



Core Knowledge[®] MATHEMATICS

Connecting Math to Our World: The Relevance of Math

Teacher Support



The Relevance of Math

Teacher Support



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The Relevance of Math Teacher Support

ABOUT THIS SERIES

Everyone uses math every day, but many people don't realize it! The Core Knowledge Connecting Math to Our World series underscores the ubiquity of math and encourages learners to “find the math” in familiar situations. When learners see situations where math skills are used to solve problems, they develop an understanding of why learning math skills is important. The instructional focus for this series is not on *practicing* math skills but on recognizing *where, when, and why* we use math.

Through both fiction and nonfiction readings, this series seeks to help learners see when and how math skills can be useful and increase their overall understanding of and interest in math. Students do not need to have achieved proficiency in specific skills to understand the importance of math. Mathematical thinking is a part of countless aspects of day-to-day life. Math appears throughout nature. Individuals, groups, and governments use math to plan and make decisions. Math is also embedded throughout creative endeavors—in poetry, music, visual art, and design. Math is integral to all sorts of discoveries. Math supports our understanding and appreciation of culture and helps us function as active and engaged citizens.

Each chapter tells a story or explores a situation in which a mathematical idea plays a role. It's important to note that these chapters are *not* intended to be a complete lesson. Instead, they can serve as a flexible resource throughout the school day and beyond.

- Because the chapters do not need to be read in order, you may wish to use a chapter to foster interest in a math idea before or after a skill is taught in your core math curriculum. Chapters are adaptable enough to be used in any situation, including enrichment or remediation, depending on the teacher's approach.
- These chapters can be used as a cross-curricular extension to support reading skills such as making inferences about content from the engaging images on the pages.
- This series is recommended to parents looking to enhance engagement with both reading and math at home.

No matter when or how you choose to use the readings or the order in which the chapters are read, introduce learners to the Student Reader with a reading of the invitation that appears on page 1.

MAKING THE MOST OF THE STUDENT READER

Preparing to use a chapter.

1. **Read the chapter's Teacher Support.** Reviewing the Teacher Support will alert you to the math connections and applications being made in the chapter, allowing you to better point them out when sharing the chapter with the class.
2. **Preview the chapter.** Identify where and how math is being used in the selection.
3. **Identify vocabulary for which students may need support.** This may include reviewing math vocabulary or providing context for non-math vocabulary.
4. **Determine activity pacing.** Depending on the depth of your question-and-answer facilitation with students during and after reading, any given chapter could take as little as 15 minutes or might be extended to 30 minutes or more.

MAKING THE MOST OF THE TEACHER SUPPORT

For each chapter, the Teacher Support pages provide several sections:

Chapter Identifier outlines where to locate the chapter in the Student Reader.

Chapter Summary provides a math-skill-centered overview of the chapter.

Math Connection describes how the math skill is used in real life.

Before Reading includes a reading prompt with strategies to help students identify how math is used in the selection.

After Reading contains questions teachers can use to reinforce the math skill as well as check for reading comprehension.

Emphasize the Main Idea suggests a student activity that reinforces the main math idea.

The *Core Knowledge Sequence* aligns with the Common Core State Standards for Mathematics, Grade 8. The following chart identifies the main math idea and the Core Knowledge Sequence Topic addressed in each chapter. You can use the chart to determine which chapters best match your curriculum throughout the year.

Chapter	Core Knowledge Sequence Topic
1. Why Do We Need Numbers? page 5	The Number System Humans have developed a number system that uses rational and irrational numbers to count, measure, compare, and understand quantities in the world.
2. Human Calculators, page 6	Mathematical Practices Some people are good at math because they practice math skills, know number patterns, and use smart strategies to solve problems.

3. A Slice of Pi, page 7	Geometry Pi is used to solve problems that involve circles and curves.
4. Famous Unsolved Problems, page 8	Mathematical Practices A math conjecture is an idea or statement that seems to be true but hasn't been proven yet.
5. Writing Large and Small Numbers, page 9	Expressions and Equations Scientific notation allows us to write and use very large or very small quantities.
6. Pick a Plan! page 10	Expressions and Equations Using a graph of multiple equations can help you make decisions.
7. Math on the Big Screen, page 11	Expressions and Equations Solving linear equations helps us figure out answers when things depend on each other.
8. Ready for Liftoff, page 12	Expressions and Equations Linear equations let us turn real-world problems into math we can solve step-by-step.
9. Math Movement, page 13	Expressions and Equations Functions help us understand cause and effect, make predictions, and solve real-world problems.
10. How Old Am I? page 14	Expressions and Equations A function gives one output for each input and can be graphed.
11. My First Paycheck, page 15	Expressions and Equations A function makes it easier to determine outcomes in a clear and consistent way.
12. Transformations in Art, page 16	Geometry Changing a shape's position or size helps show its properties and relationships to other shapes.
13. Robin Hood and the Golden Arrow, page 17	Geometry People use angles and triangular relationships to solve problems.
14. The Mathematics of Billiards, page 18	Geometry Players use the mathematical law of reflection to predict and plan when playing games.
15. Art Perspectives, page 19	Geometry Geometric transformations like dilations and translations, along with concepts of parallel lines and perspective, create realistic 3D-looking images on flat surfaces.

16. Wind and Rain, page 20	Statistics and Probability Bivariate data analysis shows the relationship between two variables.
17. Statistics in Court, page 21	Statistics and Probability Using scatterplots lets us compare groups, find patterns, and make decisions based on data.
18. Statistics Used in Marketing, page 22	Statistics and Probability We use scatterplots and statistical analysis to look for relationships between variables.

CHAPTER 1: WHY DO WE NEED NUMBERS? STUDENT READER PAGE 2

Chapter Summary: This chapter explores why humans developed numbers and number systems. Math began as a simple way to record and communicate quantities. As societies grew more complex, so did the problems people needed to solve. Over time, math evolved to include categories such as rational and irrational numbers, whole numbers, and integers to better explain ideas.

Math Connection: Math was developed and has been used throughout time to help humans think about and solve real-world problems such as counting numbers of objects; adding, subtracting, and organizing quantities; measuring.

Before Reading: Point out the chapter title: “Why Do We Need Numbers?” Explain to students that the chapter describes the development of math over time. Remind them to pay special attention to how math was developed as the needs of people changed. Ask them to consider why and how math has become more complex over time.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- What kinds of math problems do you think that humans used the Ishango bone for? (*Sample answers: They could use the bone to do addition, subtraction, multiplication, and division. They might use it for keeping track of animals they caught or tracking lunar cycles.*)
- What problems could happen when using the bone? (*Sample answers: Some people might not understand what each group of notches meant. If there were a mistake in the carving, it couldn't be erased and could cause confusion. The bone could get lost or broken.*)
- How do you think this beginning of arithmetic helped support the first cities? (*Accept reasonable answers. Arithmetic gave people a way to keep records as amounts of things changed. Arithmetic helped people trade fairly. It gave people a language for numbers.*)
- Why do you think that people developed more complex types of numbers? (*Sample answers: Problems had gotten more complex. They needed zeros to represent when someone had nothing or negative numbers to show when something was owed. Fractions and rational numbers helped them be more precise when portioning things.*)

Emphasize the Main Idea.

Humans have developed a number system that uses rational and irrational numbers to count, measure, compare, and understand quantities in the world.

Challenge students to review a mathematical concept in their math book and brainstorm what type of real-world problem it was developed to solve. Or have them review social studies or science references and brainstorm math that may have been used to support the knowledge.

CHAPTER 2: HUMAN CALCULATORS, STUDENT READER PAGE 10

Chapter Summary: This expository article explains and analyzes the different ways math prodigies and mathematicians approach math problems. While prodigies are able to quickly complete problems similar to calculators and computers, mathematicians often use creativity and problem-solving to develop solutions.

Math Connection: Problems of all types can be solved by using creativity and drawing on known strategies. Practicing skills can help in solving future problems.

Before Reading: Point out the chapter title: “Human Calculators.” Explain to students that the chapter is about how math prodigies and mathematicians approach problem-solving. Remind them to pay special attention to how both groups approach solving math problems differently. Ask them to consider how the people described draw on their strengths to help them solve problems.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- Why do you think Miguel, Nimna, and Rodrigo are considered to be prodigies? What makes them similar to and different from those who aren’t prodigies? (*Accept all reasonable answers.*)
- What is different about how humans do math and how computers do math? (*Humans solve math problems step-by-step and can explain their thinking. Computers do things automatically and super-fast, but they don’t “think” about the problem like humans do.*)
- Why do you think that understanding the *why* behind math is more important than memorizing steps? (*If you understand the math principles, you can figure out different kinds of problems, even ones you haven’t seen before. Memorizing steps only works if the problems follow those same steps.*)
- How do the stories of these mathematicians show that understanding and reasoning are more important in math than just being quick at calculations? (*They all used creative thinking and new ideas to solve problems. They weren’t always the fastest, but they understood math deeply and found solutions others couldn’t.*)
- What is something all these mathematicians had in common that helped them succeed, even though they were all different? (*Sample answer: They all kept trying and used creative thinking instead of just doing math the usual way.*)

Emphasize the Main Idea.

Some people are good at math because they practice math skills, know number patterns, and use smart strategies to solve problems.

Have student pairs pick a math, social studies, or science problem or issue that seems tricky or hard to develop a solution for. Have them think about the big idea behind the problem, look for any ways it connects to something they are familiar with, and discuss different ways to solve it.

CHAPTER 3: A SLICE OF PI, STUDENT READER PAGE 18

Chapter Summary: This historical narrative describes the use of pi from over 4,000 years ago to the present. Over time, mathematicians have worked to better understand and refine their knowledge of pi. Because of their work, many different fields have applied this knowledge to design and develop and increase the safety of many things, like buildings and Ferris wheels.

Math Connection: Many professionals, including mechanical and civil engineers, architects and surveyors, and graphic and industrial designers, rely on pi to solve problems involving circles and curves.

Before Reading: Point out the chapter title: “A Slice of Pi.” Explain to students that the chapter is about how we use pi to solve problems. Remind them to pay special attention to how being more precise with pi has changed our understanding of math. Ask them to consider how things around us would be different if mathematicians hadn’t developed this greater precision of pi.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- Calculations are easier when numbers have fewer decimal places, so why would it be important to refine the calculation of pi to more and more decimal places? *(Using more decimal places makes measurements more precise. This helps make sure that parts fit together perfectly, especially in large or complex structures.)*
- How does understanding pi help engineers design safe and smooth-moving circular structures like roller coasters and Ferris wheels? *(Sample answer: Pi helps to accurately measure and work with circular parts of structures. This lets engineers design wheels that move smoothly, keep loads balanced, and operate safely.)*
- Why do you think pi is considered to be special enough to have its own day of celebration? *(Sample answers: It’s special because it helps us understand circles and is used in lots of math and science problems. Without it, we wouldn’t have so many interesting and safe buildings and structures. It’s also a never-ending number, which makes it really interesting and fun to celebrate.)*
- What types of buildings does knowing pi help in designing? How do you think it helps? *(Knowing pi helps in designing buildings with circular shapes like stadiums, domes, towers, and arches. It helps designers know that the curved parts fit together and are built accurately.)*

Emphasize the Main Idea.

Pi is used to solve problems that involve circles and curves.

Challenge students to go on a physical or virtual scavenger hunt to find examples of where we might use pi to solve a problem.

CHAPTER 4: FAMOUS UNSOLVED PROBLEMS, STUDENT READER PAGE 26

Chapter Summary: Students investigate conjectures, educated guesses about the solution to long-unsolved problems, as well as difficult problems that have been solved. Mathematicians must look for patterns, be creative, and be persistent even when they aren't able to prove their ideas.

Math Connection: Mathematicians use creativity and persistence to make sense of difficult problems and persevere in solving them.

Before Reading: Point out the chapter title: "Famous Unsolved Problems." Explain to students that the chapter describes how mathematicians use creativity and persistence to better understand numbers. Remind them to pay special attention to the personality traits that mathematicians show as they work on the problems. Ask them to consider how the mathematicians feel as they work to uncover the problems and to solve them.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- "Every even number greater than 2 can be calculated by adding 2 prime numbers" seems relatively simple to prove. What is simple about it, and what is hard? (*It is simple because it includes basic math ideas like adding and prime numbers. It is hard because there are so many options you can't complete all of them.*)
- How can math problems have solutions but still remain unsolved? (*Sample answers: Some math problems have solutions that we know must exist, but we don't yet know exactly what the solution is or how to find it. We may know some solutions, but we don't fully understand why they work or if we've found them all.*)
- Practice the Collatz conjecture or one of the other conjectures. What does this tell us about mathematicians and the traits they have? (*Sample answer: It tells us that they are curious and creative, they think outside the box, they enjoy problem-solving, and they are persistent.*)
- What does it show about math that mathematicians keep looking for new conjectures, ideas, and patterns? (*Sample answers: It shows that math is endless, that there are always questions to be asked and things to figure out. It shows that math is like a puzzle and can be exciting to solve. You can't give up if you want to know the final answer.*)

Emphasize the Main Idea.

A math conjecture is an idea or statement that seems to be true but hasn't been proven yet.

Show some non-math conjectures, such as the existence of life on other planets, Bigfoot and the Loch Ness Monster, or the disappearance of Amelia Earhart. Elicit students' thoughts on questions such as these: Why are these conjectures important to keep trying to prove? What would be needed to prove or disprove them? How does this connect to math?

CHAPTER 5: WRITING LARGE AND SMALL NUMBERS, STUDENT READER PAGE 34

Chapter Summary: Through real-world examples, students discover the usefulness of scientific notation. As people record very large and very small numbers, the numbers get harder to write without making errors. These numbers are also hard to compare and use in calculations when written in regular form.

Math Connection: Astronomers and physicists are just two types of professionals that use scientific notation to express very large and very small numbers. Chemists use scientific notation to express quantities like Avogadro's number. Geologists use it to represent time scales. Biologists express DNA molecule sizes. These professions and more use scientific notation to more clearly communicate and manipulate data.

Before Reading: Point out the chapter title: "Writing Large and Small Numbers." Explain to students that the chapter is about how scientific notation is used to help people to accurately work with and communicate very large and very small numbers. Remind them to pay special attention to the differences in how these large and small numbers are written.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- Can you think of situations when scientific notation is more useful and situations when it might be harder to use? (*Sample answer: Scientific notation is helpful when dealing with very large or very small numbers, like the distance between planets or the size of atoms. It can be harder to use with everyday numbers, like temperatures, pricing, and times, since those are usually easier to read in standard form.*)
- How would the calculation of how long it takes light from Alpha Centauri to reach Earth be more difficult if we didn't use scientific notation? (*Without scientific notation, the number would be harder to work with because it would have so many zeros. It would take longer to do the math, and it would be easy to make a mistake when writing or calculating with such big numbers.*)
- How does scientific notation make it easier to compare large numbers? (*It's easier to compare large numbers when you look at their powers. The number with the greater power is larger, and the one with the smaller power is smaller. This makes comparing numbers quick and simple.*)
- Why would scientists choose to use scientific notation to make a chart showing the mass of different particles? (*Sample answers: It's easier to compare the masses because you can quickly look at the powers. The chart keeps the data organized, which helps in comparing. It also helps the numbers be more easily understood.*)

Emphasize the Main Idea.

Scientific notation allows us to write and use very large or very small numbers.

Have students brainstorm careers that use scientific notation. Have them choose one career to investigate and report back on how using scientific notation is useful in that career.

CHAPTER 6: PICK A PLAN! STUDENT READER PAGE 42

Chapter Summary: This chapter follows Felipe and Jessie as they use linear equations to compare smartphone plans. They graph two linear equations representing cost over time for the two plans on the same grid. By pinpointing where the two lines cross, they determine when the costs of the plans are equal and which plan saves money in the long run.

Math Connection: Graphing linear equations in two variables can help business owners, engineers, financial planners, and others make real-life decisions such as when earnings and expenses break even, when labor and machine time are optimized, and when vehicles following two bus routes with different speeds and start times will intersect.

Before Reading: Point out the chapter title: “Pick a Plan!” Explain to students that the chapter is about how using linear equations can help when making real-life decisions. Remind them to pay special attention to how Felipe and Jessie use linear equations to determine when the plans will have cost the same and the long-term cost of both. Ask them to consider how the other variables that Felipe identified affect his final choice.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- Why does Jessie feel that representing the plan options in linear equations is the most helpful way to make a decision? *(Jessie thinks it is helpful because it makes the two plans easier to compare. When they put the numbers into equations and graph them, they can actually see when one plan becomes cheaper than the other. It provides data that ultimately helps them make a smart choice without guessing.)*
- What additional variables does Jessie help Felipe see that he needs to incorporate into his plan? How is this different from his original thinking? *(Jessie helps Felipe think about how much he'll spend over time, how much money he makes, and what else he needs to buy. At first, Felipe just wants to get the cheapest plan today, but Jessie helps him see he needs to consider other options.)*
- How does making a list of pros and cons help Felipe? *(It helps him think more carefully before making a big decision. He looks at the long term, not just what he wants right now. This helps him make a smart decision that fits his budget and future needs.)*
- Why do you think Felipe thinks waiting a few months is the best option right now? *(Sample answer: It gives him time to save more money and feel more confident about his choice. He doesn't want to spend all his savings at once and then not have enough for other things he might want in the future.)*

Emphasize the Main Idea.

Using a graph of multiple equations can help you make decisions.

Have students research different types of subscriptions, such as streaming services or gym memberships, and generate linear equations to compare their costs over time. Talk about how using these equations helps them identify the best deal for things they use every day.

CHAPTER 7: MATH ON THE BIG SCREEN, STUDENT READER PAGE 50

Chapter Summary: On the first day of her internship at Stellar Studios, Hannah learns some of the ways linear equations are used in different aspects of moviemaking. By solving various linear equations, moviemakers turn creative ideas into finished scenes on screen.

Math Connection: Animators and lighting designers use simple linear equations to determine how many animation cells are shown per second or where to place lights for the best effect on a set. Similar types of equations are used by engineers to determine load, cost of materials, circuit design, and speed of moving parts such as conveyor belts.

Before Reading: Point out the chapter title: “Math on the Big Screen.” Explain to students that the chapter is about how math, including geometry, ratios and proportions, and linear equations, is used in moviemaking. Remind them to Focus on how math helps creative ideas become real and believable on screen. Ask them to pay special attention to how linear equations help them produce the desired effects.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- How do lighting designers use geometry and linear equations to create the right mood on a set? *(In the story, the simplified version of the equation is $I = P/A$, where I is intensity of the light, P is power of the light source, and A is area that the light illuminates. It is used to determine the throw of each light and how it will affect the realism of the scene. Lighting designers use geometry to figure out the best angles so the light shines where it needs to, produces shadows, or highlights important things.)*
- What math skills are used by animators, and how do they use these skills? *(Animators use geometry to understand the shape of the objects being animated and how they relate to their environment. They use a simple equation ($\text{frames per second} = \text{total frames} \div \text{time in seconds}$) to calculate the number of frames needed per second of animation to achieve the desired effect. They also use coordinate planes to track the movement of objects.)*
- What math skills do you notice being used over and over again, even in different jobs? Why might those skills be important? *(Sample answer: Measurement, timing, geometry, and solving equations are often used. They help with planning space, movement, and making sure everything looks and feels right on screen.)*
- Why do so many different jobs in moviemaking use math, even though their tasks are very different? *(Whether someone is designing a set or editing a scene, math helps them make smart choices and keep things working together smoothly. It helps solve problems like how far apart things should be, how long something should take, or how bright or fast something should be. It keeps everything organized and realistic.)*

Emphasize the Main Idea.

Solving linear equations helps us figure out answers when things depend on each other.

Have groups of students watch a section of a movie and compete to see who can identify the most instances in which they believe math was used and how. Where might linear equations have been used to solve a problem?

CHAPTER 8: READY FOR LIFTOFF, STUDENT READER PAGE 58

Chapter Summary: This fictional story about space travel in the future explores how, in order to plan and practice a space mission, math is used to solve real-world problems. The distance, rate, and time relationship is used as an example of solving real-world equations in two variables.

Math Connection: Engineers and astronauts use equations to make sure a mission is successful and safe. These equations also are used by pilots, air traffic controllers, and robotics teams. Each role uses math differently, but in each case, they must work together to solve problems.

Before Reading: Point out the chapter title: “Ready for Liftoff.” Explain to students that the chapter is about how space missions rely on systems of equations to ensure success and safety. Remind them to pay special attention to how equations are used to solve complex problems. Ask them to consider the different ways math is used in both training and spaceflight.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- How might math support Abigail in knowing that she is physically prepared for space? *(Sample answers: She uses math to measure and track her progress. The endurance tests probably timed how long she can do certain activities or how far she can go. The centrifuge g-forces are calculated using physics formulas. Movement practice probably measured her speed, distance, and time in zero gravity. She probably tracked her progress in charts.)*
- How did Abigail use the formula $d = r \times t$ in the simulation to determine how much time she had before she reached the dock? *(She rearranged the formula so that she solved for time: $t = d \div r$.)*
- Why is calculating the path of the spacecraft from Earth to base camp such a difficult problem? Why doesn't a linear equation work? *(Both the spacecraft and base camp are moving at high speeds and in curved paths. The path of neither is a straight line, so a linear equation will not work.)*
- How do you think that having many people with different roles using different types of math help make a space mission successful? *(Accept reasonable answers. Engineers, scientists, and mission controllers use data analysis, algebra, physics, and geometry as they work together to achieve a successful mission.)*

Emphasize the Main Idea.

Linear equations let us turn real-world problems into math we can solve step-by-step.

Have students measure how long it takes to walk a set distance. Have them use the equation $\text{distance} = \text{rate} \times \text{time}$ to find the rate they walked. Challenge them to do the same when jogging and then running and discuss how the rates compare.

CHAPTER 9: MATH MOVEMENT, STUDENT READER PAGE 66

Chapter Summary: In this chapter, students learn how migration means change for both the area people leave and the area they move to. They explore how the net migration helps communities plan for things like housing, schools, and jobs.

Math Connection: Demographers use functions to study how populations change over time in order to help plan for housing, schools, and jobs. Economists use this data to determine how migration may impact local economies, wages, and labor supply. Public health officials track how population movements influence the spread of diseases.

Before Reading: Point out the chapter title: “Math Movement.” Explain to students that the chapter is about how math functions can reveal relationships between things such as immigration and emigration. Remind them to pay attention to how the math function for net migration rate can impact community plans and to consider how functions help explain real-world situations.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- How does using a function like net migration rate help leaders of states with big and small cities plan fairly? *(It uses a formula that shows how many people move in or out for every 1,000 people, so big and small places can be compared the same way. This helps in planning for things like schools, housing, jobs, social connections, and hospitals.)*
- How can functions help us understand why people move from one place to another? *(Sample answer: Functions show patterns between reasons people move (like jobs or weather) and where they go. They help us see how those reasons affect migration.)*
- Why do you think it’s important to use math functions to analyze relationships and patterns when studying people and populations? *(Functions help us see relationships, like the relationship between people moving in or out and the total population. Patterns help us predict what might happen next. They show trends, like where people are moving to and why, so we can make smart decisions.)*

Emphasize the Main Idea.

Functions help us understand cause and effect, make predictions, and solve real-world problems.

Have the class consider why people move to new places. Besides how many people come in or leave, what other information might they want to track? How might a function with those factors help them analyze migration patterns? *(Sample answer: To understand why people move, I’d track things like job opportunities, housing costs, and climate/weather risks. I could set up a function that uses a –10 to +10 rating for each factor to estimate how attractive a place is for newcomers, for example:*

$$\text{Attractiveness Score} = a(\text{jobs}) + b(\text{housing cost}) + d(\text{climate})$$

A high score could predict a positive net migration rate; a low score could predict a negative one. These results would help me predict and plan housing, school, and transportation needs.)

CHAPTER 10: HOW OLD AM I? STUDENT READER PAGE 74

Chapter Summary: This scientific article examines how scientists use functions to describe the decay of certain elements, allowing them to calculate the age of once-living things by measuring how much of a specific form of an element is left. By graphing this relationship, scientists can determine when ancient people lived and how old artifacts are and confirm historical events.

Math Connection: Scientists like archeologists, geologists, anthropologists, and paleontologists apply math functions that incorporate decay rates of forms of certain elements to date ancient objects and events. Economists use functions to model supply and demand relationships. Health professionals use functions to model the spread of disease.

Before Reading: Point out the chapter title: “How Old Am I?” Explain to students that the chapter describes how scientists use math functions to figure out the age of once-living things and learn about history. Remind them to pay special attention to how the graphed function shows a pattern. Ask them to consider how that pattern allows scientists to determine the age of once-living things using the decay of carbon-14.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- How does carbon dating help us better understand life in the past? *(It shows how long ago something lived. This helps us learn more about ancient living things as well as historical events, such as when the Dead Sea Scrolls were written or when Ötzi the Iceman died.)*
- How is the decay of carbon-14 an example of a function in math? *(It's a function because every amount of time that passes (input), there is exactly one amount of carbon-14 left (output). The carbon-14 decreases the same amount each interval. This shows a pattern and a relationship between time and the carbon-14 remaining.)*
- How does the pattern of carbon-14 decay show a functional relationship over time? *(The amount of carbon-14 gets cut in half every 5,730 years. That's a pattern, and the pattern is the same every time. The function tells us about the expected pattern between carbon-14 and time.)*
- Carbon-14 dating has some limits. How can scientists use other functions that utilize potassium-40 or uranium-235 to figure out the age of ancient things? How do those functions work? *(Sample answer: Scientists can use elements like potassium-40 or uranium-235 because they also decay in a regular pattern. These elements have much longer half-lives, so their functions work better for dating things that are millions or even billions of years old. The math still works the same way—the amount of the element decreases over time, and scientists use that pattern to figure out how old something is.)*

Emphasize the Main Idea.

A function gives one output for each input and can be graphed.

Ask students to look up another way scientists use functions in the real world, such as predicting weather, tracking disease spread, or studying population growth. Have students share how the function helps solve a real-world problem.

CHAPTER 11: MY FIRST PAYCHECK, STUDENT READER PAGE 82

Chapter Summary: This comic strip follows Celia, who is trying to save money while working at an ice cream shop. In order to know how much money she can save, she must figure out her net pay, subtracting the different deductions from her gross income. She considers how the company offers bonuses and occasional raises that can help her save money.

Math Connection: Workers of all kinds receive paychecks. Workers can determine net pay using functions to figure out the amount of each deduction based on the percentage of gross pay.

Before Reading: Point out the chapter title: “My First Paycheck.” Explain to students that the chapter is about two employees discussing paycheck deductions. Remind them to pay special attention to how Celia’s idea of how much she should receive changes. Ask them to consider how understanding functions helps Celia determine each deduction in order to be sure she is receiving the right amount of pay and to predict future pay.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- Why is gross income a function? *(Sample answers: Each input has one output. It follows a pattern. It establishes the relationship between hours worked and pay. It helps us solve problems such as how much our gross pay will be and how this deduction will affect our net pay.)*
- Can the deductions in a paycheck be considered a function? Why is this helpful? *(Yes, it can be considered a function because each amount earned has one matching amount taken out (the deductions). This helps people know how much money will be taken out and how much they’ll take home. It makes it easier to plan and budget.)*
- If the percentage of deductions changes, could you still use a function to determine the net pay? Explain. *(Yes. If the percentage of deductions changes when finding net pay, this relationship is a function in which deduction percentage is the input and net pay is the output. For each possible percentage of deductions, there is only one corresponding net pay amount (assuming gross pay stays the same), so it is a function.)*
- Why is it important to know about gross pay, net pay, and deductions as someone with responsibilities? *(It is important to know about how much you make an hour and how each deduction will affect your net pay. You need to know all this so you can make decisions about how to spend your money and how to save it.)*

Emphasize the Main Idea.

A function makes it easier to determine outcomes in a clear and consistent way.

Provide students with a variety of pay stubs that demonstrate different types of deductions, such as life insurance, health insurance, dues, retirement savings accounts, etc. Ask them to identify the deductions. Have students create a function to determine how these deductions affect net pay. Discuss what the worker could change in the deductions or gross pay.

CHAPTER 12: TRANSFORMATIONS IN ART, STUDENT READER PAGE 90

Chapter Summary: Street artists use transformations—translations, reflections, rotations, and dilations—in their work. They use these mathematical ideas to create balance, movement, repetition, or scale. Transformations appear in murals, graffiti, and other forms of public art and help the artists express themselves and their ideas.

Math Connection: Artists aren't the only ones who use transformations. Architects and interior designers rotate floor plans to fit building sites, reflect layouts for symmetrical designs, and dilate blueprints for printing or modeling. Engineers (mechanical, civil, and electrical) rotate parts in CAD software for fitting and assembly, translate coordinate systems to align machinery, and scale structures during prototyping.

Before Reading: Point out the chapter title: "Transformations in Art." Explain to students that the chapter is about how artists use geometric transformations to create street art. Remind them to pay special attention to how different artists apply each kind of transformation in their work and the effects of the changes.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- How does the use of transformations help artists change or improve their artwork? (*Sample answer: Transformations help artists create balance, movement, or focus. Flipping or rotating a shape can make a design more interesting or meaningful. It can help them express emotion. For example, Keith Haring uses rotations to show movement and energy, and Ardif uses reflections to show balance between nature and machines.*)
- Why is it important that transformations keep the shape the same even if the transformation changes its size or position? How does this help in art? (*Keeping the shape the same helps the viewer recognize the object, even if it's moved or resized. This lets the artist repeat shapes while still being clear about what the image is.*)
- How does understanding transformations in math help us see how artists use them in their street art? (*If we understand how transformations work, we can better see how artists are using them. We can identify when something has been reflected or translated to make a pattern.*)
- Why would an artist want to use multiple types of transformations in their artwork? (*Sample answer: Using multiple types of transformations adds interest and variety to the art. When something is changed, it can draw the eye, make people wonder about the art, and get the artist's message across better.*)

Emphasize the Main Idea.

Changing a shape's position or size helps show its properties and relationships to other shapes.

Create an art walk. Have small groups of students each design a piece of art using photos, drawings, or digital images that incorporates at least 2 transformations. Hold an art walk, and have students discuss the types of transformations they see in each piece and the effects these changes create.

Chapter Summary: In this chapter, Ellis notices a lot of geometry as he reads a story about Robin Hood's legendary archery skills. In the story, as Robin silently calculates angles, distances, and the path the arrow will follow, he uses triangle relationships and mental math to win the contest.

Math Connection: Just like Robin Hood used math to calculate the angles needed for the perfect shot, pilots calculate the glide slope, the angle at which the plane descends, in order to safely land. They use navigation systems and visual cues to align the plane with the runway, which is like a straight line cutting across the horizontal line of the sky.

Before Reading: Point out the chapter title: "Robin Hood and the Golden Arrow." Explain to students that the chapter is about how understanding and estimating angles helps Robin Hood win an archery contest. Remind them to pay special attention to how Robin Hood uses angles, the shape of the arrow's path, and mental math to make precise shots. Ask them how calculation of range and height affects how the arrows are shot.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- What does Robin Hood do before each shot that shows he is using geometry? *(He thinks about the angle he needs to shoot the arrow and uses what he knows about triangles to aim. This shows he was estimating the angles in his head.)*
- Robin often sees competitors' arrows miss, either falling short of or overshooting the target. Based on the chapter, what is one factor these competitors may be misjudging? *(Sample answer: They may not understand how to calculate the angle of elevation that will make for an accurate shot.)*
- How does the story describe the path of Robin Hood's arrow? Why is this important for archers? *(It says that Robin mentally calculates the angle of elevation and the force he needs to use to get the arrow to hit the target. The arrow flies in a curved path through the air. Understanding this curved path helps an archer know exactly how to aim by choosing the correct angle so the arrow lands where they want it to.)*
- What role do angles play in aiming an arrow? *(The angles determine the direction and height of the arrow's path. If the angles aren't just right, the arrow might fall short, fly too high, or miss the target completely. Getting these angles correct is key.)*

Emphasize the Main Idea.

You can use angles and triangular relationships to predict the path of an object.

Have pairs explore how angles and triangles can predict the path of an arrow. Direct them to mark a starting point and a target zone on the floor and sketch a triangle on graph paper showing the angle of elevation for their "arrow" and the predicted path it will follow to reach the target. Have students take turns launching a safe projectile, like a foam arrow or dart, along the predicted path and analyzing the results. Challenge them to make adjustments until they can reliably hit the target.

CHAPTER 14: THE MATHEMATICS OF BILLIARDS, STUDENT READER PAGE 106

Chapter Summary: Alex is learning how to play 3-cushion billiards. As he prepares for and participates in a billiards tournament, he uses his understanding of the law of reflection and equations to help him predict the path of his cue ball.

Math Connection: Game designers are among the professions that utilize the law of reflection. In a game, when a player shines a flashlight on a mirror, the reflected beam must reflect off the mirror at the same angle. Sound propagation in games also uses this principle when echoes or footsteps are heard by players.

Before Reading: Point out the chapter title: “The Mathematics of Billiards.” Explain to students that the chapter describes how Alex uses the law of reflection to solve problems and improve skills while playing billiards. Remind them to pay special attention to how Alex uses the diamonds on the table rails to make his shots and to consider how math and strategy work together in billiards.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- Alex uses the rule that the ball bounces off the rail at the same angle it hits. Why is this helpful for making better shots? *(Using this rule, he can predict exactly where the ball will go after it hits the rail. Because the angle in equals the angle out, he knows how to line up the shot. This reduces guesswork.)*
- What might happen if Alex doesn’t use math to figure out his shots? *(If Alex doesn’t use math, he probably would rely on experience, luck, or just random angles. That might cause him to miss important shots, especially when the pressure is high. Because he understands the math behind the game, he has a strategy. Using math helps him be more accurate.)*
- If you wanted to teach someone how to aim a cue ball better using math, what would you tell them? *(I would tell them about the importance of geometry and describe the law of reflection: The angle at which the cue hits the rail is the same angle at which the cue will reflect off the rail. I’d also explain the diamond numbering system and show them how to use this equation: Starting Point (S) – Aiming Target Point (A) = Finish Target Point (F). If they know where the cue ball starts and where they want it to end up, they can figure out exactly where to aim.)*
- Alex gets better at billiards by using math. Can you think of a game or sport you play that uses angles, aiming, or bouncing like billiards? *(Sample answer: In basketball when I shoot off the backboard, I think about the angle I’m shooting from. If I hit the backboard at the right spot and angle, the ball bounces into the hoop. Using angles helps me line up better shots, especially when I’m not directly in front of the basket. It’s using math to predict where the ball will go.)*

Emphasize the Main Idea.

Players use the mathematical law of reflection to predict and plan when playing games.

Have small groups of students work together to design a miniature golf hole or pinball machine layout using reflection angles to guide the ball to the goal. Have them explain to the class how using reflection angles helps predict the ball’s path.

CHAPTER 15: ART PERSPECTIVES, STUDENT READER PAGE 114

Chapter Summary: This tutorial explains how math is used to make a 2D drawing appear 3D. By using geometric concepts including vanishing points, dilations, and translations, artists place objects, show distance, and add shadows to make drawings look more realistic.

Math Connection: Artists use geometry to create drawings with depth and shadows. Architects use translations when designing a floor plan. They design one unit—an apartment or office—and then translate it across the blueprint to show the entire building. They may also use translation to show a row of identical windows or columns by designing one “base shape” and translating it repeatedly along a line.

Before Reading: Point out the chapter title: “Art Perspectives.” Explain to students that the chapter is about how artists use geometry to make drawings look 3D. Remind them to pay special attention to how angles and lines together create different perspectives. Ask them to follow along with the tutorial on a sheet of paper to better experience the content.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- What would happen if the artist didn’t align the lines to the vanishing point correctly? Can you think of any times the artist might desire this effect? *(If the lines don’t point toward the vanishing point, the object would look tilted, fake, or strange. The image would not look 3D anymore and would appear unrealistic. If an artist wants a building to look like it’s falling over or a character to look like it’s floating, they might misalign the vanishing point on purpose.)*
- How would an artist use translations to make an object appear closer or farther away? *(A translation is the movement of a figure across a plane. The use of lines connecting an object to the vanishing point produces a plane. If the artist slides the object along the plane away from the vanishing point, the object will appear closer. If the artist slides the object along the plane toward the vanishing point, the object will appear farther away.)*
- How do changes in the horizon line or light source affect the way a viewer sees a drawing? *(Changing the horizon line can make the viewer feel like they are looking up at an object or down on it. Moving the light source changes the size and direction of shadows, helping the viewer understand the shape and position of the object. These changes make the drawing look more real and believable.)*
- Why do you think architects and video game designers would need to understand perspective and geometry? *(They both need to create things that look realistic. Geometry helps them figure out how things will look when viewed from different angles. It also helps them decide what the object or game will look like to the viewer when it is done.)*

Emphasize the Main Idea.

Geometric transformations like dilations and translations, along with concepts of parallel lines and perspective, create realistic 3D-looking images on flat surfaces.

Challenge student pairs to identify an optical illusion like those of M. C. Escher that incorporate transformations. Have pairs share with the class the transformations they see.

CHAPTER 16: WIND AND RAIN, STUDENT READER PAGE 122

Chapter Summary: Understanding the relationship between variables—wind speed and rainfall—helps meteorologists predict the impact of a hurricane. Bivariate data analysis allows scientists to create hazard maps that show where the strongest winds and heaviest rains will happen. This helps emergency planners and families prepare better for storms.

Math Connection: Meteorologists use bivariate data analysis to predict storms by studying wind and rainfall together. This type of analysis is used by firefighters, farmers, and city planners to prepare for disasters.

Before Reading: Point out the chapter title: “Wind and Rain.” Explain to students that the chapter is about how scientists use two weather variables to predict the impact of storms and help keep people safe. Remind them to pay special attention to how combining two sets of data helps create clearer and more accurate weather predictions. Ask them to consider how using two variables together changes what we know compared to looking at just one variable.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- Review the data in the scatterplot on page 123. What does this scatterplot tell meteorologists about the wind and rain associated with various storms? *(It shows that depending on the storm, rainfall may be more or less and winds may be stronger or weaker.)*
- How does identifying where two factors will be most severe help people stay safe? *(It helps scientists and emergency planners target emergency services and preparation assistance to areas that are in the most danger.)*
- Why do you think meteorologists track tropical storms and gather data on associated wind speeds and rainfall long before they develop into hurricanes? *(Sample answers: The track of the storm can change over time, putting different areas in possible danger. Storms may strengthen and weaken, changing forecasts of how much wind or rain a certain area may receive.)*
- What variables do you think forecasters use to compile bivariate maps for floods, droughts, or wildfires? How would these maps help people prepare for each event? *(For floods, the variables could be how much rain will fall in a period of time and the soil conditions in the area, helping forecasters identify where flooding might happen and giving people time to evacuate. For droughts, variables could include soil dryness and air temperature, providing communities information to help them save water and plan for dry conditions. For wildfires, forecasters could consider how dry vegetation is and expected wind speeds, helping firefighters and towns get ready to stop fires or evacuate if needed.)*

Emphasize the Main Idea.

Bivariate data analysis shows whether or not there is a relationship between two variables.

Divide the class into small groups. Assign each group a profession such as sports coach, doctor, city planner, or teacher. What variables might each professional study in bivariate analysis? Have students discuss whether or not the variables show a relationship and how bivariate analysis may help each professional in their work.

CHAPTER 17: STATISTICS IN COURT, STUDENT READER PAGE 130

Chapter Summary: Forensic experts use measurement, scatterplots, and statistical analysis to examine handwriting to compare signatures and detect forged signatures. Patterns and outliers revealed by analyzing the data reveal which signature is authentic.

Math Connection: Forensic handwriting experts analyze data to find patterns and outliers. This type of analysis is also used by law enforcement, bankers, and fraud investigation teams to detect fake documents. Displaying frequencies and relative frequencies in a two-way table can reveal patterns and associations between two variables.

Before Reading: Point out the chapter title: “Statistics in Court.” Explain to students that the chapter is about using math in forensic handwriting analysis. Remind them to pay special attention to how different types of math are used in identifying different patterns in the writing. Ask them to consider the role of patterns and data in making decisions.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- How do scatterplots help reveal patterns that aren’t easy to see by just looking? (*Scatterplots show data points on a graph, so you can see if most of the points are close together or if any points stand out. This helps you notice patterns or outliers that might be hard to see otherwise. It makes it easier to compare a lot of data at one time.*)
- If you had to prove someone forged your signature, what kind of data would you collect? (*Sample answer: I would collect a lot of examples of my real signature to show how I usually write. Then I would measure variables such as the size of the letters, the angle or slant, and how thick the lines are on both my sample and the suspected copy. I would use that data to make scatterplot graphs of this data to compare the examples and look for patterns that would indicate one signature might be a forgery.*)
- Why did Lydia compare a number of variable pairs and not just one? (*The more variable pairs examined, the more likely a pattern of outliers will emerge if one of the signatures is a forgery.*)
- How are outliers discovered, and why are they helpful in identifying forgeries? (*Outliers are discovered by comparing data points, such as the height, width, slant, or thickness of letters, to the usual range found in real signatures. An outlier is a measurement that’s much higher or lower than others. Outliers help identify forgeries because they identify parts of a signature that don’t match the normal pattern.*)

Emphasize the Main Idea.

Using scatterplots lets us compare groups, find patterns, and make decisions based on data.

Have students survey classmates about two things, like how many hours of sleep they get on a school night and how many minutes of screen time they use after school. Have them plot each response as a point on a scatterplot, with hours of sleep on the x-axis and screen time on the y-axis using different colors for those students who participate in sports and those that do not. Once the scatterplots are complete, have students look for patterns. Does more sleep seem to relate to less screen time? Which group spends more time on screens? Finally, have students think about what advice they might give a friend based on the patterns they see.

CHAPTER 18: STATISTICS USED IN MARKETING, STUDENT READER PAGE 136

Chapter Summary: Amy learns how her mom uses statistical data from surveys, sales, and reviews to make graphs that show trends in consumer behavior. Trends such as these help companies decide what products to sell and how to advertise them.

Math Connection: Amy's mom collects data, uses statistical analysis to find patterns, and presents her results in graphs to help businesses make decisions. Advertisers, data scientists, economists, and even city planners who study trends use statistical analysis to improve services and products.

Before Reading: Point out the chapter title: "Statistics Used in Marketing." Explain to students that the chapter is about how statistical analysis can be used to study consumer behavior and help businesses make decisions. Remind them to pay special attention to how data is collected and displayed to show patterns and relationships. Ask them to consider how different graphs help businesses understand customers and how these analyses could lead to real changes.

After Reading: Use questions like these to facilitate student engagement and help students make connections to the real-world applications of math.

- Why might companies use different types of graphs to show their data? How do they help them make decisions? *(Each type of graph shows information in a different way. This helps companies make better decisions because they can see trends in data clearly.)*
- How do scatterplots make it easier to identify patterns and trends that we might not see otherwise? *(Scatterplots show how two variables are related by putting dots on a graph. When we look at all the dots together, we can see if there's a relationship between the variables. This helps us identify trends that we might not notice just by looking at numbers in a list or chart.)*
- Why is it important for a company to know whether two variables have a positive or negative association? Give an example of how this could affect marketing or product decisions. *(Sample answer: Analyzing correlation between variables helps a company make smarter choices. For example, if there is a positive association between how much people exercise and how often they buy new running shoes, shoe companies might advertise more during sports events. If a movie theater finds a negative association between ticket sales and how long a movie has been released, they might only keep movies in theaters for a shorter time.)*

Emphasize the Main Idea.

We use scatterplots and statistical analysis to look for relationships between variables.

Have students imagine they are market research analysts like Amy's mother. They want to help a restaurant decide how to increase sales for a veggie wrap. Have small groups of students discuss the two variables they would collect data on and how a scatterplot could help them recommend a marketing strategy. Have groups share their ideas with the class.



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Managing Editor, STEM

Sally Guarino

Editorial Staff

Teresa Pressman

Subject Matter Expert

Holly Caldwell-Taylor, DBA, CPA

Associate Professor and Department Chair

Department of Economics and Business Administration

Bridgewater College

Bridgewater, VA

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