

WHY Gizmos WORK: *Research Evidence*



Summary: Based on the summarized findings of over 100 educational research studies involving 4,000+ experimental/control group comparisons, a meta-analytical study (Marzano, 1998) identified several instructional techniques that have a strong positive impact on student achievement. ExploreLearning's white paper, *Why Gizmos Work: Empirical Evidence for the Instructional Effectiveness Of ExploreLearning's Interactive Content*, demonstrates how math and science Gizmos bring these powerful instructional techniques to the classroom in a convenient, easy-to-use format.



Meta-analysis of educational research identifies effective instructional techniques

In a meta-analysis (Marzano, 1998) that summarized findings from over 100 research studies involving 4,000+ experimental/control group comparisons, the following instructional techniques were all shown to have an average effect size greater than 1 (i.e., a percentile gain of more than 34% in students' achievement):

1. Representing new knowledge in graphic/nonlinguistic formats
2. Using manipulatives to explore new knowledge and practice applying it
3. Generating and testing hypotheses about new knowledge
4. Direct presentation of new knowledge, followed by application

1. Representing New Knowledge in Graphic/Nonlinguistic Formats

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. Explicitly engaging students in the creation and usage of nonlinguistic representations has even been shown to stimulate and increase activity in the brain.

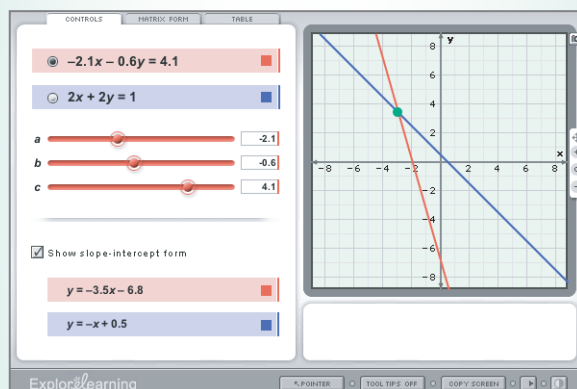
Gizmos provide teachers with a ready-made path for harnessing the power of visual imagery in instruction. ExploreLearning.com contains literally hundreds of interactive visual models for topics in both math and science. For example, there are Gizmos that help students:

- visualize the flow of current in an electrical circuit they have designed themselves (*The Circuits Gizmo*);
- study the process of triangulation in determining an earthquake's epicenter (*Earthquake - Determination of Epicenter Gizmo*);
- identify the role of the Sun and Moon in the fluctuation of ocean tides (*The Tides Gizmo*).

2. Using Manipulatives to Explore New Knowledge and Practice Applying It

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. Research has shown that computer-based manipulatives are even more effective than ones involving physical objects, in part because they can dynamically link multiple representations together.

For example, students learning about systems of linear equations can use ExploreLearning's Gizmos to manipulate lines and instantly see the results of their actions as each of the multiple representations updates in real-time.



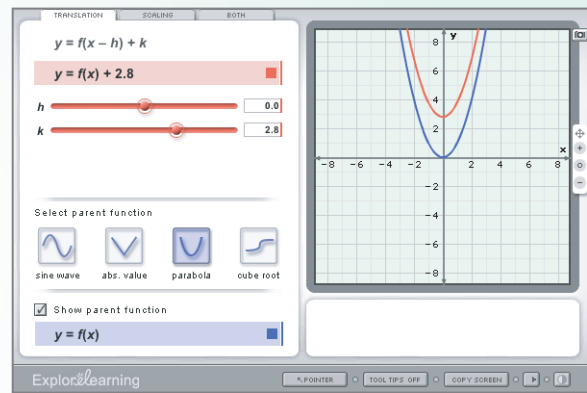
This is one of the many benefits that interactive manipulatives such as Gizmos provide over graphing calculators. Since graphing calculators cannot dynamically update a graph or show more than one graph at a time, comparing and contrasting characteristics between graphs is much more difficult for the 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, whose 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.



3. Generating and Testing Hypotheses About New Knowledge

Although research has shown that computer-based manipulatives are powerful tools, it has also shown that students derive the greatest value from them when they are guided in their use. The full pedagogical power of the manipulative is only achieved when students mindfully reflect on the actions they perform and how the manipulative responds to them.

The Exploration Guides that accompany every Gizmo are designed to support and stimulate this type of mindful interaction. A typical Exploration Guide 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.



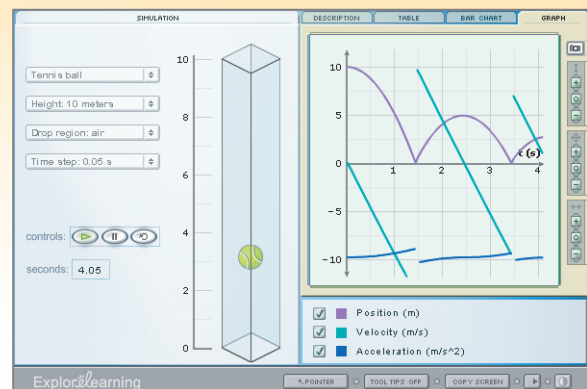
For example, in the Gizmo Translating and Scaling Functions, students first individually vary the a , b , h and k parameters in a function in form $y = af(b(x - h)) + k$. After observing the effects of increasing and decreasing these parameters, they are asked to predict how the graph of $y = f(x) + 3$ will differ from the graph of $y = f(x)$. The Gizmo is used to verify their prediction.

4. Direct Presentation of New Knowledge, Followed by Application

The Marzano meta-analysis notes that students learn effectively and efficiently when new concepts are first taught directly to them, after which they practice applying the concepts 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.

For example, using the Gizmo Freefall 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. A teacher tells her students that she is going to simulate a tennis ball dropping through a 20 meter-high tube containing a vacuum. She uses the Freefall 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 20-meter air-filled tube, and students compare the Gizmo's graphs to the ones they generated. The class discusses the results.

The teacher could then have her students explore the simulation on their own. They could make predictions about the effect that changing the type of object dropped or the length of the tube would have on the graphs, and then conduct experiments to test their hypotheses.

Interact. Discover. Know.

Conclusion: Meta-analysis of the research literature has identified broad scientific evidence for the effectiveness of certain instructional techniques. **Why Gizmos Work:** Empirical Evidence for the Instructional Effectiveness of ExploreLearning's Interactive Content demonstrates how 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.

TO READ THE FULL STUDY *Why Gizmos Work: Empirical Evidence for the Instructional Effectiveness Of ExploreLearning's Interactive Content* in PDF format, **click on LEARN MORE** at www.explorelearning.com. Or, to receive a hard copy or a copy by email, contact us at sales@explorelearning.com or 1-866-882-4141