Explore**e**learning®

WHY GIZMOS® WORK:
Empirical Evidence for the Instructional Effectiveness
Of ExploreLearning Interactive Content

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1. Introduction

Meta-analysis of **educational research** provides **empirical evidence** for the **instructional effectiveness** of ExploreLearning **Gizmos**.

1.1 What is 'empirical evidence of instructional effectiveness'?

Empirical evidence of instructional effectiveness means that claims about the effectiveness of a given instructional method or product are substantiated by scientific research. This research should be based on experimental studies where the effects of specific variables on student performance are isolated and measured. Ideally, these studies are conducted in actual classrooms across several different school settings, in order to verify that the instructional method or product will be effective for a wide range of students.

1.2 Why is empirical evidence of instructional effectiveness important?

Grounding instructional decisions in scientific research reduces the influence of pedagogical fads and gurus. Rather than struggling to constantly change and adapt to 'the latest thing,' teachers can base their teaching methods on specific pedagogical principles that have been demonstrated to be successful. These research-validated methods provide a solid foundation upon which teachers can build and adapt their own teaching styles to best respond to the diverse needs of their students.

The importance of using scientific research to drive educational decision-making has recently been ratified into law. The *No Child Left Behind Act of 2001* (NCLB), which reauthorized the Elementary and Secondary Education Act, requires that "scientifically based research" be used as the basis for decisions about instructional methods and about federally-funded education programs in general. The strong emphasis placed on scientifically based research is evident from the fact that the phrase appears more than 100 times in the NCLB legislation (Neuman, 2002).

The NCLB legislation also mandates that scientific research be factored into decisions regarding which educational products and technologies get adopted and used in K-12 classrooms. Educational technology can play an important role in disseminating best practices, because it can make research-validated instructional methods more practical to implement in the classroom on a regular basis. For example, teachers often struggle to incorporate opportunities for hands-on exploration of math and science concepts in their lesson plans due to time constraints. Well-designed computer simulations can make the incorporation of manipulatives in lesson plans much easier, and enable students to develop a richer and deeper conceptual understanding in a shorter period of time.

1.3 What kinds of empirical evidence are acceptable?

According to the federally-funded paper, *Using Research and Reason in Education: How Teachers Can Use Scientifically Based Research to Make Curricular & Instructional Decisions* (Stanovich & Stanovich, 2003), empirical evidence of instructional effectiveness can come from any of the following sources:

- Demonstrated student achievement in formal testing situations implemented by the teacher, school district, or state;

- Published findings of research-based evidence that the instructional methods being used by teachers lead to student achievement; or

- Proof of reason-based practice that converges with **a research-based consensus in the scientific literature**.

1.4 How can a research-based consensus in the scientific literature be identified?

Scientific research is not infallible. There is always the possibility that individual studies may arrive at erroneous findings by chance or through experimenter error. Basing instructional practice on the results of a single study is therefore not advisable. However, asking educators to familiarize themselves with the literally thousands of research studies available on instructional methods is obviously not a feasible approach either.

This challenge is not limited to educational research – the need to identify a research consensus from a large number of studies is common to most areas of scientific inquiry. To meet this need, a formal statistical method called *meta-analysis* has been developed for systematically comparing results across disparate studies. This method has been found to be very successful in medical research, and there is an increasing drive to make it the vehicle by which educational research is distilled for application in the nation's classrooms.
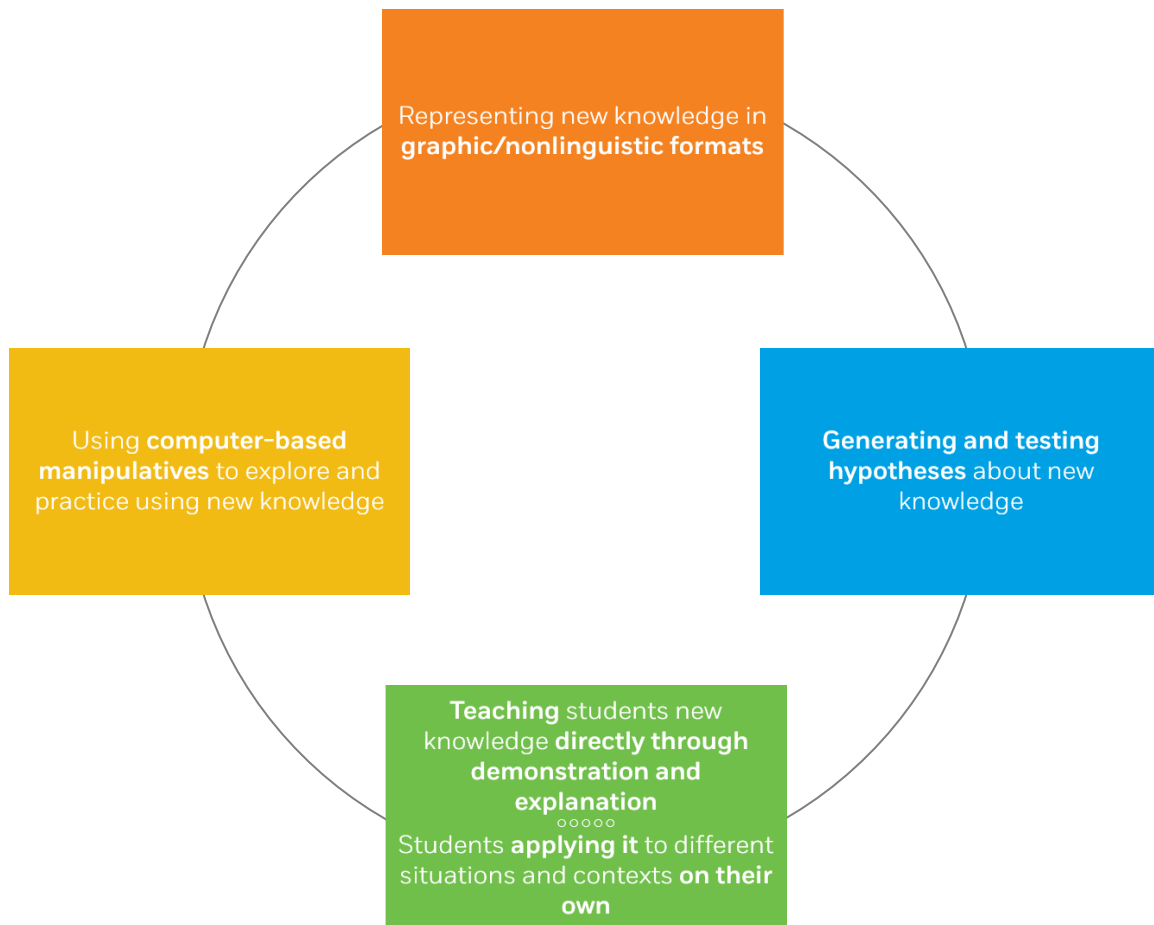
> More and more commentators on the educational research literature are calling for a greater emphasis on meta-analysis as a way of dampening the contentious disputes about conflicting studies that plague education and other behavioral sciences (Kavale & Forness, 1995; Rosnow & Rosenthal, 1989; Schmidt, 1996; Stanovich, 2001; Swanson, 1999). The method is useful for ending disputes that seem to be nothing more than a "he-said, she-said" debate. An emphasis on meta-analysis has often revealed that we actually have more stable and useful findings than is apparent from a perusal of the conflicts in our journals.
>
> (Stanovich & Stanovich , 2003, p.16-18)

This white paper is based on the findings reported in *A Theory-Based Meta-Analysis of Research on Instruction* (Marzano, 1998).
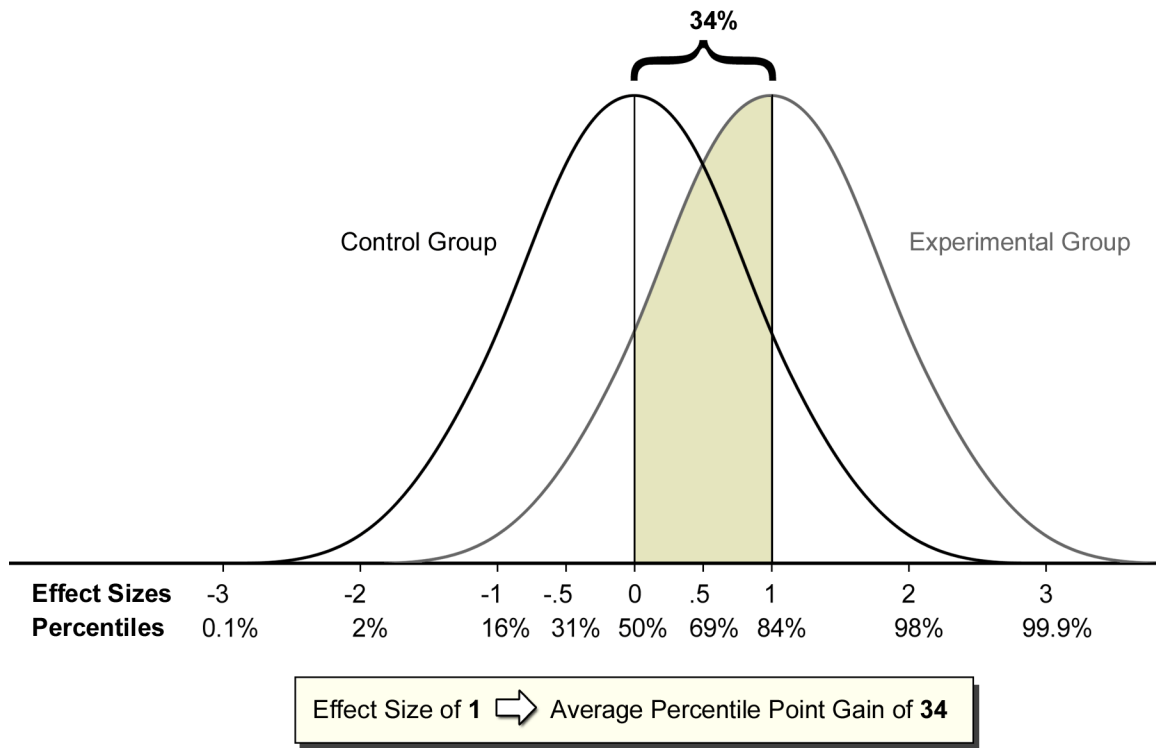
2. Research-validated instructional techniques

Using the summarized findings of over 100 research studies involving 4,000+ experimental/control group comparisons, the Marzano (1998) meta-analysis identified instructional techniques that had a positive impact on student achievement. This was done by calculating an *effect size* for each technique. Effect sizes are used in meta-analyses in order to synthesize results across numerous studies and arrive at an estimate of the typical effectiveness of a given technique. Effect sizes also enable researchers to compare the relative effectiveness of different techniques against each other.

Representing new knowledge in **graphic/nonlinguistic formats**

Using **computer-based manipulatives** to explore and practice using new knowledge

Generating and testing hypotheses about new knowledge

Teaching students new knowledge **directly through demonstration and explanation**
Students **applying it** to different situations and contexts **on their own**

Instructional techniques that have been proven effective through meta-analysis

The four instructional techniques in the graphic above were all shown to have an effect size greater than 1. An effect size that exceeds 1 means that the average student who benefited from a given instructional technique **outscored more than 84%** of students in control groups. Therefore, an average increase in student achievement of **more than 34 percentile points** is attributable to each of these four techniques.

34%

Control Group

Experimental Group

Effect Sizes	-3	-2	-1	-.5	0	.5	1	2	3
Percentiles	0.1%	2%	16%	31%	50%	69%	84%	98%	99.9%

Effect Size of **1** ⟹ Average Percentile Point Gain of **34**

The effectiveness of these techniques likely comes as no surprise to experienced educators. For them, the results of the Marzano meta-analysis may only serve to confirm and validate what they have informally observed to be effective in their own classrooms over the years. However, a pragmatic gap often exists between what a teacher knows to be effective and what is possible for her to realistically implement in the classroom on a consistent basis. A common barrier inhibiting teachers from regularly and effectively deploying these research-validated techniques are the teaching tools at their disposal. Textbooks, whiteboards, video/film and overhead projectors support relatively passive student learners much more easily than they do active learning involving manipulatives, student-generated hypotheses, and so forth. As a result, even though teachers may have always suspected or known that these techniques were instructionally effective, the ever-present time crunch in the classroom may have precluded extensive use of them.

The next section of this white paper shows how ExploreLearning's computer-based interactive simulations ("Gizmos®") are specifically designed to implement these research-validated instructional techniques in an effective and efficient manner.

## 2.1 Representing new knowledge in graphic/nonlinguistic formats

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META-ANALYSIS RESEARCH SUMMARY: IMAGE-BASED REPRESENTATIONS

Having students represent new knowledge in graphic/nonlinguistic formats results in an average percentile point gain of 39% (ES 1.24).

SOURCE: Marzano (1998), p.106

Research in cognitive psychology indicates that our brains store knowledge using both words *and* images. Instruction that targets and engages both of these systems of representation has been shown to significantly increase students' comprehension and retention. In mathematics, for example, constructing basic fraction models helps middle school students quickly see why the fractions $\frac{2}{3}$ and $\frac{4}{6}$ are equivalent:
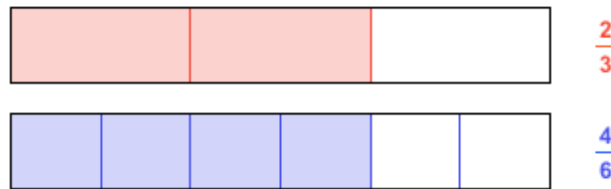

Visual model of equivalent fractions

Nonlinguistic representations also provide strong support for more advanced mathematical concepts in algebra, geometry, statistics and calculus. When learning how to find a line of best fit for a data set, for example, students need to understand that the least squares method calculates the total error for a given line using the sum of the squared deviations between that line and each value in the data set. The *Least-Squares Best Fit Lines* Gizmo has been designed to help students visualize this concept. In this Gizmo, squares are connected between each of the data points on the graph and the line being fitted to them. A given square's area therefore represents the squared vertical distance (i.e., the squared deviation) between the associated data value and the current line. [See screenshot on following page.]

As students adjust the line's slope and y-intercept, the error squares' areas are immediately and continuously updated, as is a numerical display of the total error (i.e., the combined area of the error squares). This real-time updating allows students to manually fit a line by incrementally adjusting the slope and y-intercept of the line until the total error is minimized. [The slope and intercept can be varied by typing in new values, by adjusting sliders, or by dragging the line on the graph.] By trying to fit lines to data sets that have no linear relationship as well those that have strong linear relationships, students observe that regression lines are only reliable predictors of values in data sets that exhibit linear relationships. The Gizmo's interactive display thereby provides students with a nonlinguistic representation of both the least squares method and the degree of linear association between two variables.
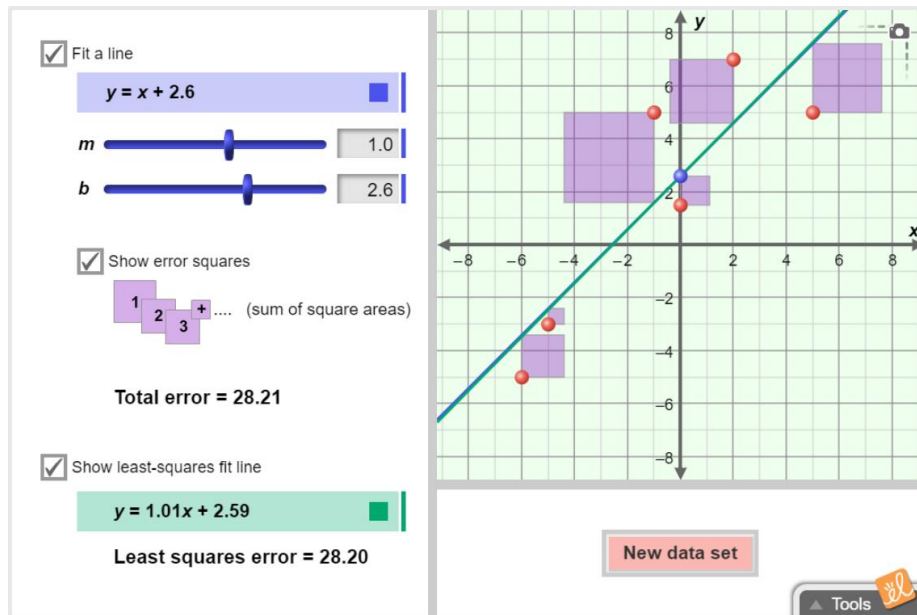
Gizmo: Least-Squares Best Fit Lines

An added advantage of the visualization in this Gizmo is that students can directly manipulate individual data points by dragging them on the graph. This allows them to witness the effect an outlier in a small data set can have on a line of best fit calculated using the least squares method.
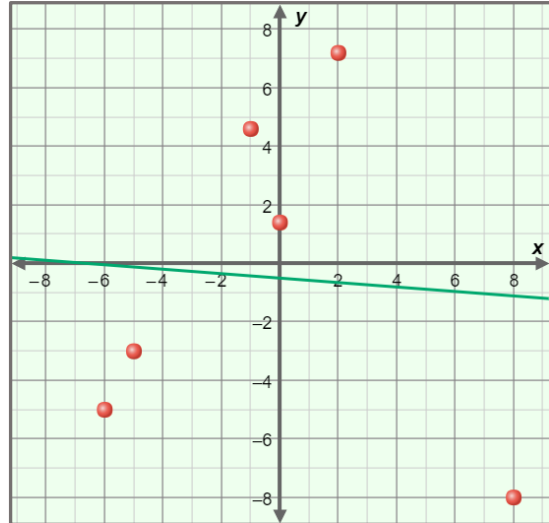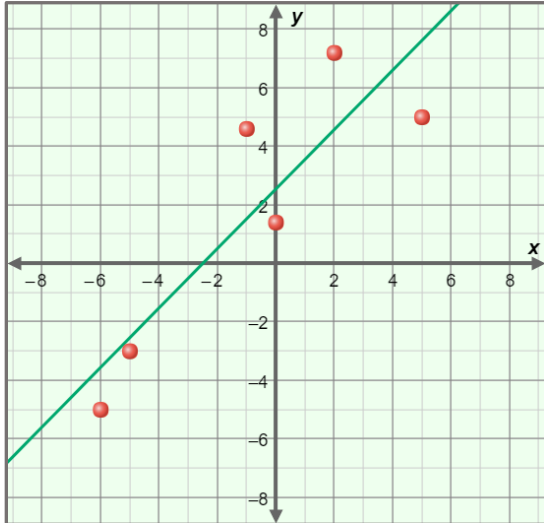
The power of these types of interactive animations is not limited to mathematics. There are numerous topics within the sciences that can be more effectively taught when they are supported by computer-based visual models. For example, interactive animations can help students to:

- Visualize the flow of current in an electrical circuit they have designed themselves;

- Study the process of triangulation in determining an earthquake's epicenter;

- Identify the role of the Sun and Moon in the fluctuation of ocean tides.

Gizmo: Circuits

Gizmo: Earthquakes 2 - Determination of Epicenter

Gizmo: Tides

When students are guided in generating and exploring nonlinguistic representations, the research shows that the effects on achievement are dramatic. As noted by Marzano in his meta-analysis, explicitly engaging students in the creation and usage of nonlinguistic representation has even been shown to stimulate and increase activity in the brain (Gerlic & Jausovec, 1999).

Unfortunately, research on actual classroom practice has also consistently shown a predominant emphasis on linguistic presentations of new knowledge to students (Marzano, Gaddy & Dean, 2000). Although many math and science textbooks have increased the number of images, diagrams, and other graphics on their pages in recent years, the fact that these visual representations cannot incorporate motion or be interactive constrains their instructional power. The pressure on educational publishers to keep page counts down in order to control costs also places a limit on the number of visuals that can be feasibly included in print-based materials. Although most teachers incorporate a certain number of visual representations into their teaching using whiteboards or overheads, it is often cumbersome and time-consuming to use these tools to enrich instruction with visuals in a comprehensive manner. From a practical standpoint, computer-based simulations are the ideal medium for visualizations of mathematical and scientific concepts.

An additional benefit of ExploreLearning's visual models is that they are user-manipulable, unlike video or film. Gizmos enable teachers and students to quickly progress through many different concepts or scenarios in a single session, dramatically expanding the range of what can be shown, explained, and explored in the classroom. Classroom discussions become more interactive and responsive to students' specific interests and difficulties, since their questions can be immediately examined and answered using manipulable visual models. Then, when students are studying on their own, Gizmos let them become active and engaged learners rather than passive observers of sequences of images in a textbook.

Research also shows how teachers can help students take full advantage of nonlinguistic representations by guiding them to incorporate visual models, diagrams and images into their study habits. The *What Works in Classroom Instruction* report (Marzano, Gaddy & Dean, 2000, p.40-47) stresses the importance of including diagrams and other images in note-taking:

> A very flexible note-taking strategy…is referred to as a *combination technique*….To use this note-taking strategy, students must stop periodically and make a graphic representation of their notes or portray the information in some visual way. At the end of their note-taking, or periodically throughout the process, students record summary statements of what they have learned….This note-taking method takes extra time, but is very useful because students review the information a number of times — first, as they record their notes; second, as they create drawings or other graphics for their notes; and third, as they record summary statements of what they have learned.
>
> …one of the common misconceptions about note-taking is that "less is more."…Researchers Nye, Crooks, Powlie, and Tripp (1984) explain that their examination of guides prepared by universities to teach students how to take notes found that "five out of ten guides examined emphasized the importance of keeping notes 'brief' and not putting too much material in notes" (p. 95). Yet, in their study of the effects of note-taking, Nye et al. found *a very strong relationship between the amount of information taken in notes and students' achievement on examinations*. (Emphasis ours.)

Note-taking strategies such as the combination technique are supported by the 'Copy Screen' button that is included in every ExploreLearning Gizmo. This button places a screenshot of the Gizmo into the computer's clipboard. [Many Gizmos also include 'camera' buttons that allow individual graphs or diagrams to be copied as well.] This enables students to quickly and easily

paste images they generate using Gizmos into their notes or assignments. Teachers can also use this feature to add customized images to their own course materials or tests.

In summary, ExploreLearning Gizmos allow teachers to richly infuse their mathematics and science courses with high-quality, easy-to-use visual models.

2.2 Using manipulatives to explore new knowledge and practice applying it

META-ANALYSIS RESEARCH SUMMARY: COMPUTER-BASED MANIPULATIVES

Overall, the use of manipulatives is associated with an average percentile point gain of 31% (ES .89). The specific use of computer simulations as manipulatives, however, produced the highest effect size (ES 1.45), corresponding to an average percentile point gain of 43%.

SOURCE: Marzano (1998), p.91

Manipulatives are concrete or symbolic artifacts that students interact with while learning new topics. They are powerful instructional aids because they enable active, hands-on exploration of abstract concepts. New mathematics and science (as well as ELA/literacy) standards and practices recognize the value of using models and simulations to build knowledge and skills.

Selected new standards related to simulations

Mathematical Practices
(5) Use appropriate tools strategically. When making mathematical models, [students] know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data.

Mathematics, Grade 3
3.NF.3.b Recognize and generate simple equivalent fractions, e.g., 1/2 = 2/4, 4/6 = 2/3). Explain why the fractions are equivalent, e.g., by using a visual fraction model.

Mathematics, Grades 9-12
F-IF.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases*.*

Science and Engineering Practices
(1) Asking questions and defining problems. Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Physical Science, Grades 6-8
MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.]

Life Sciences, Grades 9-12
HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: Examples of models could include simulations and mathematical models.]

ELA/Literacy
RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Research has shown that computer-based manipulatives are even more effective than ones involving physical objects. Some of the reasons for this increased effectiveness are outlined by Clements & McMillen (1996):

Computer manipulatives link the concrete and the symbolic by means of feedback.
For example, a major advantage of the computer is the ability to associate active experience with manipulatives to symbolic representations. The computer connects manipulatives that students make, move, and change with numbers and words. Many students fail to relate their actions on manipulatives with the notation system used to describe these actions. The computer links the two.

Computer manipulatives dynamically link multiple representations.
Such computer links can help students connect many types of representations, such as pictures, tables, graphs, and equations…[allowing] students to see immediately the changes in a graph as they change data in a table. These links can also be dynamic. Students might stretch a computer geoboard's rectangle and see the measures of the sides, perimeter, and area change with their actions.

Computers change the very nature of the manipulative.
Students can do things [using computer-based manipulatives] that they cannot do with physical manipulatives.

The ExploreLearning library contains many examples of the optimal computer manipulative described by Clements and McMillen. For example, students learning about systems of linear equations can access several Gizmos that focus on this topic, such as *Solving Linear Systems (Standard Form)*. Using these Gizmos, they can manipulate lines in their algebraic form or by dragging them directly on a graph, and instantly see the results of their actions as each of the multiple representations updates in real-time.
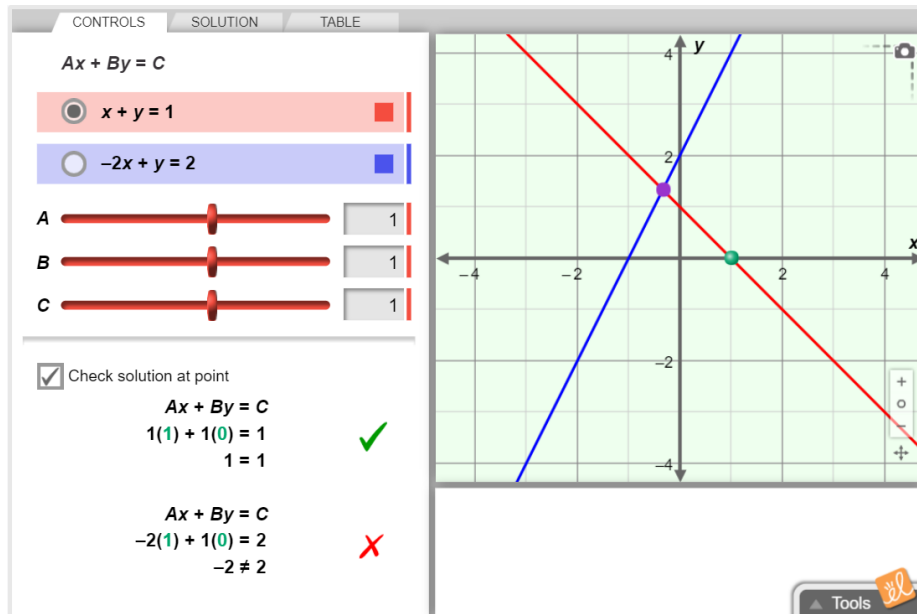
Gizmo: Solving Linear Systems (Standard Form)
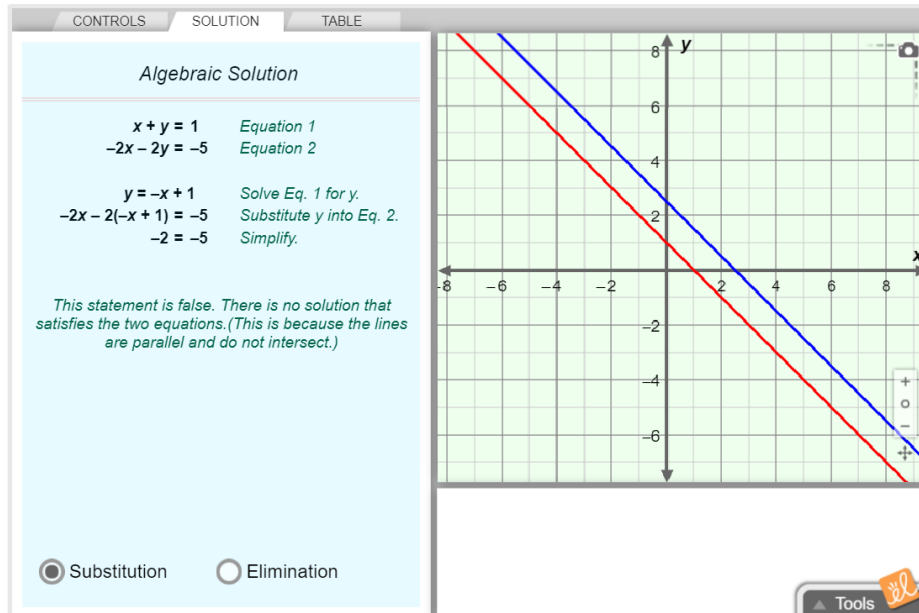
[Gizmo: Solving Linear Systems (Standard Form)](#)

This is one of the many benefits that interactive manipulatives such as Gizmos provide over graphing calculators. Since graphing calculators cannot dynamically update a graph or show more than one graph at a time, comparing and contrasting characteristics between graphs is much more difficult for the student. Accurate comparisons are dependent on the student's ability to remember the salient features of graphs that were previously seen. This problem is eliminated with Gizmos, where dynamic displays enable the student to see the results of their changes as they perform them. The ability to see more than one representation (algebraic, tabular, graphical) at the same time also facilitates comparisons between these representations.

Geometry is another area where the benefits of computer-based manipulatives are easily seen. The ExploreLearning library contains a broad selection of Gizmos that allow real-time manipulation of geometric shapes by students in the manner prescribed by the research literature. In the *Polygon Angle Sum* Gizmo, for example, students specify the number of sides of an onscreen polygon, vary its shape by dragging its vertices, and then explore the sum of its interior and exterior angles:

Gizmo: Polygon Angle Sum

The Gizmo also demonstrates how to divide student-generated polygons into triangles, enabling students to more easily see the relationship between the sum of the interior angles in the polygon and the number of sides it has:
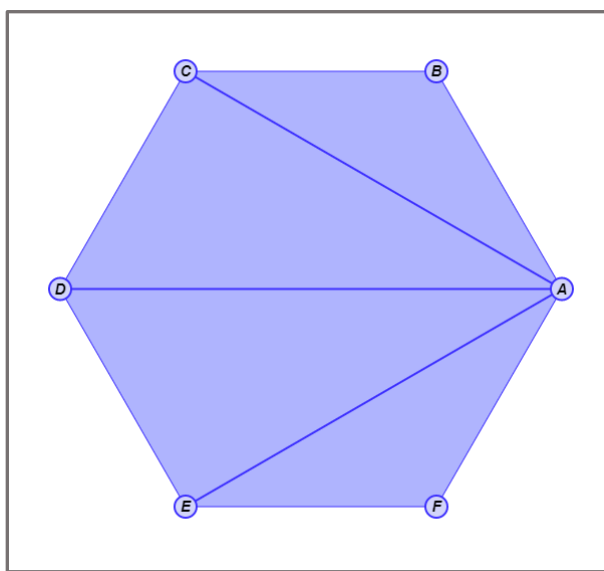
Dynamic, manipulable models of cylinders, pyramids, cones, and prisms are provided in the ExploreLearning library to support students in understanding the logic underlying formulas for calculating areas and volumes of three-dimensional objects:

Gizmo: Surface and Lateral Area of Prisms and Cylinders

In summary, ExploreLearning Gizmos are flexible computer-based manipulatives that serve as critical bridges between concrete and abstract thinking. They provide a high degree of interactivity, enabling students to immediately observe the results of their experimentation and be able to relate concepts across multiple representations.

2.3 Generating and testing hypotheses about new knowledge

META-ANALYSIS RESEARCH SUMMARY: HYPOTHESIS GENERATION & TESTING

Generating and testing hypotheses about new knowledge results in an average percentile point gain of 37% (ES 1.14).

SOURCE: Marzano (1998), p.106

Although computer-based manipulatives are powerful tools, students derive the greatest value from them when they are guided in their use. As noted by Clements & McMillen (1996), the full pedagogical power of the manipulative is achieved when students mindfully reflect on the actions they perform and how the manipulative responds to them.

The Student Exploration Sheet that accompany every Gizmo are designed to support and stimulate this type of mindful interaction. Although the Exploration Sheets use different formats (depending on the nature of the associated Gizmo), they all provide a sequence of activities that guide students in using and thinking about the manipulative. These activities are followed by a set of assessment items that evaluate each student's progress. The Gizmos system automatically scores these assessments and provides teachers with online progress reports.

A typical Exploration Sheet starts with students engaging in a set of exercises where they perform specific actions and record the results. Then, they are prompted to make predictions about new situations, after which they verify their answers using the Gizmo. For example, in the _Gizmo Translating and Scaling Functions_, students first individually vary the a, b, h and k parameters in a function in form $y = af(b(x - h)) + k$. After observing the effects of increasing and decreasing these parameters, they are asked to predict how the graph of $y = f(x) + 3$ will differ from the graph of $y = f(x)$. The Gizmo is used to verify their prediction.
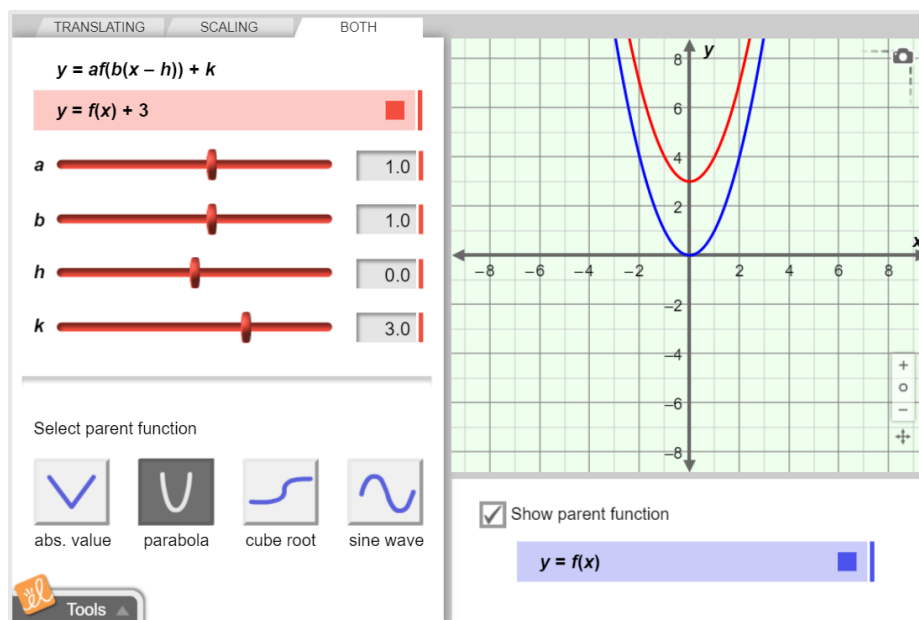
Gizmo: Translating and Scaling Functions

Other Student Exploration Sheets follow the format of typical science lab activities. In the *Seed Germination* Gizmo, for example, students are lead through a set of experiments where they vary the amount of water and light a group of seeds is exposed to, as well as the temperature of the seeds' incubator. Then, they observe the number of seeds that germinate into sprouts. In addition to learning about the effects the manipulated variables have on seed germination rates, students also develop firsthand experience with principles of experimental design – such as why scientists perform several trials of an experiment and then average the results, and how they isolate the effects of individual variables as well as study their combined impact. The Exploration Sheet highlights these important aspects of scientific inquiry, and guides students in evolving and refining their hypotheses through careful experimentation.

Gizmo: Seed Germination

Using Gizmos in conjunction with their associated Student Exploration Sheets, students can generate and test a very wide range of hypotheses quickly and safely, without the need to set up and configure any physical apparatus. Science Gizmos can also serve as invaluable preparatory tools before students perform lengthy experiments with real equipment in labs.

2.4 Direct presentation, followed by application

META-ANALYSIS RESEARCH SUMMARY: PRESENTATION FOLLOWED BY APPLICATION

Demonstrating new concepts to students in a direct fashion and then having them apply the concepts to different situations is an effective instructional sequence.

- Initial direct presentation of conceptual categories, generalizations, and principles is associated with an average percentile point gain of 49% (ES = 2.55).

- Having students apply conceptual categories, generalizations, and principles to new situations after being taught them is associated with an average percentile point gain of 38% (ES = 1.16).

SOURCE: Marzano (1998), p.106

Although the Student Exploration Sheets that accompany all ExploreLearning Gizmos permit them to be used by students in a self-directed manner, this is not the only way in which Gizmos are designed to be used. As the Marzano (1998) meta-analysis notes, students learn effectively and efficiently when they are first taught new conceptual categories, generalizations, and principles directly, only after which they apply them on their own. Ideally, then, educational software should support this instructional sequence by serving two main objectives: first, it should support teachers in presenting new knowledge to students, and second, it should support students in applying and extending what they have learned on a more individual basis.

Most educational software products, however, are designed exclusively for use by individual students in extended tutorial-style one-on-one sessions, with no explicit role for the teacher. This kind of software is cumbersome or impossible to integrate directly into classroom teaching as a demonstration or explanation aid. As a result, these products provide little or no support to teachers when they are first introducing a topic to their students, or when they are trying to stimulate classroom discussion. Furthermore, when a set tutorial is integrated within the software, teachers cannot flexibly differentiate the level or focus of instruction for different groups of students.

ExploreLearning Gizmos, on the other hand, are highly modular and flexible. They are designed to fit the needs of a broad range of teachers and instructional settings, regardless of whether a classroom has a single computer connected to an overhead projector or whether there is one computer per student. Teachers can integrate Gizmos as presentation aids when they are first teaching a topic to their students, then use them to anchor and stimulate classroom discussions, and finally have students apply and practice new concepts and skills on their own through the Gizmo.

For example, using the [Gizmo *Free-Fall Laboratory*](), teachers can quickly discuss and demonstrate the effect of varying parameters in an experiment, and then have students make conjectures about the results:
1. The teacher tells her students that she is going to simulate a tennis ball dropping through a 12-meter tube containing a vacuum. She uses the *Free-Fall Laboratory* Gizmo (projected on a screen at the front of her class) to demonstrate this scenario and show the graphs of position, velocity and acceleration that result.

2. Next, she asks the students how the graphs might change if the tube was filled with air instead of a vacuum. She directs the students to sketch their ideas.

3. Using the Gizmo, she quickly performs a trial involving a 12-meter air-filled tube, and students compare the Gizmo's graphs to the ones they generated. The class discusses the results.

4. The class moves on to consider how the graphs would change if the object dropped was a shuttlecock rather than a tennis ball, or if the drop distance was shortened or lengthened.
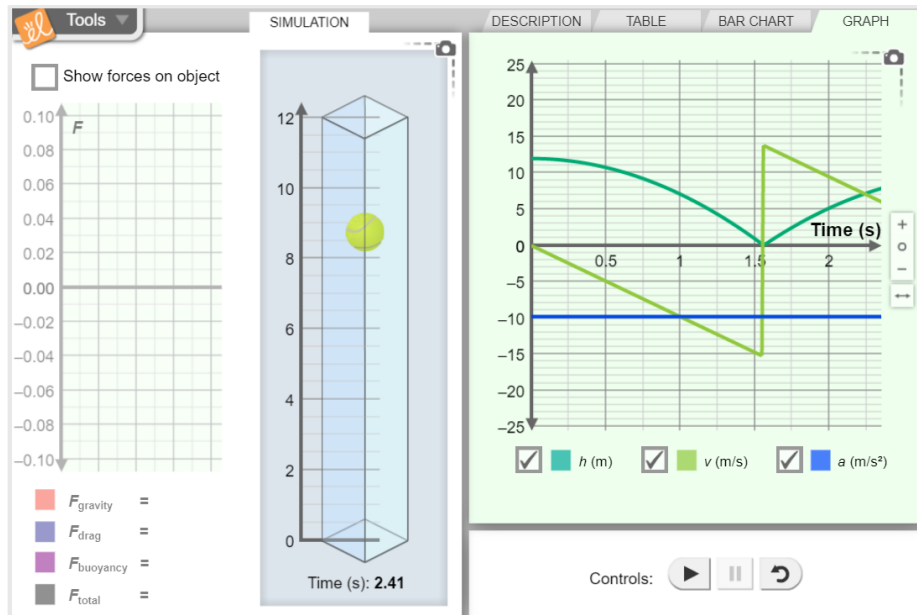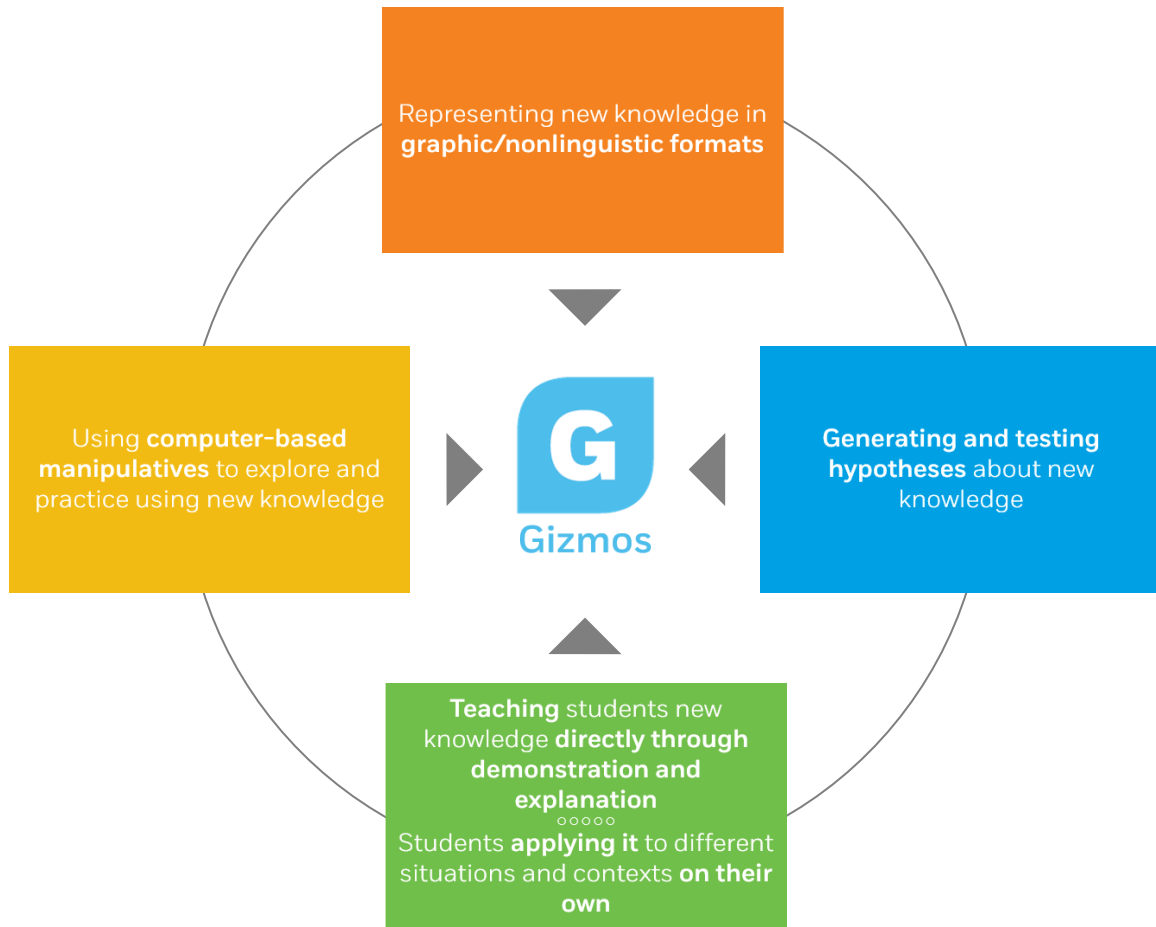

Gizmo: Free-Fall Laboratory

Teachers who already integrate demonstrations with physical objects into their teaching will find that Gizmos allow them to do a greater number of more varied demonstrations in the same amount of time. Teachers who are unaccustomed to incorporating demonstrations into their teaching will need to do a certain degree of preparation and planning before using Gizmos in this manner, as this will represent a departure from the presentation style they are accustomed to. It is important to bear in mind, however, that the Student Exploration Sheets that accompany each Gizmo provide teachers with a very convenient way to add Gizmos to their lesson plans. The ready-made exercises and integrated assessment that the Exploration Sheets contain means that advance preparation is never required on the teacher's part. This ensures that all teachers can use Gizmos in their classrooms quickly and easily, and that students can benefit from these learning tools immediately. Over time, as Gizmos become more familiar instructional tools, teachers can begin to integrate them more fully into their own teaching styles, and thereby realize the full potential of this new form of interactive content.

3. Summary

Meta-analysis of the research literature has identified broad scientific evidence for the effectiveness of certain instructional techniques. ExploreLearning's comprehensive library of mathematics and science Gizmos brings these powerful instructional techniques to the classroom in a convenient, easy-to-use format that makes them practical and efficient as well as effective.

Representing new knowledge in **graphic/nonlinguistic formats**

G

Gizmos

Using **computer-based manipulatives** to explore and practice using new knowledge

Generating and testing hypotheses about new knowledge

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Students **applying it** to different situations and contexts **on their own**

Instructional techniques that have been proven effective through meta-analysis

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Complete List of ExploreLearning Gizmos

Updated Spring 2019

2D Collisions
2D Eclipse
3D and Orthographic Views
3D Eclipse

Absolute Value Equations and Inequalities
Absolute Value with Linear Functions
Adding and Subtracting Integers
Adding and Subtracting Integers with Chips
Adding Fractions (Fraction Tiles)
Adding on the Number Line
Adding Vectors
Adding Whole Numbers and Decimals (Base-10 Blocks)
Addition and Subtraction of Functions
Addition of Polynomials
Additive Colors
Advanced Circuits
Air Track
Ants on a Slant (Inclined Plane)
Archimedes' Principle
Area of Parallelograms
Area of Triangles
Arithmetic and Geometric Sequences
Arithmetic Sequences
Atwood Machine
Average Atomic Mass

Balancing Blocks (Volume)
Balancing Chemical Equations
Basic Prism
Beam to Moon (Ratios and Proportions)
Beam to Moon (Ratios and Proportions) - metric
Biconditional Statements
Big Bang Theory - Hubble's Law
Binomial Probabilities
Bohr Model of Hydrogen
Bohr Model: Introduction
Box-and-Whisker Plots
Boyle's Law and Charles' Law
Building DNA
Building Pangaea
Building Topographic Maps

Calorimetry Lab
Cannonball Clowns (Number Line Estimation)
Carbon Cycle
Cargo Captain (Multi-digit Subtraction)

Cat and Mouse (Modeling with Linear Systems)
Cat and Mouse (Modeling with Linear Systems) - metric
Cell Division
Cell Energy Cycle
Cell Structure
Cell Types
Center of Mass
Charge Launcher
Chemical Changes
Chemical Equations
Chicken Genetics
Chocomatic (Multiplication, Arrays, and Area)
Chords and Arcs
Circles
Circuit Builder
Circuits
Circulatory System
Circumference and Area of Circles
City Tour (Coordinates)
Cladograms
Classifying Quadrilaterals
Classifying Triangles
Coastal Winds and Clouds
Coastal Winds and Clouds - metric
Colligative Properties
Collision Theory
Color Absorption
Comparing and Ordering Decimals
Comparing Climates (Customary)
Comparing Climates (Metric)
Comparing Earth and Venus
Compound Inequalities
Compound Interest
Concurrent Lines, Medians, and Altitudes
Conditional Statements
Conduction and Convection
Congruence in Right Triangles
Constructing Congruent Segments and Angles
Constructing Parallel and Perpendicular Lines
Coral Reefs 1 - Abiotic Factors
Coral Reefs 2 - Biotic Factors
Correlation
Cosine Function
Coulomb Force (Static)
Covalent Bonds

Critter Count (Modeling Multiplication)

Dehydration Synthesis
Density
Density Experiment: Slice and Dice
Density Laboratory
Density via Comparison
Describing Data Using Statistics
Determining a Spring Constant
Determining Density via Water
Displacement
Dichotomous Keys
Diffusion
Digestive System
Dilations
Direct and Inverse Variation
Disease Spread
Distance Formula
Distance-Time and Velocity-Time Graphs
Distance-Time and Velocity-Time Graphs - Metric
Distance-Time Graphs
Distance-Time Graphs - Metric
Dividing Exponential Expressions
Dividing Fractions
Dividing Mixed Numbers
Dividing Polynomials Using Synthetic Division
DNA Analysis
Doppler Shift
Doppler Shift Advanced
Drug Dosage
Dye Elimination

Earthquakes 1 - Recording Station
Earthquakes 2 - Determination of Epicenter
Eclipse
Effect of Environment on New Life Form
Effect of Temperature on Gender
Effect of Temperature on Gender - metric
Elapsed Time
Electromagnetic Induction
Electron Configuration
Element Builder
Elevator Operator (Line Graphs)
Ellipses
Embryo Development
Energy Conversion in a System
Energy Conversions
Energy of a Pendulum
Enzymes (STEM Case)
Equilibrium and Concentration
Equilibrium and Pressure
Equivalent Algebraic Expressions I
Equivalent Algebraic Expressions II
Equivalent Fractions (Fraction Tiles)

Erosion
Erosion Rates
Estimating Population Size
Estimating Sums and Differences
Evolution (STEM Case)
Evolution: Mutation and Selection
Evolution: Natural and Artificial Selection
Exploring Linear Inequalities in One Variable
Exponential Functions
Exponential Growth and Decay
Exponents and Power Rules

Factor Trees (Factoring Numbers)
Factoring Special Products
Fan Cart Physics
Fast Plants® 1 – Growth and Genetics
Feel the Heat
Fido's Flower Bed (Perimeter and Area)
Finding Factors with Area Models
Finding Patterns
Flower Pollination
Food Chain
Force and Fan Carts
Forest Ecosystem
Fraction Artist 1 (Area Models of Fractions)
Fraction Artist 2 (Area Models of Fractions)
Fraction Garden (Comparing Fractions)
Fraction, Decimal, Percent (Area and Grid Models)
Fractions Greater than One (Fraction Tiles)
Fractions with Unlike Denominators
Free Fall Tower
Free-Fall Laboratory
Freezing Point of Salt Water
Function Machines 1 (Functions and Tables)
Function Machines 2 (Functions, Tables, and Graphs)
Function Machines 3 (Functions and Problem Solving)

General Form of a Rational Function
Genetic Engineering
Geometric Probability
Geometric Sequences
Germination
GMOs and the Environment
Golf Range
Graphing Skills
Graphs of Derivative Functions
Graphs of Polynomial Functions
Gravitational Force
Gravity Pitch
Greenhouse Effect
Greenhouse Effect - metric
Growing Plants

Half-life
Hardy-Weinberg Equilibrium
Hearing: Frequency and Volume
Heat Absorption
Heat Transfer by Conduction
Herschel Experiment
Herschel Experiment - metric
Histograms
Holiday Snowflake Designer
Homeostasis
Honeybee Hive
Household Energy Usage
H-R Diagram
Human Evolution - Skull Analysis
Human Homeostasis
Human Karyotyping
Hurricane Motion
Hurricane Motion - metric
Hyperbolas

Identifying Nutrients
Improper Fractions and Mixed Numbers
Inclined Plane - Rolling Objects
Inclined Plane - Simple Machine
Inclined Plane - Sliding Objects
Independent and Dependent Events
Inheritance
Inscribed Angles
Integers, Opposites, and Absolute Values
Introduction to Exponential Functions
Introduction to Functions
Investigating Angle Theorems
Ionic Bonds
Isosceles and Equilateral Triangles
Isotopes

Laser Reflection
Least-Squares Best Fit Lines
Levers
Limiting Reactants
Linear Functions
Linear Inequalities in Two Variables
Linear Programming
Logarithmic Functions
Logarithmic Functions: Translating and Scaling
Longitudinal Waves
Lucky Duck (Expected Value)

Magnetic Induction
Magnetism
Mascot Election (Pictographs and Bar Graphs)
Mean, Median, and Mode
Measuring Motion
Measuring Trees

Measuring Volume
Meiosis
Melting Points
Meowsis (STEM Case)
Microevolution
Mineral Identification
Modeling and Solving Two-Step Equations
Modeling Decimals (Area and Grid Models)
Modeling Fractions (Area Models)
Modeling One-Step Equations
Modeling the Factorization of ax2+bx+c
Modeling the Factorization of x2+bx+c
Modeling Whole Numbers and Decimals (Base-10 Blocks)
Moment of Inertia
Moonrise, Moonset, and Phases
Mouse Genetics (One Trait)
Mouse Genetics (Two Traits)
Movie Reviewer (Mean and Median)
Multiplying Decimals (Area Model)
Multiplying Exponential Expressions
Multiplying Fractions
Multiplying Mixed Numbers
Multiplying with Decimals
Mystery Powder Analysis

Natural Selection
No Alien Left Behind (Division with Remainders)
Nuclear Decay
Nuclear Reactions
Number Line Frog Hop (Addition and Subtraction)
Number Systems

Observing Weather (Customary)
Observing Weather (Metric)
Ocean Mapping
Ocean Tides
Operations with Radical Expressions
Orbital Motion - Kepler's Laws
Order of Operations
Ordering and Approximating Square Roots
Ordering Percents, Fractions, and Decimals Greater Than 1
Osmosis

Parabolas
Parallel, Intersecting, and Skew Lines
Parallelogram Conditions
Paramecium Homeostasis
Part-to-part and Part-to-whole Ratios
Pattern Finder
Pattern Flip (Patterns)
Pendulum Clock
Penumbra Effect

Percent of Change
Percents and Proportions
Percents, Fractions, and Decimals
Perimeter and Area of Rectangles
Perimeters and Areas of Similar Figures
Period of a Pendulum
Period of Mass on a Spring
Periodic Trends
Permutations and Combinations
pH Analysis
pH Analysis: Quad Color Indicator
Phase Changes
Phased Array
Phases of the Moon
Phases of Water
Photoelectric Effect
Photosynthesis (STEM Case)
Photosynthesis Lab
Pith Ball Lab
Plants and Snails
Plate Tectonics
Points in the Complex Plane
Points in the Coordinate Plane
Points, Lines, and Equations
Point-Slope Form of a Line
Pollination: Flower to Fruit
Polling: City
Polling: Neighborhood
Polygon Angle Sum
Polynomials and Linear Factors
Pond Ecosystem
Populations and Samples
Porosity
Potential Energy on Shelves
Prairie Ecosystem
Prisms and Cylinders
Probability Simulations
Proportions and Common Multipliers
Proving Triangles Congruent
Pulley Lab
Pulleys
Pyramids and Cones
Pythagorean Theorem
Pythagorean Theorem with a Geoboard

Quadratic Inequalities
Quadratics in Factored Form
Quadratics in Polynomial Form
Quadratics in Vertex Form
Quilting Bee (Symmetry)

Rabbit Population by Season
Radiation
Radical Functions
Rainfall and Bird Beaks
Rainfall and Bird Beaks - metric

Rational Functions
Rational Numbers, Opposites, and Absolute Values
Ray Tracing (Lenses)
Ray Tracing (Mirrors)
Reaction Energy
Reaction Time 1 (Graphs and Statistics)
Reaction Time 2 (Graphs and Statistics)
Reading Topographic Maps
Real-Time Histogram
Reflections
Refraction
Relative Humidity
Reverse the Field
Riemann Sum
Ripple Tank
River Erosion
RNA and Protein Synthesis
Road Trip (Problem Solving)
Rock Art (Transformations)
Rock Classification
Rock Cycle
Roller Coaster Physics
Roots of a Quadratic
Rotations, Reflections, and Translations
Rounding Whole Numbers (Number Line)

Seasons Around the World
Seasons in 3D
Seasons: Earth, Moon, and Sun
Seasons: Why do we have them?
Seed Germination
Segment and Angle Bisectors
Senses
Shoot the Monkey
Sight vs. Sound Reactions
Similar Figures
Similarity in Right Triangles
Simple Harmonic Motion
Simplifying Algebraic Expressions I
Simplifying Algebraic Expressions II
Simplifying Radical Expressions
Simplifying Trigonometric Expressions
Sine Function
Sine, Cosine, and Tangent Ratios
Sled Wars
Slope
Slope-Intercept Form of a Line
Solar System
Solar System Explorer
Solubility and Temperature
Solving Algebraic Equations I
Solving Algebraic Equations II
Solving Equations by Graphing Each Side
Solving Equations on the Number Line
Solving Formulas for any Variable

Solving Linear Inequalities in One Variable
Solving Linear Systems (Matrices and Special Solutions)
Solving Linear Systems (Slope-Intercept Form)
Solving Linear Systems (Standard Form)
Solving Two-Step Equations
Solving Using Trend Lines
Sound Beats and Sine Waves
Special Parallelograms
Spin the Big Wheel! (Probability)
Square Roots
Standard Form of a Line
Star Spectra
Stem-and-Leaf Plots
Stoichiometry
Subtracting Whole Numbers and Decimals (Base-10 Blocks)
Subtractive Colors
Sum and Difference Identities for Sine and Cosine
Summer and Winter
Sums and Differences with Decimals
Surface and Lateral Areas of Prisms and Cylinders
Surface and Lateral Areas of Pyramids and Cones
Systems of Linear Inequalities (Slope-intercept form)

Tangent Function
Target Sum Card Game (Multi-digit Addition)
Temperature and Particle Motion
Temperature and Sex Determination
Temperature and Sex Determination - Metric
Theoretical and Experimental Probability
Tides
Tides - metric
Time Estimation
Titration
Torque and Moment of Inertia
Toy Factory (Set Models of Fractions)
Translating and Scaling Functions
Translating and Scaling Sine and Cosine Functions
Translations
Treasure Hunter (Decimals on the Number Line)
Trebuchet
Trends in Scatter Plots
Triangle Angle Sum
Triangle Inequalities
Triple Beam Balance

Uniform Circular Motion
Unit Conversions

Unit Conversions 2 - Scientific Notation and Significant Digits
Using Algebraic Equations
Using Algebraic Expressions

Vectors
Virus Lytic Cycle

Water Cycle
Water Pollution
Waves
Weather Maps
Weather Maps - metric
Weathering
Weight and Mass
Wheel and Axle
Whole Numbers with Base-10 Blocks

Zap It! Game