Pick-a-Path for iOS and Android
Instructional Guide

Using Pick-a-Path
in Grades 3-7

ILLUMIN∆TIONS
NCTM
Resources for Teaching Math

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The National Council of Teachers of Mathematics is the public voice of mathematics education, supporting teachers to ensure equitable mathematics learning of the highest quality for all students through vision, leadership, professional development, and research.

Overview of Pick-a-Path

Okta the Octopus is caught in a mathematical net. Guide Okta through the net by choosing a path that will help Okta reach a puzzle's specified target. Players navigate through seven levels, testing mental math skills with integers, factors, powers of ten, fractions, measurement, decimals, and exponents.

Players can focus on a specific skill by concentrating on one or two levels, or they can test their mathematical aptitude by advancing through all seven puzzles at each of the seven levels. When all seven puzzles within a level are completed, a random puzzle generator is unlocked that allows the player to access literally an infinity of puzzles of the same type.
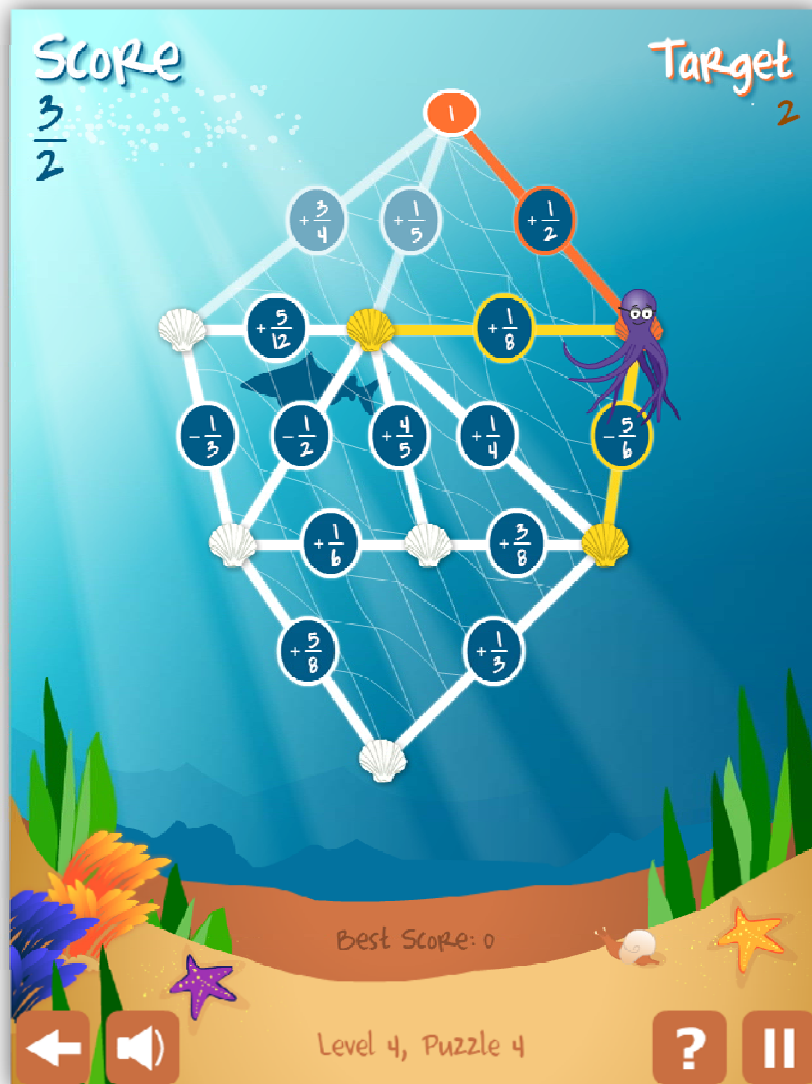
Introduction

This instructional guide provides suggestions for using the Pick-a-Path math strategy app in the classroom, as well as resources to teach and reinforce the concepts used in Pick-a-Path. This guide includes the following sections:

- **Accessing Pick-a-Path**
  web link for app download
- **Instructions for Play**
  description of how to play
- **Math Concepts in Pick-a-Path**
  outline of concepts and operations used at each level
- **Using Pick-a-Path in the Classroom**
  suggested classroom activities
- **Instructional Activities for All Levels of Play**
  general activities that work with all levels of play
- **Corresponding Illuminations Lessons and Activities**
  links to lessons and activities on Illuminations that support use of Pick-a-Path
- **References**

Accessing Pick-a-Path

The Pick-a-Path math strategy app can be downloaded from:

http://illuminations.nctm.org/pickapath

You may wish to display the app for the entire class. It's possible to connect your iPad or Android tablet to an interactive whiteboard in a few easy steps. Search the web for details.

For a low-tech alternative, place your mobile device under a document camera.

This guide can be downloaded from:

http://illuminations.nctm.org/   7   #   °   ins

Instructions for Play

The Pick-a-Path app is based on a puzzle from Janet Morris' book *How to Develop Problem Solving Using a Calculator* (NCTM, 1981) and the lesson *Too Big or Too Small*, available from **http://illuminations.nctm.org/**ᴜ ˝ ᴜ ᴏ The app develops problem-solving and mental math skills in a fun and interactive way for players of all ages.

As shown in **Figure 1**, Players guide Okta from the top of the maze to the bottom, performing mathematical operations along the way. The goal is to obtain a maximum, minimum, or specified value, known as the target.
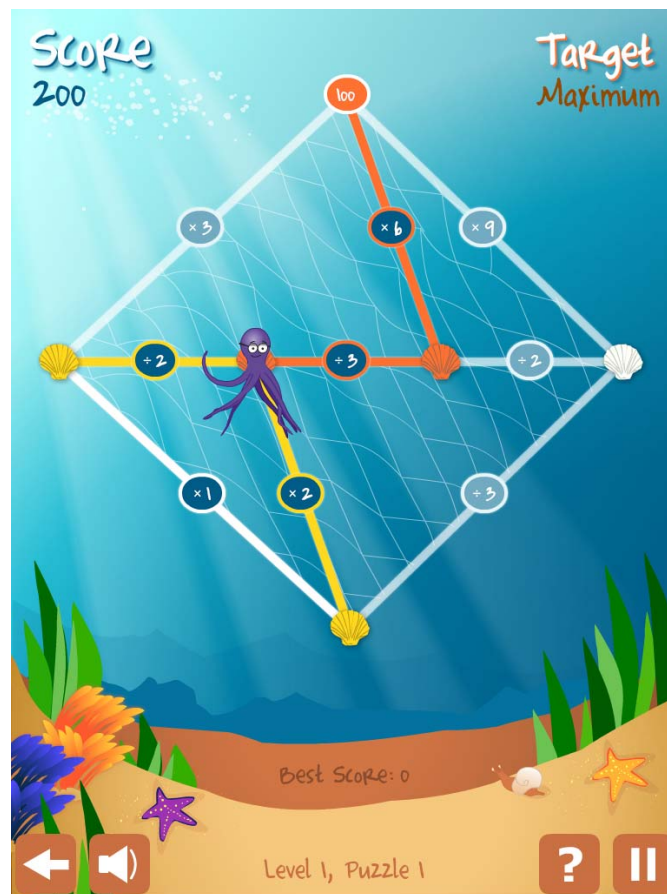

Figure 1. Level 1, Puzzle 1 from Pick-a-Path.

Okta can move right, left, or down, but she can't go up or cross a segment more than once. As Okta moves, the operations are performed, and an updated score is displayed in the upper left corner. For example, **Figure 1** shows Level 1, Puzzle 1 from the Pick-a-Path game; this particular puzzle involves only multiplication and division with integers. The player begins with a score of 100 points at the top of the maze and attempts to attain a maximum score by the time Okta reaches the bottom vertex. The player moves through the maze until successfully completing the expression 100 × 6 ÷ 3 × 2, which has a value of 400. If the player reaches the bottom without achieving the maximum target, the player is instructed to, "Try Again…".

Segments that have already been traversed are colored orange, and possible segments are colored yellow. For instance, the image in Figure 1 shows that Okta has already traversed segments with × 6 and ÷ 3, and from her current location she can traverse segments with ÷ 2 and × 2.

Players earn up to three starfish for completing a puzzle successfully. If the puzzle gives a specific target value, the player receives three starfish when the target is reached. For maximum and minimum puzzles, players receive one, two or three starfish, depending on the difference between the earned score and the target value. For example, in Level 1, Puzzle 1, three starfish are awarded for the best score of 400. But a player who reaches a score of 300 will be awarded two starfish. Note that some puzzles have more than one path that will yield the target value. The starfish can be used to buy Okta some swag in Okta's Boutique.

When all seven puzzles within a level are completed, a random puzzle generator is unlocked that allows the player to access literally an infinity of puzzles of the same type.

Earning at least one starfish in a puzzle unlocks the next puzzle within the level. Further, completing the first two puzzles within a level unlocks the next level. For instance, completing Level 1, Puzzle 2 unlocks both Level 1, Puzzle 3 and Level 2, Puzzle 1.

There are seven levels with seven puzzles in each level. Each level provides play with puzzles that emphasize a different mathematical concept:

- Level 1: Integers
- Level 2: Factors
- Level 3: Powers of 10
- Level 4: Fractions
- Level 5: Measurement
- Level 6: Fractions and Decimals
- Level 7: Exponents

Math Concepts in Pick-a-Path

Each level of the game focuses on a different math concept, and each puzzle explores an increasingly more challenging aspect of that concept. Difficulty is increased by including more operations, by using fractions and decimals instead of whole numbers, or by having more possible paths from Start to Finish within the maze.

Level 1: Integers

Using the four operations and integers, players try to achieve the maximum score possible. Up to three starfish are awarded for each puzzle.

The puzzles in Level 1 serve as an introduction to the types of puzzles within the app.

Puzzle	Operations	Number(s)	Target
Puzzle 1	multiplying, dividing	single-digit integers	maximum
Puzzle 2	adding, subtracting, multiplying, dividing	single-digit integers	maximum
Puzzle 3	adding	single-digit integers	maximum
Puzzle 4	adding, subtracting, multiplying, dividing	integers up to 11	maximum
Puzzle 5	adding	two- and three-digit integers	maximum
Puzzle 6	adding, subtracting, multiplying, dividing	integers up to 11	maximum
Puzzle 7	adding, subtracting, multiplying, dividing	single-digit integers	maximum

Level 2: Factors

Using only multiplication and division, players identify the factors required to reach a specific target number. Three starfish are awarded for the correct answer.

The factor puzzles in Level 2 require students to work backwards — what are the factors of the target number, and what numbers must be multiplied to reach the target?

Puzzle	Operations	Number(s)	Target
Puzzle 1	multiplying	1, 2	16
Puzzle 2	multiplying	2, 3	216
Puzzle 3	multiplying	2, 3, 5	3,000
Puzzle 4	multiplying	whole numbers up to 6	720
Puzzle 5	multiplying	prime numbers up to 13	30,030
Puzzle 6	dividing	single-digit whole numbers	1
Puzzle 7	multiplying, dividing	whole numbers up to 11	280

Level 3: Powers of 10

Using all operations, players use powers of 10 to reach a target. Up to three starfish are awarded for each puzzle.

The powers of 10 puzzles in Level 3 will establish and reinforce ideas of place value.

Puzzle	Operations	Number(s)	Target
Puzzle 1	multiplying, dividing	10	1
Puzzle 2	adding, subtracting, multiplying, dividing	10	maximum
Puzzle 3	multiplying, dividing	10	10,000
Puzzle 4	adding, subtracting, multiplying, dividing	powers of 10, including integers and fractions from 1/1000 to 1000	maximum
Puzzle 5	adding, subtracting, multiplying, dividing	powers of 10, including integers and decimals from 0.001 to 1000	maximum
Puzzle 6	adding, subtracting, multiplying, dividing	powers of 10, including integers, fractions, and decimals	maximum
Puzzle 7	adding, subtracting, multiplying, dividing	powers of 10, including fractions, decimals, and positive and negative exponents	100

Level 4: Fractions

Using all operations, players use fractions to reach a target. Up to three starfish are awarded for each puzzle.

For most puzzles in Level 4, students will need to find common denominators.

Puzzle	Operations	Number(s)	Target
Puzzle 1	adding	fractions with common denominators	maximum
Puzzle 2	multiplying	fractions with unlike denominators	minimum
Puzzle 3	adding, subtracting	fractions with denominators of 3 or 9 only	maximum
Puzzle 4	adding, subtracting	fractions with unlike denominators	2
Puzzle 5	adding, subtracting, multiplying, dividing	fractions with unlike denominators	maximum
Puzzle 6	adding	fractions with unlike denominators	maximum
Puzzle 7	adding, subtracting, multiplying, dividing	fractions with unlike denominators, including improper fractions	maximum

Level 5: Measurement

Using all operations, players use measurements to reach a target. Up to three starfish are awarded for each puzzle.

Both metric and standard measurements are used for the puzzles in Level 5, though students will not be required to convert between the two systems within a given puzzle.

Puzzle	Operations	Number(s)	Target
Puzzle 1	adding	whole numbers and decimals; conversions between milliliters and liters	1 liter
Puzzle 2	adding, subtracting, multiplying, dividing	whole numbers, fractions, and decimals; conversions between inches, feet, yards, and miles	minimum
Puzzle 3	adding	fractions with unlike denominators in multiples of 2; only inches used	2 inches
Puzzle 4	adding	whole one- or two-digit numbers; conversions between pints, cups, quarts, and fluid ounces	1 gallon
Puzzle 5	adding	whole numbers and decimals; conversions between millimeters, centimeters, and meters	1 meter
Puzzle 6	adding, multiplying, dividing	whole numbers and fractions; conversions between inches, feet, and yards	1 yard
Puzzle 7	adding, subtracting, multiplying	whole numbers and fractions; conversions between cups, pints, quarts, and fluid ounces	maximum

Level 6: Fractions and Decimals

Using all operations, players use fractions and decimals to reach a target. Up to three starfish are awarded for each puzzle.

Students will need to be facile in converting between fractions and decimals to solve the puzzles in Level 6.

Puzzle	Operations	Number(s)	Target
Puzzle 1	multiplying, dividing	whole numbers, fractions, and decimals	maximum
Puzzle 2	adding, subtracting, multiplying	fractions with unlike denominators in multiples of 2	1
Puzzle 3	multiplying, dividing	whole numbers, fractions, and decimals	1
Puzzle 4	adding	decimals and fractions with common denominators	2
Puzzle 5	adding, subtracting, multiplying, dividing	fractions with unlike denominators; all denominators are factors of 12	maximum
Puzzle 6	adding, subtracting, multiplying, dividing	fractions and decimals	maximum
Puzzle 7	adding, subtracting, multiplying, dividing	fractions and decimals	minimum

Level 7: Exponents

Using all operations, players use exponents to reach a target. Up to three starfish are awarded for each puzzle.

The puzzles in Level 7 can be used to help identify the laws associated with exponents, such as the Power of a Power rule or the Quotient of Powers rule.

Puzzle	Operations	Number(s)	Target
Puzzle 1	adding, multiplying	one-digit integers with exponents	maximum
Puzzle 2	multiplying, dividing	powers of 2	2^5
Puzzle 3	adding, multiplying, dividing	one- and two-digit integers with exponents	maximum
Puzzle 4	multiplying, dividing	one-digit integers with exponents	maximum
Puzzle 5	adding, subtracting	positive and negative one-digit integers with exponents	maximum
Puzzle 6	multiplying, dividing	one-digit integers with positive and negative exponents	maximum
Puzzle 7	adding, subtracting, multiplying	positive and negative one-digit integers with exponents	maximum

Using Pick-a-Path in the Classroom

Although there's no right or wrong way to use this app in the classroom, the following are some suggestions for how it might be integrated.

As an Introduction to a Concept

Resist the temptation to use the puzzles in Pick-a-Path for just skill practice; instead, use the puzzles to introduce concepts.

Students can attempt the puzzles in the Pick-a-Path app as a means to discover some rules about numbers. For instance,

- Puzzles in Level 2 could be used to promote thinking about factors;
- Puzzles in Level 3 could teach place value;
- Puzzles in Level 6 can be used to illuminate the difference when multiplying and dividing by a number less than one compared to multiplying or dividing by a number greater than one; and,
- Puzzles in Level 7 can be used to teach the rules of exponents.

Rather than spend time teaching a bunch of numerical rules and then having students practice a large number of related exercises, why not let students use Pick-a-Path to discover the rules on their own and teach themselves? After they solve several puzzles at a particular level, a whole-class discussion could be used to highlight what they learned, reinforce the rules, and correct any misconceptions. In that way, students take control of their own learning, and the role of the teacher shifts from being a keeper of all knowledge to one of ensuring that students learn from a self-guided activity.

Puzzle 6, Level 6 is the original maze puzzle from Janet Morris' book *How to Develop Problem Solving Using a Calculator*. The puzzle was intended to highlight the result of operations with numbers greater and less than one, and it provides an opportunity for students to develop conceptual understanding on their own. Students who attempt this puzzle without previous knowledge about the affect of these operations are often surprised to find that dividing by 0.09 actually *increases* the result — and by a significant amount! When trying this puzzle, students often ask, "Why does that happen?" which provides an opportunity to explore further and discover concepts in a fun and investigative way.

As a Lesson Extension

After teaching a unit, assign students to work on a specific level to reinforce the classroom learning.

For example, after teaching a fractions unit, assign students to play Level 4 of the app. This level has players adding, subtracting, multiplying, and dividing fractions with common and unlike denominators as well as improper fractions. This is an excellent review and provides application for the skills learned during the unit. (Note: Students will have to complete at least two puzzles each in Levels 1, 2, and 3 before they can advance to Level 4.)

To Motivate Discussions about Problem-Solving Strategies

The puzzles in Pick-a-Path are able to help students develop the eight mathematical practices described in the Common Core State Standards for Mathematics. In particular, Pick-a-Path requires students to:

- **Persevere in solving problems.** Rarely will students reach the target value on their first try. Learning from failed attempts will be necessary to make progress toward a solution.
- **Make sense of quantities and their relationships in problem situations.** Students need to understand the meaning of operations, not just how to compute them. While using Pick-a-Path, students must recognize how a number and an operation will affect the result.
- **Justify their conclusions, communicate them to others, and respond to the arguments of others.** The puzzles in Pick-a-Path naturally encourage communication. When one student finds a path with an improved score, other students instinctively ask, "How'd you do that?" Capitalize on this by encouraging dialogue that uncovers mathematical concepts.
- **Consider various tools when solving a mathematical problem, including pencil and paper, a calculator, or a spreadsheet.** Intermediate values are calculated directly within the app, which is analogous to using a calculator. Alternatively, students can use other tools to investigate results more broadly, such as using a spreadsheet to generate many examples. Pick-a-Path can serve as the impetus for these types of investigation.
- **Look closely to discern a pattern or structure.** While solving a puzzle involving fractions, students might notice that dividing by 2/5 and multiplying by 5/2 yield the same result. More generally, students could observe that dividing by a fraction or decimal less than 1 yields an increase in the total value.

The eight mathematical practices are aligned with the process standards first described by NCTM (2000) in the *Principles and Standards for School Mathematics*. Among these processes is communication, wherein students describe their mathematical thinking coherently and clearly to peers, teachers, and others.

To promote communication, assign a small group of students to work on the same level of play. After allowing time to work through the puzzles at that level, initiate a group discussion about the problem-solving strategies students used to solve the puzzles.

- Were students mentally calculating the results as they went?
- Were students relying on a calculator to work through the problems?
- Did anyone work the problems on paper? For example, Level 2 deals with factors. Did anyone find the factors of the target number before starting the puzzle?
- If students reached the target, do they believe they did so through luck, strategy, or skill? Ask them to explain their answer.
- Did anyone work backward, considering the numbers and operations at the end of the maze *before* starting the maze?
- What other strategies did students use? For example, did anyone use guess-and-check, logical reasoning, or find a pattern?

As a Mental Math Workout

Ask students to cover the "score" section in the upper left corner of the screen. This will push them to work more on their mental math skills as they work the puzzle. You could allow them to lift the cover periodically to check their progress. (Note: While it may be too difficult for students to mentally calculate the exact values for the puzzles in Level 6 (Fractions and Decimals) and Level 7 (Exponents), students can estimate as they guide Okta through the maze.)

To Explore Number Sentences and Order of Operations

For puzzles in which the target is a minimum or maximum score, have students record the number sentences and answers for various paths. Create a class chart or table to organize the results.

This may be difficult with puzzles that contain multiple operations, such as Level 1, Puzzle 2, because the order of operations will come into play. But it provides a great real-life application of the math concept.

For example, if Okta starts with 100, then moves to × 5, + 10, ÷ 10, and + 10, it's not as simple as $100 \times 5 + 10 \div 10 + 10 = 61$. Instead, it has to be written as $(100 \times 5 + 10) \div 10 + 10 = 61$. Otherwise, the order of operations would give $100 \times 5 + 10 \div 10 + 10 = 500 + 1 + 10 = 511$.

To Strengthen the School-Home Connection

Extend the learning in the classroom to the home environment by recommending that students download Pick-a-Path and play the game at home. You can even send a note home to parents to tell them about the game. Even informally, the game can be used to reinforce skills and concepts learned at school.

For a more formal use, encourage students to teach an adult at home how to play Pick-a-Path. After play, have students interview the person regarding their math learning. Possible questions might include:

- How was math taught when you were in school?
- What was your attitude toward math when you were a student? Has that remained the same or changed after you graduated?
- Do you think your attitude toward math would be different if today's technology had been available when you were in school?
- How have you seen technology change since you were my age?
- How do you use technology in your everyday life (at home and at work)?
- How do you use mental math in your everyday life?
- What did you like about playing this app? What didn't you like?
- What mathematical strategies did you use while solving the puzzles?

Instructional Activities for All Levels of Play

Each level provides an opportunity to explore the effect of various operations on different numbers. As players reflect on their target goal and the operations and numbers available on the maze, they will build number sense while determining if their path results in numbers larger or smaller than the target.

The activities that follow can be used with any level of the game. (The next section contains activities specific to each level.)

Experimenting with Operations

Write five numbers on the board, such as:

        4   9   2   5   6

Ask students to write operation signs between the numbers to achieve a:

- maximum score
- maximum score using more than one operation
- maximum score using exactly two operations
- maximum score using each operation exactly once
- minimum score
- minimum score that does not result in a negative number
- specific score, such as 17

The card game Primary Krypto® can be used for this last idea. In this game, students are asked to use five cards to generate a target value. An online version of this game appears on the Illuminations web site at **http://illuminations.nctm.org/tools/Krypto**.

Discuss:

- What operations are needed to reach the target?
- Why did you choose those operations?
- Does changing the order of the numbers affect the final answer?

For the purposes of this activity, explain that the order of operations will not be used. Instead, students should perform the computation left-to-right as if each operation and number is presented one at a time, as in Pick-a-Path. Students must compute the number sentence in a chain.

Experimenting with Numbers

Write five operations on the board, such as:

        +   +   ×   ÷   +

Ask students to write whole numbers between the operations to achieve a:

- score under 100
- score over 100
- score of exactly 100
- final answer of a decimal
- final answer of a fraction
- specific target score

Discuss:

- What numbers did you use in each number sentence?
- Why did you choose those numbers?
- Does changing the order of the numbers affect the final answer?

Puzzles of Your Own

Get creative! Develop puzzles for your students to fit the concept(s) you are working on in class. For example, a teacher whose students were learning to combine like terms in an algebra class created the following puzzle:
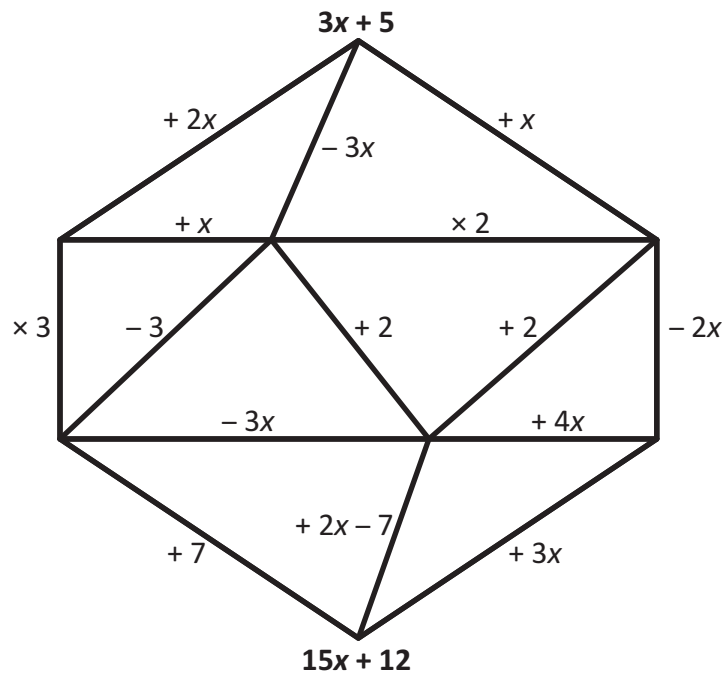
Figure 2. Maze created for an algebra class.

The goal for this puzzle was to start with $3x + 5$ and finish with $15x + 12$. The puzzle reinforced the ideas of combining like terms since students had to distinguish between variables and constants, but it also exposed students to the distributive property ($\times 2$, $\times 3$).

Puzzles of Their Own

Creating Pick-a-Path puzzles can be fun and educational for students, too. Sometimes, creating one puzzle can be more beneficial to student understanding than solving a dozen puzzles created by someone else.

Students can create puzzles entirely from scratch, or they can use the Blank Maze template shown below. The blank maze can be modified for any mathematical topic to fit the needs of your classroom.
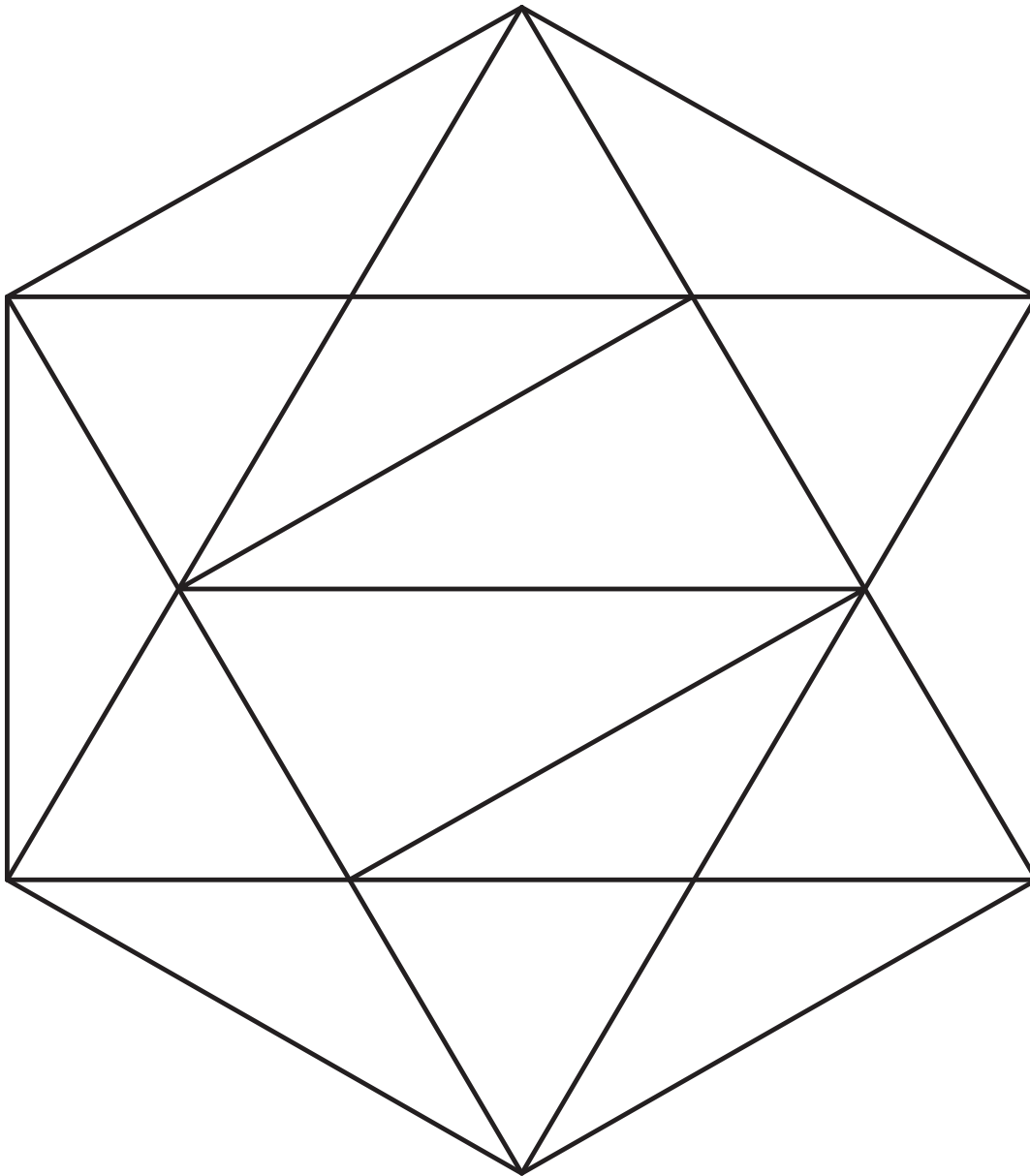
Figure 3. Blank maze template, which can be downloaded from the Extensions section of http://illuminations.nctm.org/TooBigTooSmall.

Corresponding Illuminations Lessons and Activities

The Pick-a-Path mobile math app was developed as part of the NCTM Illuminations project, which contains 600+ lesson plans and 100+ online activities for use by teachers and students. The following Illuminations resources can be used in conjunction with Pick-a-Path to create a rich and robust mathematical experience.

Level 1: Integers

Lesson: Exploring Krypto
http://illuminations.nctm.org/Lesson. spx?ID=
Grades 3–8

The rules of Krypto are amazingly simple: Combine five numbers using the standard arithmetic operations to create a target number. Finding a solution to one of the more than 3,000,000 possible combinations can be quite a challenge, but students love it. And you'll love that the game helps to develop number sense, computational skill, and an understanding of the order of operations.

Activity: Primary Krypto
http://illuminations.nctm.org/Activity aspx?I) =
Grades K–8

The rules of Krypto are simple: Combine five numbers using the four arithmetic operations (+, −, ×, ÷) to arrive at a target number. This online version of Primary Krypto uses the numbers 1 to 10 only.

Level 2: Factors

Lesson: The Factor Game
http://illuminations.nctm.org/Lesson. spx?ID=
Grades 6–8

The Factor Game engages students in a friendly contest in which winning strategies involve distinguishing between numbers with many factors and numbers with few factors. Students are then guided through an analysis of game strategies and introduced to the definitions of prime and composite numbers.

Activity: Factor Game
http://illuminations.nctm.org/Activity.aspx?I) =
Grades 3–8

Description: The Factor Game is a fun, interactive game that exercises your factoring ability. You can play against the computer or against a friend. (Note that this game also appears within the game suite at Calculation Nation®, http://calculationnation.nctm.org, under the name Factor Dazzle.)

Lesson: Factor Trail Game

http://illuminations.nctm.org/Lesson. spx?Φ=

Grades 3–5

Students must identify the factors of a number to earn points. Built into this game is cooperative learning — students check one another's work before points are awarded. The score sheet used for this game provides a built-in assessment tool that you can use to check students' understanding.

Activity: Product Game

http://illuminations.nctm.org/Activity.aspx?I) =

Grades 3–8

The Product Game is a fun, interactive game that exercises your skill with factors and multiples.

Level 3: Powers of 10

Lesson: Multiply and Conquer

http://illuminations.nctm.org/Lesson. spx?ID=

Grades 3–5

Students decompose two-digit numbers, model area representations using the distributive property and partial product arrays, and align paper-and-pencil calculations with the arrays. The lessons provide conceptual understanding of what occurs in a two-digit multiplication problem. Partial product models serve as a transition to understanding the standard multiplication algorithm.

Level 4: Fractions

Activity: Fraction Game

http://illuminations.nctm.org/Activity.aspx?I) =

Grades 3–8

This app allows individual students to practice working with relationships among fractions and ways of combining fractions. For a two-person version of this app, see E-Example 5.1, "Communicating about Mathematics Using Games," at http://www.nctm.org/fractiontrack.

Lesson: Weighing Your Car

http://illuminations.nctm.org/Lesson. spx?ID=

Grades 6–8

Students learn how to measure the area of the tire footprint of a car and how to find air pressure using a tire gauge. Students then calculate the weight of the car using their fraction multiplication skills.

Level 5: Measurement

Lesson: Do You Measure Up?

http://illuminations.nctm.org/Lesson. spx?ID=

Grades 6–8

Students learn the basics of the metric system. They identify which units of measurement are used to measure specific objects, and they learn to convert between units within the same system.

Lesson: Discovering Gallon Man

http://illuminations.nctm.org/Lesson. spx?ID=

Grades 6–8

Students experiment with units of liquid measure used in the customary system of measurement. They also practice making volume conversions.

Level 6: Fractions and Decimals

Lesson: Too Big or Too Small?

http://illuminations.nctm.org/Lesson. spx?ID=

Grades 6–8

Students develop number sense through a series of three hands-on activities. Students explore the following concepts: the magnitude of a million, fractions between 0 and 1, and the effect of decimal operations.

Lesson: Summer Daze

http://illuminations.nctm.org/Lesson. spx?ID=

Grades 6–8

Students begin by breaking down a typical summer day into a variety of activities and the amount of time they spend on each. They then translate their activity times into a simplified fraction, a decimal, and a percent. Students create a pie chart for this information that is unique to them. Students who struggle with the calculations have the opportunity to practice these conversions by playing a game that can easily be differentiated for various levels of learners.

Level 7: Exponents

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http://illuminations.nctm.org/Lesson.aspx?ID=3820

Grades 9-12

This lesson allows students to explore the idea that rainforest deforestation is occuring at an exponential rate. Students will use provided research about Amazon deforestation and conduct their own research to determine whether deforestation is occurring exponentially.

Lesson: Balancing Algebraic Understanding

http://illuminations.nctm.org/Lesson.aspx?ID=2151

Grades 6-8

Using a balance in the classroom is a first step to algebraic understanding. Use an online pan balance tool to practice the order of operations when simplifying numerical expressions and to demonstrate the conventions of using algebraic logic.

References

Morris, Janet. (1981). *How to Develop Problem Solving Using a Calculator.* Reston, VA: NCTM.

National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics*. Reston, VA: NCTM.