right, obtuse, acute, scalene, isosceles, or equilateral. 8. identifies and defines circumference, radius, and diameter of circles and semicircles. 9. recognize that the sum of the angles of a triangle equals 180° (2.4.K1g). 10. determines the radius or diameter of a circle given one or the other.	The student… 1. solves real-world problems by applying the properties of (2.4.A1g): a. plane figures (regular polygons through 10 sides, circles, and semicircles) and the line(s) of symmetry, e.g., twins are having a birthday party. The rectangular birthday cake is to be cut into two equal sizes of the same shape. How would you cut the cake? b. solids (cubes, rectangular prisms, cylinders, cones, spheres, triangular prisms) emphasizing faces, edges, vertices, and bases, e.g., lace is to be glued on all of the edges of a cube. If one edge measures 34 cm, how much lace is needed? c. intersecting, parallel, and perpendicular lines, e.g., railroad tracks form what type of lines? Two roads are perpendicular, what is the angle between them? 2. decomposes geometric figures made from (2.4.A1g): a. regular and irregular polygons through 10 sides, circles, and semicircles, e.g., draw a picture of a house (rectangular base) with a roof (triangle) and a chimney on the side of the roof (trapezoid). Identify the three geometrical figures. b. nets (two-dimensional shapes that can be folded into three-dimensional figures), e.g., the cardboard net that becomes a shoebox. 3. composes geometric figures made from (2.4.A1g): a. regular and irregular polygons through 10 sides, circles, and semicircles; b. nets (two-dimensional shapes that can be folded into three-dimensional figures).

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Teacher Notes: Geometry is the study of shapes, their properties, and their relationships to other shapes. Symbols and numbers are used to describe their properties and their relationships to other shapes. The fundamental concepts in geometry are point (no dimension), line (one-dimensional), plane (two-dimensional), and space (three-dimensional). Plane figures are referred to as two-dimensional. Solids are referred to as three-dimensional. The base, in terms of geometry, generally refers to the side on which a figure rests. Therefore, depending on the orientation of the solid, the base changes.

From the Mathematics Dictionary and Handbook (Nichols Schwartz Publishing, 1999), **property** as a mathematical term means a characteristic (an attribute) of a number, geometric shape, mathematical operation, equation, or inequality. To give an example:

- Property of a number: 8 is divisible by 2.
- Property of a geometric shape: Each of the four sides of a square is of the same length.
- Property of an operation: Addition is commutative. For all numbers x and y, $x + y = y + x$.
- Property of an equation: For all numbers a, b, and c, if $a = b$, then $a + c = b + c$.
- Property of an inequality: For all numbers a, b, and c, if $a > b$, then $a – c > b – c$.

The application of the Knowledge Indicators from the Geometry Benchmark, Geometric Figures and Their Properties are most often applied within the context of the other Geometry Benchmarks — Measurement and Estimation, Transformational Geometry, and Geometry From an Algebraic Perspective — rather than in isolation.

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Standard 3: Geometry – The student uses geometric concepts and procedures in a variety of situations.

Benchmark 2: Measurement and Estimation – The student estimates, measures, and uses measurement formulas in a variety of situations.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. determines and uses whole number approximations (estimations) for length, width, weight, volume, temperature, time, perimeter, and area using standard and nonstandard units of measure (2.4.K1a) **($)**. 2. selects, explains the selection of, and uses measurement tools, units of measure, and level of precision appropriate for a given situation to find accurate rational number representations for length, weight, volume, temperature, time, perimeter, area, and angle measurements (2.4.K1a) **($)**. 3. converts (2.4.K1a): a. within the customary system, e.g., converting feet to inches, inches to feet, gallons to pints, pints to gallons, ounces to pounds, or pounds to ounces; b. ▲ within the metric system using the prefixes: kilo, hecto, deka, deci, centi, and milli; e.g., converting millimeters to meters, meters to millimeters, liters to kiloliters, kiloliters to liters, milligrams to grams, or grams to milligrams. 4. uses customary units of measure to the nearest sixteenth of an inch and metric units of measure to the nearest millimeter (2.4.K1a). 5. recognizes and states perimeter and area formulas for squares, rectangles, and triangles (2.4.K1g). a. uses given measurement formulas to find perimeter and area of: squares and rectangles, b. figures derived from squares and/or rectangles. 6. describes the composition of the metric system (2.4.K1a): a. meter, liter, and gram (root measures); b. kilo, hecto, deka, deci, centi, and milli (prefixes). 7. finds the volume of rectangular prisms using concrete objects (2.4.K1g). 8. estimates an approximate value of the irrational number pi (2.4.K1a).	The student… 1. solves real-world problems by applying these measurement formulas **($)**: a. ▲ perimeter of polygons using the same unit of measurement (2.4.A1a,g), e.g., measures the length of fence around a yard; b. ▲ ■ area of squares, rectangles, and triangles using the same unit of measurement (2.4.A1g), e.g., finds the area of a room for carpeting; c. conversions within the metric system (2.4.A1a), e.g., your school is having a balloon launch. Each student needs 40 centimeters of string, and there are 42 students. How many meters of string are needed? 2. estimates to check whether or not measurements and calculations for length, width, weight, volume, temperature, time, perimeter, and area in real-world problems are reasonable and adjusts original measurement or estimation based on additional information (a frame of reference) (2.4.A1a) **($)**, e.g., students estimate, in feet, the height of a bookcase in their classroom. Then a student who is about 5 feet tall stands beside it. The students then adjust the estimate.

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Teacher Notes: The term *geometry* comes from two Greek words meaning "earth measure." **Measurement** provides the tools required to apply geometric concepts in the real-world. **Estimation in measurement** is defined as making guesses as to the exact measurement of an object without using any type of measurement tool. Estimation helps students develop a relationship between the different sizes of units of measure. It helps students develop basic properties of measurement and it gives students a tool to determine whether a given measurement is reasonable.

Using concrete objects (mathematical models) to conduct experiments to compare the circumference and the radius/diameter of a circle is important in developing students' understanding of pi, its approximate value, and the circumference formula. The circumference formula will be emphasized in the seventh grade.

Mathematical models such as concrete objects, pictures, diagrams, number lines, unifix cubes, hundred charts, or base ten blocks are necessary for conceptual understanding and should be used to explain computational procedures. If a mathematical model can be used to represent the concept, the indicator in the Models benchmark is identified in the parentheses. For example, (2.4.K1a) refers to Standard 2 (Algebra), Benchmark 4 (Models), and Knowledge Indicator 1a (process models). Then, the indicator in the Models benchmark lists some of the mathematical models that could be used to teach the concept. In addition, each indicator in the Models benchmark is linked back to the other indicators. Those indicators are identified in the parentheses. For example, *process models* are linked to 1.1.K3, 1.2.K6, 1.3.K1, … with 1.1.K3 referring to Standard 1 (Number and Computation), Benchmark 1 (Number Sense), and Knowledge Indicator 3.

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Standard 3: Geometry – The student uses geometric concepts and procedures in a variety of situations.

Benchmark 3: Transformational Geometry – The student recognizes and performs transformations on two- and three-dimensional geometric figures in a variety of situations.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. ▲ ■ identifies, describes, and performs one or two transformations (reflection, rotation, translation) on a two-dimensional figure (2.4.K1a). 2. reduces (contracts/shrinks) and enlarges (magnifies/grows) simple shapes with simple scale factors (2.4.K1a), e.g., tripling or halving. 3. recognizes three-dimensional figures from various perspectives (top, bottom, sides, corners) (2.4.K1a). 4. recognizes which figures will tessellate (2.4.K1a).	The student… 1. describes a transformation of a given two-dimensional figure that moves it from its initial placement (preimage) to its final placement (image) (2.4.A1a). 2. makes a scale drawing of a two-dimensional figure using a simple scale (2.4.A1a), e.g., using the scale 1 cm = 30 m, the student makes a scale drawing of the school.

Teacher Notes: Transformational geometry is another way to investigate and interpret geometric figures by moving every point in a plane figure to a new location. To help students form images of shapes through different transformations, students can use concrete objects, figures drawn on graph paper, mirrors or other reflective surfaces, or appropriate technology. Some **transformations**, like translations, reflections, and rotations, do not change the figure itself. Other transformations like reduction (contraction/shrinking) or enlargement (magnification/growing) change the size of a figure, but not the shape (congruence vs. similarity).

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Standard 3: Geometry – The student uses geometric concepts and procedures in a variety of situations.

Benchmark 4: Geometry From An Algebraic Perspective – The student relates geometric concepts to a number line and a coordinate plane in a variety of situations.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. uses a number line (horizontal/vertical) to order integers and positive rational numbers (in both fractional and decimal form) (2.4.K1a). 2. organizes integer data using a T-table and plots the ordered pairs in all four quadrants of a coordinate plane (coordinate grid) (2.4.K1a). 3. ▲ uses all four quadrants of the coordinate plane to (2.4.K1a): a. identify the ordered pairs of integer values on a given graph; b. plot the ordered pairs of integer values.	The student… 1. represents, generates, and/or solves real-world problems using a number line with integer values (2.4.A1a) **($)**, e.g., the difference between $^-2$ degrees and 10 degrees on a thermometer is 12 degrees (units); similarly, the distance between $^-2$ to $^+10$ on a number line is 12 units. 2. represents and/or generates real-world problems using a coordinate plane with integer values to find (2.4.A1a,g-h): a. the perimeter of squares and rectangles, e.g., Alice made a scale drawing of her classroom and put it on a coordinate plane marked off in feet. The rectangular table in the back of the room was described by the points (8,9), (8,12), (14,12) and (14,9). Now Alice wants to put a skirting around the outer edge of the table. Using the drawing, find the amount of skirting she will need. b. the area of triangles, squares, and rectangles, e.g., a scale drawing of a flower garden is found in a book with the coordinates of the four corners being (9,5), (9,13), (18,13) and (18,5). The scale is marked off in meters. How many square meters is the flower garden?

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Teacher Notes: A **number line** (a mathematical model) is a diagram that represents numbers with equal distances marked off as points on a line, and is an example of one-to-one correspondence (a relation). A number line can be used as a visual representation of numbers and operations. In addition, a number line used horizontally and vertically is a precursor to the coordinate plane; and the distance between two numbers on a number line is a precursor to absolute value.

A **coordinate plane** (coordinate grid) consists of a horizontal number line called the *x*-axis and a vertical number line called the *y*-axis. These two lines intersect at a point called the origin. The x-axis and the y-axis divide the plane into four sections called quadrants. Any point on the coordinate plane can be named with two numbers called coordinates. The first number is the x-coordinate. The second number is the y-coordinate. Since the pair is always named in order (first x, then y), it is called an ordered pair.

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Standard 4: Data – The student uses concepts and procedures of data analysis in a variety of situations.

Benchmark 1: Probability – The student applies the concepts of probability to draw conclusions and to make predictions and decisions including the use of concrete objects in a variety of situations.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. recognizes that all probabilities range from zero (impossible) through one (certain) and can be written as a fraction, decimal, or a percent (2.4.K1i) **($)** , e.g., when you flip a coin, the probability of the coin landing on heads (or tails) is ½, .5, or 50%. The probability of flipping a head on a two-headed coin is 1. The probability of flipping a tail on a two-headed coin is 0. 2. ▲ ■ lists all possible outcomes of an experiment or simulation with a compound event composed of two independent events in a clear and organized way (2.4.K1h-j), e.g., use a tree diagram or list to find all the possible color combinations of pant and shirt ensembles, if there are 3 shirts (red, green, blue) and 2 pairs of pants (black and brown). 3. recognizes whether an outcome in a compound event in an experiment or simulation is impossible, certain, likely, unlikely, or equally likely (2.4.K1i). 4. ▲ represents the probability of a simple event in an experiment or simulation using fractions and decimals (2.4.K1c,i), e.g., the probability of rolling an even number on a single number cube is represented by ½ or .5.	The student… 1. conducts an experiment or simulation with a compound event composed of two independent events including the use of concrete objects; records the results in a chart, table, or graph; and uses the results to draw conclusions about the events and make predictions about future events (2.4.A1j-k). 2. analyzes the results of a given experiment or simulation of a compound event composed of two independent events to draw conclusions and make predictions in a variety of real-world situations (2.4.A1j-k), e.g., given the equal likelihood that a customer will order a pizza with either thick or thin crust, and an equal probability that a single topping of beef, pepperoni, or sausage will be selected – 1) What is the probability that a pizza ordered will be thin crust with beef topping? 2) Given sales of 30 pizzas on a Friday night, how many would the manager expect to be thin crust with beef topping? 3. compares what should happen (theoretical probability/expected results) with what did happen (empirical probability/experimental results) in an experiment or simulation with a compound event composed of two independent events (2.4.A1j).

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Teacher Notes: Ideas from **probability** reinforce concepts in the other Standards, especially Number and Computation and Geometry. Students need to develop an intuitive concept of chance – whether or not something is unlikely or likely to happen. Probability experiences should be addressed through the use of concrete objects (process models); spinners, number cubes, or dartboards (geometric models); and coins (money models). Probabilities are ratios, expressed as fractions, decimals, or percents, determined by considering results or outcomes of experiments. Some examples of uses of probability in every day life include: There is a 50% chance of rain today. What is the probability that the team will win every game?

Mathematical models such as concrete objects, pictures, diagrams, number lines, unifix cubes, hundred charts, or base ten blocks are necessary for conceptual understanding and should be used to explain computational procedures. If a mathematical model can be used to represent the concept, the indicator in the Models benchmark is identified in the parentheses. For example, (2.4.K1a) refers to Standard 2 (Algebra), Benchmark 4 (Models), and Knowledge Indicator 1a (process models). Then, the indicator in the Models benchmark lists some of the mathematical models that could be used to teach the concept. In addition, each indicator in the Models benchmark is linked back to the other indicators. Those indicators are identified in the parentheses. For example, *process models* are linked to 1.1.K3, 1.2.K6, 1.3.K1, … with 1.1.K3 referring to Standard 1 (Number and Computation), Benchmark 1 (Number Sense), and Knowledge Indicator 3.

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Standard 4: Data – The student uses concepts and procedures of data analysis in a variety of situations.

Benchmark 2: Statistics – The student collects, organizes, displays, and explains numerical (rational numbers) and non-numerical data sets in a variety of situations with a special emphasis on measures of central tendency.

Sixth Grade Knowledge Base Indicators	Sixth Grade Application Indicators
The student… 1. organizes, displays, and reads quantitative (numerical) and qualitative (non-numerical) data in a clear, organized, and accurate manner including a title, labels, categories, and rational number intervals using these **data displays** (2.4.K1j) **($)**: a. graphs using concrete objects; b. frequency tables and line plots; c. bar, line, and circle graphs; d. Venn diagrams or other pictorial displays; e. charts and tables; f. single stem-and-leaf plots; g. scatter plots; 2. selects and justifies the choice of data collection techniques (observations, surveys, or interviews) and sampling techniques (random sampling, samples of convenience, or purposeful sampling) in a given situation (2.4.K1j). 3. uses sampling to collect data and describe the results (2.4.K1j) **($).** 4. determines mean, median, mode, and range for (2.4.K1a,c) **($)**: a. a whole number data set, b. a decimal data set with decimals greater than or equal to zero.	The student… 1. uses data analysis (mean, median, mode, range) of a whole number data set or a decimal data set with decimals greater than or equal to zero to make reasonable inferences, predictions, and decisions and to develop convincing arguments from these **data displays** (2.4.A1k) **($)**: a. graphs using concrete objects; b. frequency tables and line plots; c. bar, line, and circle graphs; d. Venn diagrams or other pictorial displays; e. charts and tables; f. single stem-and-leaf plots. 2. explains advantages and disadvantages of various data displays for a given data set (2.4.A1k) **($).** 3. recognizes and explains the effects of scale and/or interval changes on graphs of whole number data sets (2.4.A1k).

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Teacher Notes: Graphs (data displays) are pictorial representations of mathematical relationships, are used to tell a story, and are an important part of statistics. When a graph is made, the axes and the scale (numbers running along a side of the graph) are chosen for a reason. The difference between numbers from one grid line to another is the **interval.** The interval will depend on the lowest and highest values in the data set. Emphasizing the importance of using equal-sized pictures or intervals is critical to ensuring that the data display is accurate.

Graphs take many forms:
– bar graphs and pictographs compare discrete data,
– frequency tables show how many times a certain piece of data occurs,
– circle graphs (pie charts) model parts of a whole,
– line graphs show change over time,
– Venn diagrams show relationships between sets of objects,
– line plots show frequency of data on a number line,
– single stem-and-leaf plots (closely related to line plots except that the number line is usually vertical and digits are used rather than x's) show frequency distribution by arranging numbers (stems) on the left side of a vertical line with numbers (leaves) on the right side, and
– scatter plots show the relationship between two quantities.

An important aspect of data is its *center.* The **measures of central tendency** (averages) of a data set are mean, median, and mode. Conceptual understanding of mean, median, and mode is developed through the use of concrete objects that represent the data values.

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