HOUGHTON MIFFLIN HARCOURT

A Research-Based Framework for *Houghton Mifflin Harcourt GO Math!*

Grades K–6

A Research-Based Framework for *Houghton Mifflin Harcourt GO Math!*

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The Research Base

When judging a mathematics program, it is imperative to understand the distinction between theories or expert opinion on how students learn and the research base that provides evidence to support such theories and opinions. This document illustrates how the *Houghton Mifflin Harcourt GO Math!* write-in student editions are based on the collective knowledge and expertise of noted scholars and educators as well as numerous research studies from various sources.

Background

The purpose of this report is to demonstrate clearly and explicitly the scientific research base **Houghton Mifflin Harcourt** utilized to develop the *Houghton Mifflin Harcourt GO Math!* student editions. Five major research strands underpin the program: Writing to Learn, Vocabulary, Scaffolding, Metacognition, and Graphic Organizers. These strands identify the key components of mathematics instruction identified by recent research.

To help readers make the connections between the research strands and our student editions, the following sections are used within each strand:

- **Defining the Strand.** This section summarizes the terminology and provides an overview of the research related to the strand.
- **Research that Guided the Development** of *Houghton Mifflin Harcourt GO Math!* student editions. This section identifies subtopics within each strand and provides excerpts from and summaries of relevant research on each subtopic.
- **From Research to Practice.** This section explains how the research data is exemplified in *Houghton Mifflin Harcourt GO Math!* student editions.

The combination of the major research recommendations and the related features of *Houghton Mifflin Harcourt GO Math!* student editions should help readers better understand how *Houghton Mifflin Harcourt GO Math!* incorporates research into its instructional design.

A complete bibliography of all works cited is provided at the end of this section.

Strand 1: Writing to Learn

Defining the Strand

For most students, writing is a fundamental part of school. Nearly all students are asked to engage in some sort of writing on a daily basis, and the writing they do is typically used to determine whether or not they know or understand something they have been taught. Producing pieces of writing in order to demonstrate skills, knowledge, and understandings is a common and valuable purpose for classroom writing. There is another purpose for writing in the classroom, however, that is equally as important – writing to learn.

Regardless of the content area, the very act of writing can help students to process new information, make sense of complex ideas, and connect to their prior knowledge and experiences (Knipper & Duggan, 2006). According to Vygotsky (1962), such cognitive functions as analyzing and synthesizing develop more fully through writing engagement. Lance and Lance (2006), who use the term "exploratory writing" to refer to writing that has as its goal idea investigation and discovery, contend that such writing encourages students to make sense of new ideas for which they do not yet have a solid understanding. Research has shown that learners become more engaged in the learning process when they are asked to explain and reflect on their thinking processes (Surbeck, 1994; Good & Whang, 1999; Hettich, 1976).

Often, in addition to or instead of writing, students choose to draw pictures in order to make sense of and reflect on new content. Research suggests "that through drawing [students] are not only able to see what they are thinking, they are also able to play around with and transform their ideas" (Brooks, 2009, p.319). Regardless of whether students represent their ideas in writing or through drawings, the very act of putting their ideas down on paper can help students work through confusion and make sense of complex ideas, ultimately contributing to their academic success.

Research that Guided the Development of the *Houghton Mifflin Harcourt GO Math!* Student Editions

Tiering and scaffolding: Two strategies for providing access to important mathematics

The purpose of this study was to determine whether students who wrote about their executive processes of problem-solving when solving math problems achieved at higher levels in mathematics than a control group that did not engage in the same type of writing. Results indicate that the students who wrote about their problem-solving processes made greater mathematical achievements than those who did not. The researchers conclude that "writing about the executive processes of problem-solving and the problem-solving process in general may not only improve students' problem-solving performance but may also help students more clearly understand the problem-solving process" (Williams, 2003, p. 187).

Writing in mathematics

Researchers have found that students' conceptual understanding and problem-solving skills improve when they are encouraged to make sense of mathematics by writing about… their mathematical thinking (Putnam, 2003).

Writing in mathematics

The results of this study suggest that students who often struggle to communicate their problem-solving processes and explain their mathematical reasoning orally can more easily do so in writing (Baxter, Woodward, & Olson, 2005).

Writing in mathematics

"Writing in math class … provide[s] a way for students to reflect on their own learning and to explore, extend, and cement their ideas about the mathematics they study" …it supports learning because it requires students to organize, clarify and reflect on their ideas." (Burns, 2004, p. 30).

"Mathematics instruction should… teach [students] to monitor and reflect on their problem solving processes. Writing enhances… [this] skill," (Burns, 2004, p. 31).

Writing to learn mathematics

"…students are asked to 'describe,' 'compare,' 'investigate,' 'explain.' This kind of question requires an answer in written form. It encourages students to think about their thinking and to better understand that mathematics is more than a lot of short symbolic answers" (Russek, 1998, p. 40).

Writing and the ecology of learning

Writing develops thought processes useful in doing mathematics: abilities to define, classify, or summarize; methods of close, reactive reading; metacognition, an awareness of one's own thinking and learning; and an awareness of attitudes toward mistakes and errors" (Connolly, 1989, p. 120).

Writing to Reduce Math Anxiety

"[Writing] is used to open doors of communication with students who may have math anxiety or who have 'I hate math! Feelings…" (Russek,1998, p. 36).

"Studies showed writing to have a positive impact predominately on mathematics anxiety, the acquisition of problem solving skills and the use of cognitive and metacognitive processes" (Taylor & McDonald, 2007, p. 640).

"Another practical idea for addressing math anxiety is to use journal writing for students to express their understanding of mathematical concepts" (Furner & Duffy, 2002, p. 70).

"Writing… helps many students become comfortable with mathematical terms and ideas" (Wadlington & Wadlington, 2008, p. 5–6).

From Research to Practice

The *Houghton Mifflin Harcourt GO Math!* student editions are designed to provide students with numerous opportunities to write about and reflect on the processes they used to solve problems and make sense of new mathematical concepts. Throughout the student editions, students are asked to write in response to prompts that ask them to engage in the following types of thinking and reflection:

Explain approaches to solving problems. Students are asked to describe the steps they went through in order to arrive at solutions to problems. Doing so helps students identify and become more aware of their own processes, which will help them transfer those processes to more complex problems they will encounter later on.

Reflect on information use. In order to help students think about the types of information with which they are provided to solve different kinds of math problems, students are asked to consider how they used certain pieces of information to help them arrive at solutions. Writing about and reflecting on information use can help students identify and clear up confusion and make better use of information in the future.

Draw pictures and diagrams to support problem-solving. Students are asked to represent their ideas and problem-solving processes by drawing pictures or representing their thoughts on paper in other non-verbal ways. Doing so helps students see what they are thinking and makes abstract ideas more concrete.

Because the student editions are write-in, students can write and draw in the same space in which they are making sense of and solving problems. Avoiding the need to transfer ideas and responses to a separate piece of paper helps ensure that students' thoughts will be uninterrupted. Furthermore, recording ideas in the same space that information is presented will help students come back to, make sense of, and benefit from their written reflections in the future.

Strand 2: Vocabulary

Defining the Strand

Sometimes, what we say (or what we mean to say) is misunderstood by others. The words we choose are vital components of our communication with others. Whether that communication is heard or spoken, read or written, or viewed or performed, the vocabulary we select to convey our message is critical.

Broadly defined, vocabulary is knowledge of words and word meanings. It is important to note, however, that vocabulary does not solely consist of knowing words and their meanings; vocabulary encompasses comprehending how words are used in oral and written formats. As Steven Stahl states, "Vocabulary knowledge is knowledge; the knowledge of a word not only implies a definition, but also implies how that word fits into the world" (Stahl, 2005).

Vocabulary knowledge is fundamental to learning in school and throughout life. In order to comprehend what is taught or encountered, students must have access to the meanings of words so that they can understand what is being said or written. Because most of students' success in school and beyond depends upon their ability to read and write while showing understanding, there is a need to offer instruction that equips students with the skills and strategies necessary for lifelong vocabulary development. Research shows that "By giving students explicit instruction in vocabulary, teachers help them learn the meaning of new words and strengthen their independent skills of constructing the meaning of text" (Kamil et al., 2008, p. 11).

Research that Guided the Development of the *Houghton Mifflin Harcourt GO Math!* Student Editions

Vocabulary to Communicate Mathematically

"…students should have many opportunities to use language to communicate mathematical ideas…Opportunities to explain, conjecture and defend one's ideas orally and in writing about mathematics is an integral part of learning mathematics" (NCTM, 1989, p. 78).

Students need to know the meaning of mathematics vocabulary words—whether written or spoken—in order to understand and communicate mathematical ideas. "…terms, phrases, and symbols are essential in communicating mathematical ideas; and becoming fluent with them is vital for children's mathematical learning" (Rubenstein & Thompson, 2002, p. 107).

"[Students] learn to use language to focus on and work through problems, to communicate ideas coherently and clearly…" (Martinez & Martinez, 2001, p. 5).

"The language of mathematics is an important component of our instruction…We teach through the medium of language. It is our major means of communication" (Thompson & Rubenstein, 2000, p. 568).

Vocabulary to Increase Achievement in Mathematics

Research reveals that knowledge of mathematics vocabulary directly affects achievement in arithmetic, particularly problem solving. Earp notes, "Reading comprehension and arithmetic comprehension tend to be positively related. Almost without exception instruction in vocabulary and/or reading skills in arithmetic paid off in terms of greater achievement, especially in the area of problem solving (Earp, 1970, p. 531).

Research by Stahl and Fairbanks indicates that student achievement will increase by 33 percentile points when vocabulary instruction focuses on specific words that are important to what students are learning (Stahl & Fairbanks, 1986).

"Enhancing students' academic background knowledge…is a worthy goal of public education from a number of perspectives. In fact, given the relationship between academic background knowledge and academic achievement, one can make the case that [vocabulary instruction] should be at the top of any list of interventions intended to enhance student achievement" (Marzano, 2004, p. 4).

Vocabulary to Connect Concepts and Terminology

"Establishing connections between relationships of mathematical concepts and terminology is essential" (Renne, 2004, p. 258).

"The language of mathematics is an important component of our instruction…Students build understanding as they process ideas through language" (Thompson & Rubenstein, 2000, p. 568).

As Usiskin's research indicates, "If a student does not know how to read the mathematics…it is difficult to register the mathematics" (Usiskin, 1996, p. 236).

From Research to Practice

The *Houghton Mifflin Harcourt GO Math!* student editions were designed to introduce students to the mathematical vocabulary necessary to build on learning in mathematics. Throughout the student editions, students are presented with vocabulary terms relevant to the mathematics they are learning.

The vocabulary is introduced and reinforced through teacher instruction and student practice and review:

Explain meanings of words and how they are used. In addition to teachers explaining vocabulary words and their specialized meanings or how they might be represented with a sign or a symbol, students are offered reminders in the student editions about the definitions of words. Students are also provided with context for the new vocabulary as related to the concept they are studying.

Practice vocabulary as related to the mathematical concepts. In order to help students understand and use the terminology, they are presented with problems to practice the terms and concepts introduced.

Review meanings of words and how they are used. Prior to each new lesson, students are given a chance to show what they know from previous study. Students are given opportunities to use the terms in various ways, such as written responses, flow maps, and fill-in-the-blank sentences to further verify what they have learned about a concept.

By addressing vocabulary at both the teacher-level and the student-level, students have greater opportunity to connect vocabulary and concepts. Teachers have the chance to address new vocabulary and to intercept student misconceptions, and students have the chance to practice and review what they have learned. Because the worktexts are consumable, students can write notes about the meanings of new words in the places that make sense to them. Students can also jot down symbols or graphics that help them to make sense of the new words.

Strand 3: Scaffolding

Defining the Strand

Many times learning a concept requires guidance in order to maintain and build on the knowledge that is acquired. When that concept is the foundation for another concept, it is necessary to ensure that the transition between concepts is carefully supported. Similar to scaffolds used by contractors to erect a structure, scaffolds are put in place to support students while gaining knowledge in school.

Scaffolding is an educational technique that involves providing support to students as they learn, and gradually decreasing the amount of support provided until students are completing tasks independently. In scaffolding, students receive support as they reach competence and continue to develop on their own—building on what they have learned. Vygotsky defined scaffolding as the "role of teachers and others in supporting the learner's development and providing support structures to get to that next stage or level" (Raymond, 2000, p. 176).

When scaffolding instruction, the types of scaffolds can vary but should consistently provide adequate support as needed. Scaffolds can be effective in many forms, including but not limited to, activating prior knowledge, modeling, questioning, or using cues or tools. "[Scaffolding] connotes a custom-made support that can be easily disassembled when no longer needed. It also connotes a structure that allows for the accomplishment of some goal that would otherwise be either unattainable or quite cumbersome to complete" (Stone, 1998, p. 344).

Research that Guided the Development of the *Houghton Mifflin Harcourt GO Math!* Student Editions

Scaffolding to Deepen Mathematical Understanding

Research presented in *Adding It Up* accounts how scaffolding can be used to improve students' problem solving. "By offering a subtle hint, posing a similar problem, or asking for ideas from other students, [the teacher] provides some scaffolding to assist his students as they reason through the grid problems… without reducing the complexity of the task at hand or specifying exactly how to proceed… thus affording the students an opportunity to learn by considering and discussing solution strategies" (Kirkpatrick et al., 2001, p. 336). In a study conducted by Williams (2008), teachers used scaffolding throughout mathematics learning which resulted in helping "…the class as a whole move toward deeper understanding of the key concepts being studied" (Williams, 2008, p. 327).

As noted by Barton and Heidema (2002), one way to scaffold is to make sure students have a firm handle of concepts they need for future learning. Making sure students have a solid grasp of prior knowledge is important to future knowledge acquisition. This relationship "…has a direct effect on their acquiring new knowledge and skill. For example, the student who does not understand addition will be ill-equipped to learn multiplication…" (Barton & Heidema, 2002, p. 4).

Baker, Schirner, and Hoffman (2006) share observations of classroom activities in which scaffolding is occurring. In their observations, "…scaffolding is provided that will be the support, or foundation for later learning. When these students hear of the addition concept again, it will heighten their readiness to formally begin a guided inquiry" (Baker, Schirner, & Hoffman, 2006, p. 20).

Scaffolding to Meet Individual Student Needs

In describing how her research shows that scaffolding meets varying student needs, Walker (2008) noted, "After demonstrations, teachers continue to support or scaffold the new learning. They often provide continuous support and sustain learning by scaffolding students' attempts. For example, teachers can deal effectively with inappropriate student responses by using part of the response to probe reasoning" (Walker, 2008, p. 18-19). This account demonstrates that scaffolding can be used to intervene with students on an individual level by using an incorrect response to explore thinking.

Research presented in *Adding It Up* highlights that "Scaffolding…helps to maintain student engagement at a high level" (Kirkpatrick et al., 2001, p. 336).

When presenting information about how scaffolding works to meet individual student needs, Barton and Heidema observe that "Discovering what students already know about a topic helps teachers design instruction around the missing knowledge" (Barton & Heidema, 2002, p. 6).

Scaffolding to Build Confidence and Independence

Scaffolding is necessary support to enable students to become responsible for their own learning. As Hyde notes, "Scaffolding does not necessarily make the problem easier, and the teacher does not do the work for students or show them how to do it. Like scaffolding along the side of a building that enables the painters to safely work on the outside wall, the scaffolding does not do the work. It enables the person to do it" (Hyde, 2006, p. 28).

Williams (2008) notes that "Scaffolding tasks allowed students to work independently at appropriately challenging levels, make sense of ideas, and develop a sense of self-confidence in their mathematics knowledge and skills" (Williams, 2008, p. 329).

"Providing opportunities for… scaffolding enables students to have success at their level and also to be challenged to reach their developmental potential" (Baker, Schirner & Hoffman, 2006, p. 21).

As highlighted in research by Anghileri, scaffolding in the form of reviewing concepts helps "… to refocus [students'] attention and give them further opportunity to develop their own understanding rather than relying on that of the teacher" (Angileri, 2006, p. 41). Reviewing helps students develop their own understanding of mathematics.

Larkin (2001) learned from interviewing and observing teachers who scaffolded instruction that their students became more independent learners. "Scaffolding principles and techniques can guide teachers to assist students on any grade level to become more independent learners" (Larkin, 2001, p. 34).

From Research to Practice

The *Houghton Mifflin Harcourt GO Math!* student editions were designed to provide students with ample guidance as they learn mathematical concepts. Throughout scaffolds exist to help students solidify what they know in order to build on it. Scaffolds are in place to help students in the following ways:

Build meaningful learning experiences. Students are given opportunities to solve problems that are relevant to the world around them. Offering students meaningful contexts that brush their prior knowledge base is one way to support them as they learn new concepts.

Review and reflect on previous concepts before moving on. In order to prepare students for new learning, they are given a chance to review the concepts and vocabulary they have learned previously. This scaffold allows for students to show what they know or reflect on what they have not quite mastered yet, and responsibility for learning can shift to the student.

Complete problems in a graduated way. In order to help students as they practice on their own, graduated questioning is used as a scaffold. Often students are asked how to solve a problem before they actually solve the problem, or students are given a less difficult problem to solve before a more difficult one. This helps to organize their thinking as they work on their own.

Provide opportunities to model or show what they can do. In order to meet students' different learning styles, the worktext includes several ways to demonstrate learning. Students encounter problems that use manipulatives, graphics, pictures, line graphs, and many other techniques to help support their thinking. These are scaffolds in place to guide students as needed as they practice independently.

Because the student editions are write-in, students are able to flip back and forth between pages in a lesson to look for relevant support to uncover the answers they need. Students are given space to write and illustrate freely allowing them to explore their own thinking to solve problems as it makes sense to them. Furthermore, the worktext follows a logical sequence by scaffolding before, during, and after each lesson in order to best support learning.

Strand 4: Metacognition

Defining the Strand

Developing a range of thinking strategies needed to solve problems and knowing which strategy to choose are important developments for students. Students need to be aware of what they can do well and what they need to work on. This encourages them to think about their thinking and learning in order to better solve problems they encounter. Supporting metacognition in school fosters the development of good thinkers who are successful problem-solvers and lifelong learners. Recognizing, developing, and improving the metacognitive capabilities of students is fundamental to learning.

Metacognition is thinking about thinking—knowing "what we know" and "what we don't know"—and how we can use that information. Some basic metacognitive strategies include connecting new information to that previously learned, selecting thinking strategies purposefully, and planning, monitoring, and evaluating thinking processes (Dirkes, 1985). Studies show that the use of metacognitive strategies increases learning. These results suggest that supporting thinking strategies is useful and that independent learning will develop gradually (Scruggs, 1985).

Regardless of the content area in school, problem-solving and other activities provide opportunities for strengthening metacognitive strategies. It is therefore important to focus student attention on how tasks are accomplished. Emphasizing content goals and process goals will help students discover that understanding and applying thinking processes expands learning.

Research that Guided the Development of *Houghton Mifflin Harcourt GO Math!*

Metacognition to Build Mathematical Problem-Solving

"Competent problem solvers are efficient at keeping track of what they know and of how well or poorly their attempt to solve a problem is proceeding. They continuously ask, 'What am I doing?' 'Why am I doing it?' 'How will it help me?'" (Reys, Suydam, Lindquist, & Smith, 1998, p. 27).

"[W]hen students… reflect on their own thinking, it makes a significant impact on their ability to solve problems now and in the future" (Roberts & Tayeh, 2006-07, p. 23

"Individual reflection or interaction with others (both teachers and peers) encourages students to communicate and explain their thinking" (Reys, Suydam, Lindquist, & Smith, 1998, p. 32).

Metacognition to Increase Performance in Mathematics

Results from a study conducted by Lucangeli, Corndoli, and Tellarini (1998), show that supporting students' metacognitive thinking and strategy use has resulted in increased performance in mathematics. Researchers found that the group of students who received metacognitive support outperformed peers who did receive the same training (Lucangeli, Corndoli, and Tellarini, 1998).

Research by Pogrow (1999) suggests that helping students understand their own metacognitive processes and strategies will help their academic performance (Pogrow, 1999).

"Students learn more and better when they can take control of their learning by defining their goals and monitoring their progress… Effective learners recognize the importance of reflecting on their thinking and learning from their mistakes" (NCTM, 2000, p. 21).

Metacognition to Improve Attitudes Toward Mathematics

Research shows that what students recognize and believe about themselves as students of mathematics not only affects their performance, but it also affects the way they approach mathematics (Campione, Brown, & Connell,1998).

One study found students' positive attitudes toward mathematics increased through the use of metacognitive approaches in learning. This approach appears to provide a more advantageous learning atmosphere for students. Support of metacognitive strategies encourages students to be more active and critical in their learning and thinking (Muin, Sumarmo, & Sabandar, 2006).

Research conducted by Maqsud (1998) examined the effects of metacognitive instruction on students' mathematics achievement and their attitudes toward mathematics. The experimental group used metacognitive strategies while learning, but the control group did not. The comparisons of pretest and posttest measures revealed that the posttest scores for the experimental group were significantly higher than the control group in relation to general ability, metacognitive awareness, attitude towards mathematics, and mathematics achievement (Maqsud, 1998, pp. 237-243).

From Research to Practice

The *Houghton Mifflin Harcourt GO Math!* student editions were designed to provide students with numerous opportunities to think about their thinking and learning while solving problems and making sense of mathematical concepts. Throughout, students are asked to respond to prompts that ask them to engage in the following types of planning, monitoring, and reflecting:

Plan how to solve a problem. Throughout the student editions, students are asked to think about the steps they need to go through in order to solve problems. By planning how to solve a problem, students can determine what they to know, how they will use that information, and what steps they will need to take.

Monitor success by periodic assessment. In order to help students remember what they have learned, they are given chances to show what they know throughout. By providing these sections, students are able to assess their own strengths and weaknesses regularly.

Monitor success by trying other ways. In *Houghton Mifflin Harcourt GO Math!*, students are prompted to solve a problem "one way" first, and then they are asked to solve it "another way." This enables students to gain a better, and more thorough, understanding of mathematical concepts. They are learning to monitor what they know in order to apply it to different ways of solving problems.

Reflect in a visual or written format. Students are asked to show what they know by drawing pictures or providing written explanations of what they did and why. Visual and written responses challenge students to think about what they are doing – leading them to contemplate what it is they are trying to solve, how they are actually going to solve it, and why they are going to solve in this way.

Because the student editions are write-in, students can plan directly on the pages as they solve problems. Allowing this flexibility, students can look to previous lessons or within a lesson for support in planning to solve new material. Students can also write notes or use other strategies, such as underlining, to think through problems. Furthermore, providing space for drawings and written responses, allows students to develop their metacognitive skill set by writing out what they are thinking. This also allows teachers to read students' responses enabling them to support weaknesses and build on successes.

Strand 5: Graphic Organizers

Defining the Strand

Sometimes in order to grasp a concept, it is helpful to think about it visually—using visual representations. Visual representations can be expressed in many ways; graphic organizers are one way for students to arrange their ideas visually. Graphic organizers come in many varieties and have been widely researched for their effectiveness in improving education outcomes for students.

Graphic organizers are illustrations used to organize and highlight key content and/or vocabulary (Lovitt, 1994). Graphic organizers are visual representations that show relationships between facts, terms, and or ideas within a task or when learning a concept. Graphic organizers help students develop a clearer understanding of concepts by enabling them to connect content in a meaningful way. Graphic organizers can be used for a variety of purposes before, during, and after instruction, such as drawing out prior knowledge, organizing information, processing information, or summarizing ideas.

"Graphic organizers are perhaps the most common way to help students generate nonlinguistic representations" (Marzano, Pickering, & Pollock, 2001, p. 75). Research indicates that use of graphic organizers is effective for helping students organize and remember content area information (Horton, Lovitt, & Bergerud, 1990). Additional research indicates that using graphic organizers can be valuable in teaching students how to represent problems in an illustrative format and how to determine the operation or operations necessary to solve a problem (Jitendra, 2002).

Research that Guided the Development of the *Houghton Mifflin Harcourt GO Math!* Student Editions

Graphic Organizers to Sort Information

In research on using graphic organizers in mathematics, results suggest that "The organizer seemed to provide [students] with a framework that gave them confidence in their ability to be successful and also required them to think through problem situations before beginning mathematical calculations…Several factors accounted for the effectiveness of the graphic organizer. Of most significance was the fact that the organizer required students to slow down and think through each problem. At first, students with more impulsive learning styles resisted the slower process, but they accepted the organizer as they saw their improved performance and ability to successfully solve problems" (Braselton & Decker, 1994, pp. 280-281).

"Organizing data into a table helps children to discover a pattern and to identify information that is missing. It is an efficient way to classify data and order large amounts of information or data, and it provides a record so that children need not retrace nonproductive paths or do computations repeatedly to answer new questions" (Reys, Suydam, Lindquist, & Smith, 1998, p. 78).

Monroe & Pendergrass (1997) recommend the use of graphic organizers to "teach to the brain's natural capacity for thinking and organizing information" (Monroe & Pendergrass, 1997, p. 3).

Graphic Organizers to Support Varied Learning Styles

"Graphic organizers are effective differentiation strategies that affect student achievement in the classroom by providing a "big picture" view of concepts and by helping to organize the relationships between concepts" (Shores & Chester, 2009, p. 71).

According to Hyerle, the use of graphic organizers can help learners who need support in making connections between what the assignment is and how it will be completed. "These visual tools can do double duty by helping the teacher clarify a stated set of objectives and giving individual students—especially students with special needs—a tool to complete the task" (Hyerle, 1996, p. 62).

Graphic Organizers to Connect Ideas

"Teachers can help students grasp embedded concepts as well as how other concepts are related by demonstrating these relationships with graphic organizers" (Barton & Heidema, 2002, p. 20).

"[Graphic] organizers are especially helpful in representing abstract information in concrete forms" (Shores & Chester, 2009, p. 71).

"Students who are able to apply and translate among different representations of the same problem situation or of the same mathematical concept will have at once a powerful, flexible set of tools for solving problems and a deeper appreciation of the consistency and beauty of mathematics" (National Council of Teachers of Mathematics, 1990, p. 146).

"Visual brainstorming webs, task-specific organizers, and thinking-process maps thus provide a bridge between their own forms and the structures that are embodied in the text but hidden in the guise of linear strings of words" (Hyerle, 1996, p. 15).

"[Words] on paper, arranged to represent an individual's understanding of the relationship between words. Whereas conventions of sentence structure make most writing linear in form, graphic organizers take their form from the presumed structure of relationships among ideas" (Clarke, 1991, p. 30).

In addition to helping students learn how to process, organize, and store new information, regular use of graphic organizers can increase comprehension, retention, and recall of information (Jones, Palincsar, Ogle, & Carr, 1987).

Research by Braselton & Decker (1994) showed that "After engaging in independent practice with the graphic organizer, students showed marked improvement in problem solving. This strategy was effective with students of all ability levels" (Braselton & Decker, 1994, p. 278).

From Research to Practice

The *Houghton Mifflin Harcourt GO Math!* student editions were designed to provide students with numerous opportunities to write about and reflect on the processes they used to solve problems and make sense of new mathematical concepts. Throughout the student editions, students are asked to write in response to prompts that ask them to engage in the following types of thinking and reflection:

Engage in powerful thinking. Before writing in the graphic organizers, students have to engage in powerful information processing and higher order thinking Students are asked to recognize important information, make decisions about what to do, consolidate information, show what they know, and solve problems.

Reflect on problems visually. Throughout, students are asked to use pictorial representations to solve problems. Solving problems this way gives students a chance to show what they know and can do in a non-linguistic way which is an effective way to meet the needs of diverse learners.

Show relationships among information. Students are asked to show what they know by drawing pictures or providing written explanations of how to set up problems before actually solving them. Using graphic organizers in this way helps students slow down their thinking in order to plan and sort out the information they have.

Extend understanding of important concepts. Using graphic organizers allows students to record information so that they do not need to repeat steps or go back over information. All of the information they need is in the graphic organizer so they can build on what they already know.

Because the student editions are write-in, the graphic organizers are ready-to-use for each lesson. Students can demonstrate their understanding of key concepts visually and in writing as they move through the worktext – without language processing demands getting in the way. Furthermore, the process of being able to write information directly on the graphic organizers will promote students' active learning and creativity.

Bibliography

Anghileri, J. (2006). Scaffolding practices that enhance mathematics learning. *Journal of Mathematics Teacher Education*, 9, 33–52.

Baker, A., Schirner, K., & Hoffman, J. (2006). Multiage mathematics: Scaffolding young children's mathematical learning. *Teaching Children Mathematics, 13*(1), 19–21.

Baxter, J. A., Woodward, J., & Olson, D. (2005). Writing in mathematics: An alternative form of communication for academically low–achieving students. *Learning Disabilities Research & Practice, 20*(2), 119–135.

Barton, M. L., & Heidema, C. (2002). *Teaching reading in mathematics*. Aurora, CO: Mid–continent Research for Education and Learning.

Bransford, J. D., Brown, A. L., & Cocking, R. R., Eds. (1999). *How People Learn: Brain, Mind, Experience, and School*. Washington, D.C.: National Academy Press.

Braselton, S., & Decker, C. (1994). Using graphic organizers to improve the reading of mathematics. *Reading Teacher, 48* (3), 276–81.

Brooks, M. (2009). Drawing, visualization, and young children's exploration of "big ideas," *International Journal of Science Education, 3*(1), 319–341.

Burns, M. (2004). Writing in math. *Educational Leadership, 62*(2), 30–33.

Campione, J. C., Brown, A. L. & Connell, M. L. (1988). Metacognition: On the importance of understanding what you are doing. In Randall I. Charles & Edward A. Silver (Eds.), *The Teaching and Assessing of Mathematical Problem Solving* (pp. 93–114). Reston, Va.: NCTM.

Chang, K., Chen, I., & Sung, Y. (2002). The effect of concept mapping to enhance text comprehension and summarization. *The Journal of Experimental Education 71*(1), 5–23.

Clarke, J. H. (1991). *Patterns of Thinking*. Needham Heights, Mass.: Allyn & Bacon.

Connolly, P. (1989). Writing and the ecology of learning. In P. Connolly & T. Vilardi (Eds.), *Writing to learn mathematics and science* (pp. 1–14). New York: Teachers College Press.

Dirkes, M. A. (1988). Self-directed thinking in the curriculum. *Roeper Review, 11*(2), 92–94.

Earp, N. W. (1970). Observations on teaching reading in mathematics. *Journal of Reading, 13*, 529–33.

Furner, J. M., & Duffy, M. L. (2002). Equity for all students in the new millennium: Disabling math anxiety. *Intervention in School and Clinic, 38*(2), 67–74.

Gagnon, J. C., & Maccini, P. (2001). Preparing students with disabilities for algebra. *Teaching Exceptional Children, 34*(1), 8–15.

Good, J. M., & Whang, P. A. (1999). Making meaning in educational psychology with student response journals. *Paper presented at the annual meeting of the American Educational Research Association*, Montreal, Canada.

Hartman, H. (2002). Scaffolding & Cooperative Learning. *Human Learning and Instruction* (pp. 23–69). New York: City College of City University of New York.

Hettich, P. (1976). The journal: An autobiographical approach to learning. *Teaching of Psychology, 3*(1), 60–63.

Horton, S. V., Lovitt, T. C., & Bergerud, D. (1990). The effectiveness of graphic organizers for three classifications of secondary students in content area classes. *Journal of Learning Disabilities, 23*, 12–22, 29.

Hyde, A. (2006). Comprehending math: Adapting reading strategies to teach mathematics K–6. Portsmouth, NH: Heinemann.

Hyerle, D. (1998). *Visual Tools for Constructing Knowledge*. Alexandria, Va.: Association for Supervision and Curriculum Development.

Jitendra, A. (2002). An exploratory study of schema-based word-problem-solving instruction for middle school students with learning disabilities: An emphasis on conceptual and procedural knowledge. *The Journal of Special Education, 36*(1), 23–28.

Jones, B. F., Palincsar, A. S., Ogle, D. S., & Carr, E. G. (Eds.). (1987). *Strategic teaching and learning: Cognitive instruction in the content areas*. Alexandria, Va. and Elmhurst, Il.: Association for Supervision and Curriculum Development andNorth Central Regional Educational Laboratory.

Kaméenui, E. J., Carnine, D. W., Dixon, R. C., Simmons, D. C., & Coyne, M. D. (2002). Effective teaching strategies that accommodate diverse learners (2nd ed.). Upper Saddle River, NJ: Merrill Prentice Hall.

Kamil, M. L., Borman, G. D., Dole, J., Kral, C. C., Salinger, T., and Torgesen, J. (2008). *Improving adolescent literacy: Effective classroom and intervention practices: A Practice Guide* (NCEE #2008–4027). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved from http://ies.ed.gov/ncee/wwc.

Kilpatrick, J., Swafford, J., & Findell, B., Eds. (2001). Mathematics LearningStudy Committee, National Research Council: Conclusions and recommendations. In *Adding It Up: Helping Children Learn Mathematics* (pp. 407–432). Washington, D.C.: The National Academies Press.

Knipper, K. J., & Duggan, T. J. (2006). Writing to learn across the curriculum: Tools for comprehension in content area classrooms. *Reading Teacher, 59*(5), 462–470.

Lance, D. M., & Lance, S. (2006). Writing-learn-assignments in content driven courses, *Communication Disorders Quarterly, 28*(1), 18–23.

Larkin, M. J. (2001). Providing support for student independence through scaffolded instruction. *Teaching Exceptional Children, 34*(1), 30–34.

Lovitt, S. V. (1994). Strategies for adapting science textbooks for youth with learning disabilities. *Remedial and Special Education, 15*(2), 105–116.

Lucangeli, D., Corndoli, C., & Tellarini, M. (1998). Metacognition and learning disabilities in mathematics. In T. E. Scruggs & M. A. Mastropieri (Eds.), *Advances in learning and behavioral disabilities* (Vol. 12, pp. 219–244). Greenwich, CT: JAI Press.

Maccini, P., & Gagnon, J. (2005). Math graphic organizers for students with disabilities. *American Institutes for Research*, 1–10.

Maqsud, M. (1998). Effects of metacognitive instruction on mathematics achievement and attitude toward mathematics of low mathematics achievers. *Educational Research, 40*(2), 237 – 243.

Martinez, J. G. R., & Martinez, N. C. (2001). *Reading and writing to learn mathematics: A guide and a resource book*. Boston: Allyn & Bacon.

Marzano, R. J. (2004). *Building background knowledge for academic achievement: Research on what works in schools*. Alexandria, Va.: Association for Supervision and Curriculum Development.

Marzano, R. J., Pickering, D. J., & Pollock, J. E. (2001). *Classroom Instruction that Works: research-based strategies for increasing student achievement*. Alexandria, Va.: Association for Supervision and Curriculum Development.

Monroe, E. E., & Pendergrass, M. R. (1997). *Effects of mathematical vocabulary instruction on fourth grade students*. Paper presented at 1997 Brigham Young University Public School Partnership Symposium on Education. ED 414 182.

Muin, A., Sumarmo, U., & Sabandar, J. (2006). Metacognitive approach to improve mathematics skills of high school students. *International Journal of Education, 1*(1).

National Council of Teachers of Mathematics. (1989). *Curriculum and Evaluation Standards for School Mathematics*. Reston, Va.: NCTM.

National Council of Teachers of Mathematics. (1990). *Curriculum and Evaluation Standards*. Washington, D. C.: NCTM.

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

National Reading Panel (2000). Report of the National Reading Panel: Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction. Washington, D.C.: National Institute of Child Health and Human Development, National Institutes of Health.

Pogrow, S. (1999). Systematically using powerful learning environments to accelerate the learning of disadvantaged students in grades 4–8. In Charles M. Reigeluth (Ed.), Instructional Design Theories and Models, Volume II, A New Pardigm of Instructional Theory. Mahway, NJ: Lawrence Erlbaum Associates.

Putnam, R. (2003). Commentary on four elementary math curricula. In S. Senk & D. Thompson (Eds.), *Standards-oriented school mathematics curricula: What does it say about student outcomes?* (pp. 161–180). Mahwah, NJ: Erlbaum.

Raymond, E. (2000). Cognitive Characteristics. *Learners with Mild Disabilities* (pp. 169–201). Needham Heights, MA: Allyn & Bacon.

Renne, C. G. (2004). Is a rectangle a square? Developing mathematical vocabulary and conceptual understanding. *Teaching Children Mathematics*, 258–263.

Reys, R. E., Suydam, M. N., Lindquist, M. M.,& Smith, N. L. (1998). *Helping Children Learn Mathematics*. Needham Heights, MA: Allyn & Bacon.

Roberts, S., & Tayeh, C. (2006–07). It's the thought that counts: Reflecting on problem solving. *Mathematics Teaching in the Middle School, 12*(5), 232–237.

Rubenstein, R. N. & Thompson, D. R. (2002). Understanding and supporting children's mathematical vocabulary development. *Teaching Children Mathematics*. 107–112.

Russek, B. (1998). Writing to learn mathematics. *The WAC Journal, 9*, 36–45.

Schoenfeld, A. H. (1987). What's all the fuss about metacognition? In A. H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 189–215). Hillsdale, NJ: Lawrence Erlbaum Associates.

Scruggs, T. E., Mastropieri, M. A., Monson, J., & Jorgenson, C. (1985). Maximizing what gifted students can learn: Recent findings of learning strategy research. *Gifted Child Quarterly, 29*(4), 181–185. EJ 333 116.

Shores, C., & Chester, K. (2009). *RTI for School Improvement*. Thousand Oaks, CA.: Corwin Press & Council for Exceptional Children.

Stahl, S. A. (2005). Four problems with teaching word meanings (and what to do to make vocabulary an integral part of instruction). In E.H. Hiebert and M.L. Kamil (eds.), *Teaching and learning vocabulary: Bringing research to practice*. Mahwah, NJ: Erlbaum.

Stahl, S. A., & Fairbanks, M. M. (1986). The effects of vocabulary instruction: A model-based meta-analysis. *Review of Education Research, 56*(1), 72–110.
Stone, C. A. (1998). The metaphor of scaffolding: Its utility for the field of learning disabilities. *Journal of Learning Disabilities, 31*, 344–364.
Surbeck, E. (1994). A glimpse through the door: Journal writing with preservice teachers. *Childhood Education, 70*(4), 232–235.
Taylor, J. A., & McDonald, C. (2007). Writing in groups as a tool for non-routine problem solving in first year university mathematics, *International Journal of Mathematical Education in Science and Technology, 38*(5), 639–655.
Thompson, D. R., & Rubenstein, R. N. (2000). Learning mathematics vocabulary: Potential pitfalls and instructional strategies. *Mathematics Teacher, (93)*7, 568–574.
Usiskin, Z. (1996). Mathematics as a Language. In *Communication in Mathematics, K–12 and Beyond*, 1996 Yearbook of the National Council of Teachers of Mathematics (NCTM), edited by Portia C. Elliott and Margaret J. Kenney, pp. 231–43. Reston, Va.: NCTM.
Vygotsky, L. S. (1962). *Thought and language*, Cambridge, MA: MIT Press.
Wadlington, E., & Wadlington, P. L. (2008). Helping students with mathematical disabilities to succeed. *Preventing school failure, 53*(1), 2–7.
Walker, B. (2008). Adjusting instruction to meet students' needs. (June 2008). *Reading Today, 25*(6), 18–19.
Williams, K. M. (2003). Writing about the problem-solving process to improve problem-solving performance. *Mathematics Teacher, 96*(3), 185–187.
Williams, L. (2008). Tiering and scaffolding: Two strategies for providing access to important mathematics. *Teaching Children Mathematics. 14*(6), 324–330.

Experimental Efficacy Studies

The efficacy of *Houghton Mifflin Harcourt GO Math!* has been well documented through several recent studies. All of these studies, as well as future planned studies, meet the various requirements of scientific research as set forth by the *No Child Left Behind* legislation, including rigorous, systematics, and objective methods, as well as replicable and valid results. This scientifically based research documents how *Houghton Mifflin Harcourt GO Math!* helps students achieve in mathematics by improving understanding, achievement and test scores.

Evaluation of the effectiveness of the concept development and vocabulary development components

Experimental Efficacy

Concept Study and Vocabulary Study

This report describes the results of two efficacy studies to determine the effectiveness of the concept development and vocabulary approaches evident in *Houghton Mifflin Harcourt GO Math!*.

Background Information

Houghton Mifflin Harcourt Publishers contracted with the Educational Research Institute of America (ERIA) to evaluate the efficacy of lesson components in terms of their effectiveness in enhancing conceptual understanding and developing content-area vocabulary understanding as a means to help students understand the mathematics being studied. The effectiveness of the program was evaluated by two separate studies, a Concepts Study and a Vocabulary Study. The studies were conducted with Grade 3 students as Grade 3 is the mid-point of the grades for which the program is available.

Research Questions

The following research questions guided the design of the two studies:
Are the concepts development component and vocabulary acquisition component instructionally effective in increasing the mathematics scores of:

- Grade 3 students?
- Lower achieving as well as higher achieving Grade 3 students?
- Grade 3 students who are receiving special services?
- Grade 3 students who are not English proficient as well as those who are English proficient?
- Grade 3 students who are identified as coming from families of low socio-economic status as well as those identified as coming from families of high socio-economic status?
- Grade 3 students identified as minority students as well as those identified as non-minority students?

Design and Procedures of the Study

Research Design

ERIA followed an experimental pretest/posttest design for these studies. The sample included five schools for the Concepts Study and three different schools for the Vocabulary Study. All of the teachers volunteered to participate in one or the other of the two studies. Teachers received no specific training for the studies. For their efforts, teachers were awarded nominal product credits that they could use to purchase classroom materials from the **Houghton Mifflin Harcourt Publishers** catalog.

Results of the Analysis: Concepts Study

Total Group Analysis

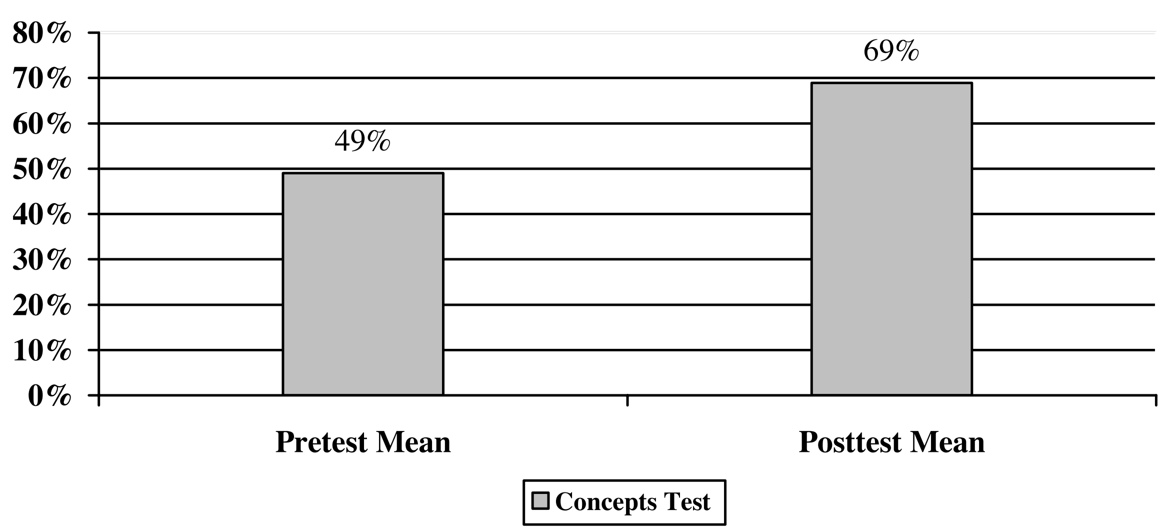
Table 1 and Figure 1 provide the results for all of the Grade 3 students included in the study. The results show statistically significant (<.0001) improvement from pretest to posttest indicating that such a change would have occurred by chance fewer than once out of 10,000 times if the study were repeated. Figure 1 shows the percent increase.

Table 1
Paired *t*-test Comparison of Pretest/Posttest Scores
Concepts Study
Total Group (N=104)

Pretest Scores		*Posttest Scores*		*Analysis*	
Mean	*Standard Deviation*	*Mean*	*Standard Deviation*	t-*test*	*Significance*
49.1	26.0	68.9	23.8	9.584	<.0001

Cohen's *d* statistic for the strength of relationship was .8. A statistic of .8 indicates a large effect size. The .8 result, therefore, indicates a large effect size for the gain scores of all students in the Concepts Study.

Figure 1
Comparison of Pretest and Posttest Percent Correct
Concepts Study
Total Sample (N=104)



Achievement Level Group Analysis

In order to divide the students into achievement groups, the pretest scores of the 104 students were ranked from low to high and then divided into three equal-sized groups. The low achievement group included 34 students and the average and high achieving groups included 35 students each. After categorizing the students into these three categories, a paired comparison t-test analysis was conducted using the pretest/posttest scores.

Table 2 and Figure 2 provide the results for each of the three achievement groups. Table 2 shows that students in all three groups showed statistically significant (<.0001) improvement from pretest to posttest indicating that such a change would have occurred by chance fewer than once out of 10,000 times if the study were repeated.

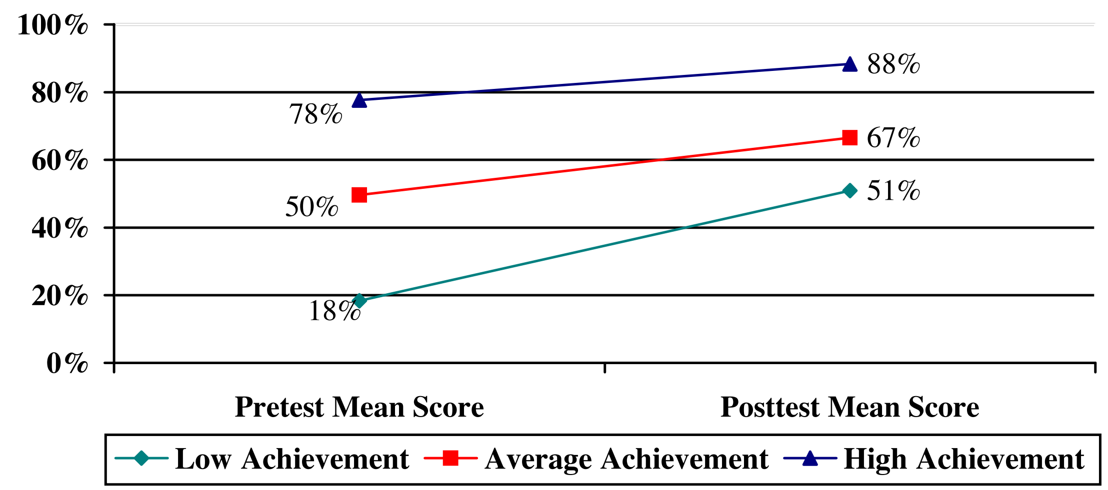
Figure 2 shows the percent of raw score increase for the three achievement groups. By design, because of how the sorting for the student groups in this achievement-level group analysis was done, the low and average groups started out with lower percentage correct scores. However, all three groups showed significant improvement.

Table 2
Paired *t*-test Comparison of Pretest/Posttest Scores
Concepts Study
Three Achievement Level Groups
(N=104)

	Pretest Scores		*Posttest Scores*		*Analysis*	
Group (N)	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*	t-*test*	*Significance*
High Achievement (35)	77.7	8.9	88.3	9.0	6.671	<.0001
Average Achievement (35)	49.6	8.0	66.5	16.1	6.011	<.0001
Low Achievement (34)	18.4	12.0	50.9	26.2	7.097	<.0001

Cohen's *d* statistic for the strength of relationship for the high achievement group was 1.2, for the average group the statistic was 1.3, and for the low group the statistic was 1.6. A statistic of .8 indicates a strong effect. The results, therefore, indicate a very strong effect size for all three achievement groups.

Figure 2
Comparison of Pretest and Posttest Percent Correct
Concepts Study
Three Achievement Level Groups
(N=104)



Special Services Group Analysis

Teachers were asked to identify those students receiving special services such as special education as well as those not receiving such services. Of the 104 students teachers categorized 98 students, 44 as receiving special services and 54 as not receiving such services. Only six students were not categorized by teachers.

Table 3 and Figure 3 provide the results for each of these two groups. The students in both groups showed statistically significant (<.0001) improvement from pretest to posttest indicating that such a change would have occurred by chance fewer than once out of 10,000 times if the study were repeated.

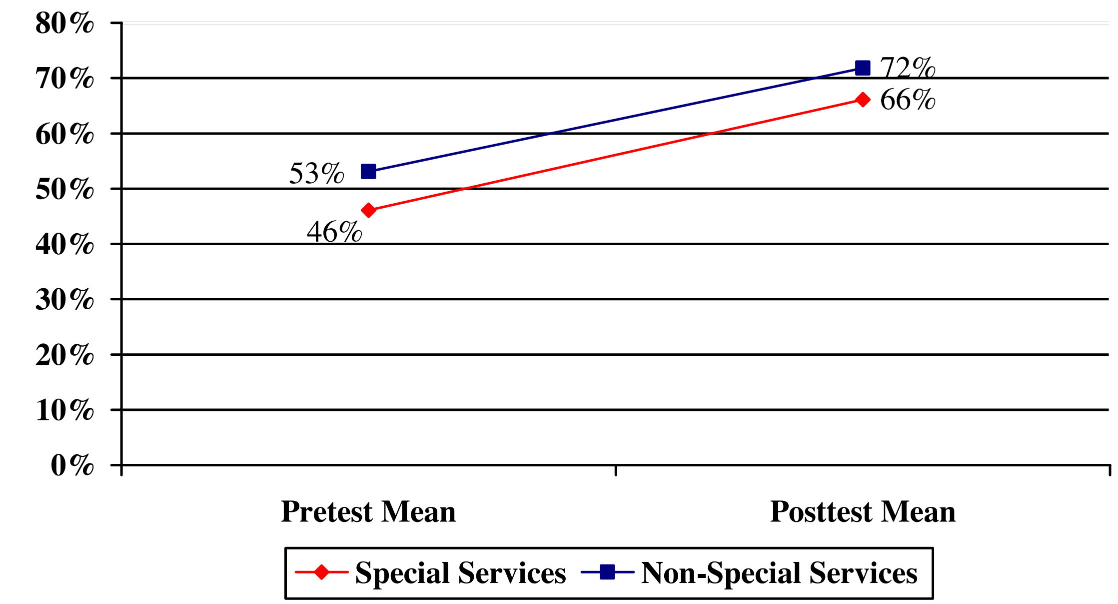
Figure 3 shows the percent of raw score increase for each of the groups. The special services group started out with somewhat lower percentage correct scores. However, both groups improved approximately the same amount from pretesting to posttesting.

Table 3
Paired *t*-test Comparison of Pretest/Posttest Scores
Concepts Study
Special Services Groups
(N=98)

	Pretest Scores		*Posttest Scores*		*Analysis*	
Group (N)	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*	*t-test*	*Significance*
Special Services (44)	46.2	30.1	66.1	30.5	5.592	<.0001
Non-Special Services (54)	53.1	22.4	71.8	17.7	7.703	<.0001

Cohen's *d* statistic for the strength of relationship for the special services group was .7 and for the non-special services group the Cohen's *d* statistic was .9. A statistic of .8 indicates a large effect size and a statistic of .5 indicates a medium effect size. The results, therefore, indicate a large effect size for the non-special services students and a medium effect size for the special services group.

Figure 3
Comparison of Pretest and Posttest Percent Correct
Concepts Study
Special Services Students and Non-Special Services Students
(N=98)



English Proficiency Group Analysis

Teachers were asked to identify those students who were English proficient and those students who were not English proficient. Of the 104 students teachers categorized 98 students, 54 as non-English proficient and 44 as English proficient. Only six students were not categorized by teachers.

Table 4 and Figure 4 provide the results for each of these two groups. The students in both groups showed statistically significant (<.0001) improvement from pretest to posttest indicating that such a change would have occurred by chance fewer than once out of 10,000 times if the study were repeated.

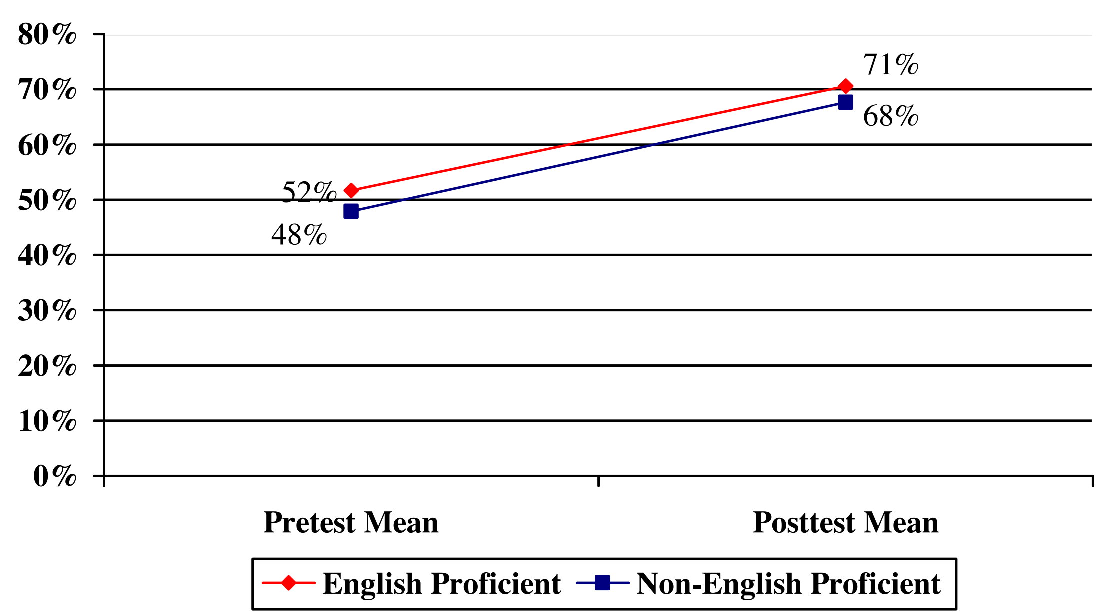
Figure 4 shows the percent of raw score increase for each of the English proficiency groups. The non-English proficient group started out with somewhat lower percentage correct scores. However, both groups improved approximately the same amount from pretesting to posttesting.

Table 4
Paired *t*-test Comparison of Pretest/Posttest Scores
Concepts Study
Two English Proficiency Groups
(N=98)

	Pretest Scores		*Posttest Scores*		*Analysis*	
Group (N)	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*	*t-test*	*Significance*
English Proficient (44)	51.7	27.0	70.6	25.7	6.816	<.0001
Non-English Proficient (54)	47.9	25.3	67.7	22.5	6.264	<.0001

Cohen's *d* statistic for the strength of relationship for the English proficient group was .7 and for the non-English proficient group the Cohen's *d* statistic was .8. A statistic of .8 indicates a large effect size and a statistic of .5 indicates a medium effect size. The results, therefore, indicate a large effect size for the non-English proficient students and a medium effect size for the English proficient group.

Figure 4
Comparison of Pretest and Posttest Percent Correct
Concepts Study
English Proficient and Non-English Proficient Students
(N=98)



Socio-Economic Group Analysis

To determine if the program favored higher socio-economic students over those who were categorized as lower socio-economic students, teachers were asked to categorize students as high or low socio-economic status. The scores of these two groups of students were then compared. Teachers identified 57 students as low socio-economic status and 35 students as high socio-economic status. Twelve students were not categorized by teachers.

Table 5 and Figure 5 provide the results for each of these two groups. The students in both groups showed statistically significant (<.0001) improvement from pretest to posttest indicating that such a change would have occurred by chance fewer than once out of 10,000 times if the study were repeated.

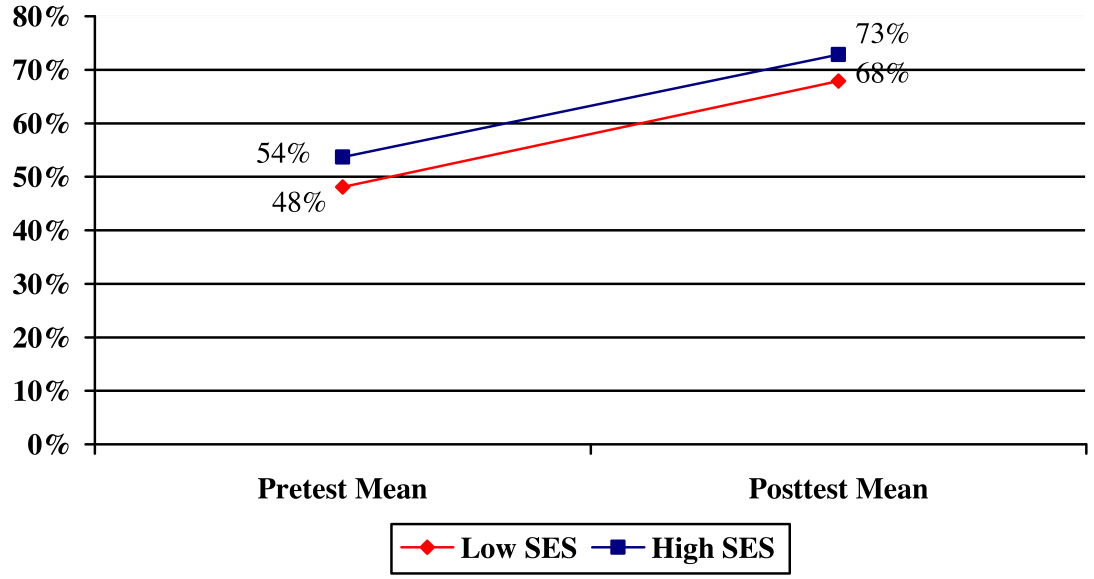
Figure 5 shows the percent of raw score increase for each of the socio-economic groups. The low socio-economic group started out with somewhat lower percentage correct scores. However, both groups improved approximately the same amount from pretesting to posttesting.

Table 5
Paired *t*-test Comparison of Pretest/Posttest Scores
Concepts Study
Two Socio-Economic Groups
(N=92)

	Pretest Scores		*Posttest Scores*		*Analysis*	
Group (N)	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*	*t-test*	*Significance*
Low Socio-Economic Status (57)	48.1	26.3	67.9	25.5	8.998	<.0001
High Socio-Economic Status (35)	53.7	27.6	72.9	23.1	4.417	<.0001

Cohen's *d* statistic for the strength of relationship for the low socio-economic group was .8 and for the high socio-economic group the Cohen's *d* statistic was .8. A statistic of .8 indicates a large effect size. The results, therefore, indicate a large effect size for both the low and high socio-economic groups.

Figure 5
Comparison of Pretest and Posttest Percent Correct
Concepts Study
Low and High Socio-Economic Students
(N=92)



Minority and Non-Minority Group Analysis

To determine if the program favored non-minority students over those who were categorized as minority, teachers were asked to categorize students as minority or non-minority. The scores of these two groups of students were then compared. Teachers identified 60 students as minority and 36 students as non-minority. Only eight students were not categorized by teachers.

Table 6 and Figure 6 provide the results for each of these two groups. The students in both groups showed statistically significant (<.0001) improvement from pretest to posttest indicating that such a change would have occurred by chance fewer than once out of 10,000 times if the study were repeated.

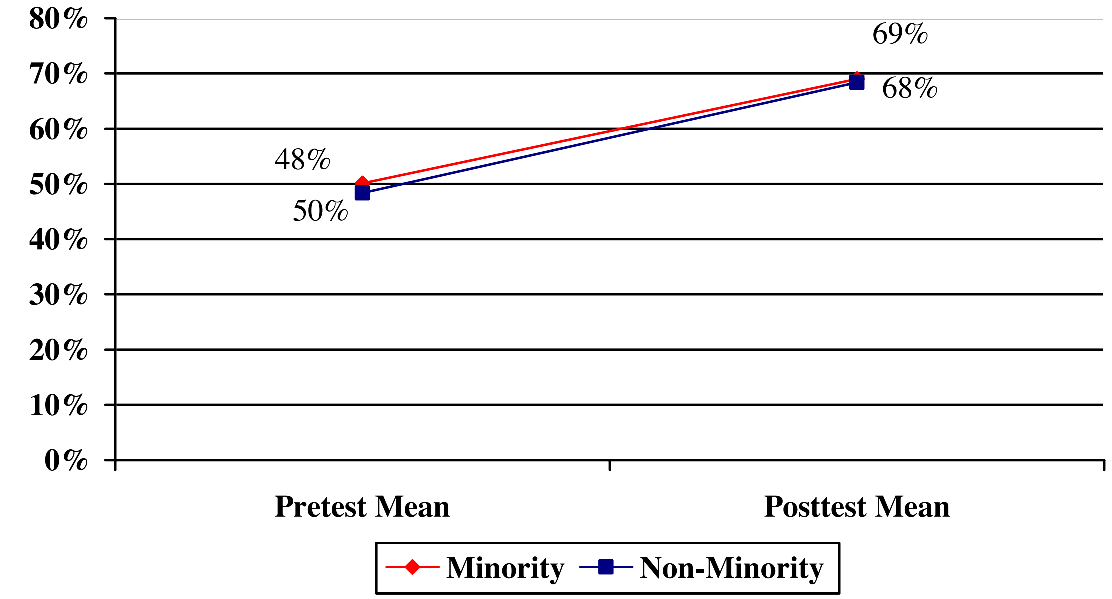
Figure 6 shows the percent of raw score increase for each of the two groups. The minority and non-minority groups had almost exactly the same pretest and posttest average scores.

Table 6
Paired *t*-test Comparison of Pretest/Posttest Scores
Concepts Study
Minority and Non-Minority Groups
(N=96)

	Pretest Scores		*Posttest Scores*		*Analysis*	
Group (N)	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*	*t-test*	*Significance*
Minority Group (60)	50.2	29.3	69.0	27.6	6.316	<.0001
Non-Minority Group (36)	48.3	20.5	68.4	17.6	7.326	<.0001

Cohen's *d* statistic for the strength of relationship for the minority group was .7 and for the non-minority group the Cohen's *d* statistic was 1.1. A statistic of .8 indicates a large effect size and a statistic of .5 indicates a medium effect size. The results, therefore, indicate a large effect size for the non-minority group and a medium effect size for the minority group.

Figure 6
Comparison of Pretest and Posttest Percent Correct
Concepts Study
Minority and Non-Minority
(N=96)



Results of the Analysis: Vocabulary Study

Total Group Analysis

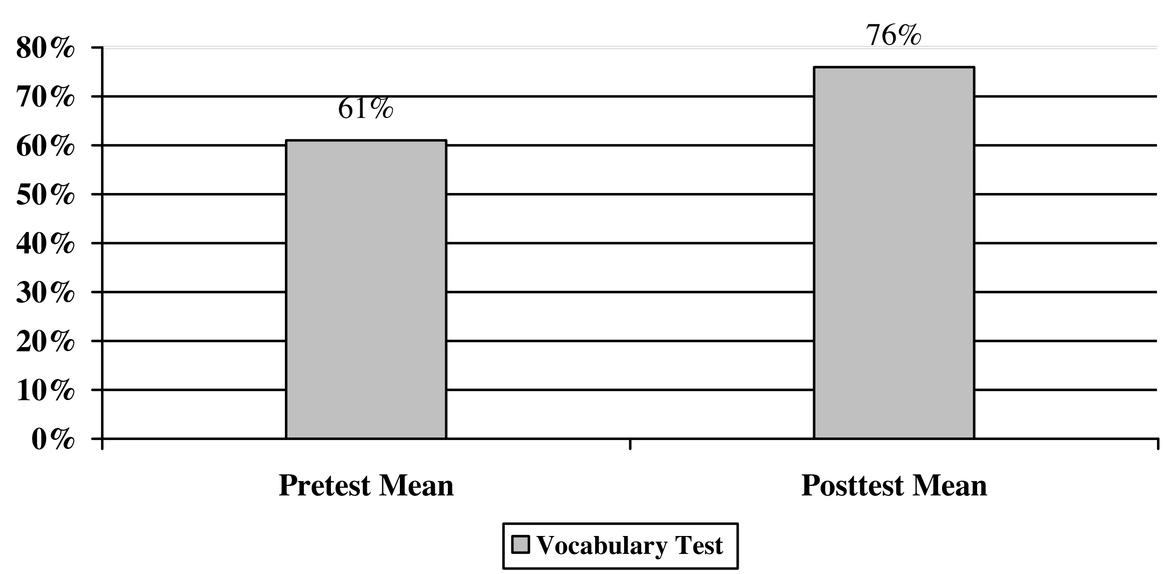
Table 7 and Figure 7 provide the results for all of the Grade 3 students included in the study. The results show statistically significant (<.0001) improvement from pretest to posttest indicating that such a change would have occurred by chance fewer than once out of 10,000 times if the study were repeated. Figure 7 shows the percent increase.

Table 7
Paired *t*-test Comparison of Pretest/Posttest Scores
Vocabulary Study
Total Group (N=101)

Pretest Scores		*Posttest Scores*		*Analysis*	
Mean	*Standard Deviation*	*Mean*	*Standard Deviation*	t-*test*	*Significance*
61.1	24.3	76.0	22.0	8.375	<.0001

Cohen's *d* statistic for the strength of relationship was .8. A statistic of .8 indicates a large effect size. The .8 result, therefore, indicates a large effect size for the gain scores of all students in the Vocabulary Study.

Figure 7
Comparison of Pretest and Posttest Percent Correct
Vocabulary Study
Total Sample (N=101)



Achievement Level Group Analysis

In order to divide the students into achievement groups, the pretest scores of the 101 students were ranked from low to high and then divided into three equal-sized groups. The low achievement group included 33 students and the average and high achieving groups included 34 students each. After categorizing the students into these three categories, a paired comparison t-test analysis was conducted using the pretest/posttest scores.

Table 8 and Figure 8 provide the results for each of the three achievement groups. Table 8 shows that the students in all three groups showed statistically significant (<.0001) improvement from pretest to posttest indicating that such a change would have occurred by chance fewer than once out of 10,000 times if the study were repeated.

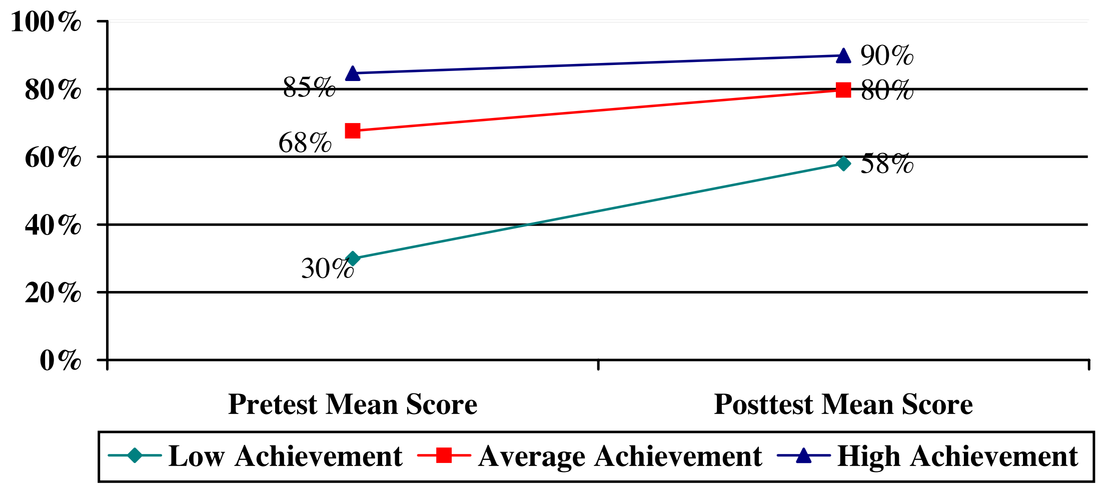
Figure 8 shows the percent of raw score increase for the three achievement groups. By design, because of how the sorting for the student groups in this achievement-level group analysis was done, the low and average groups started out with lower percentage correct scores. However, all three groups showed significant improvement.

Table 8
Paired *t*-test Comparison of Pretest/Posttest Scores
Vocabulary Study
Three Achievement Level Groups
(N=101)

	Pretest Scores		*Posttest Scores*		*Analysis*	
Group (N)	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*	t-*test*	*Significance*
High Achievement (34)	84.6	3.1	89.9	7.7	4.047	<.0001
Average Achievement (34)	67.7	6.8	79.7	13.6	5.383	<.0001
Low Achievement (33)	30.0	12.8	58.1	26.8	7.292	<.0001

Cohen's *d* statistic for the strength of relationship for the high achievement group was .9, for the average group the statistic was 1.1, and for the low group the statistic was 1.3. A statistic of .8 indicates a strong effect. The results, therefore, indicate a very strong effect size for all three achievement groups.

Figure 8
Comparison of Pretest and Posttest Percent Correct
Vocabulary Study
Three Achievement Level Groups
(N=101)



Special Services Group Analysis

Teachers were asked to identify those students receiving special services such as special education as well as those not receiving such services. Of the 101 students, teachers categorized 44 as receiving special services and 57 as not receiving such services.

Table 9 and Figure 9 provide the results for each of these two groups. The students in both groups showed statistically significant (<.0001) improvement from pretest to posttest indicating that such a change would have occurred by chance fewer than once out of 10,000 times if the study were repeated.

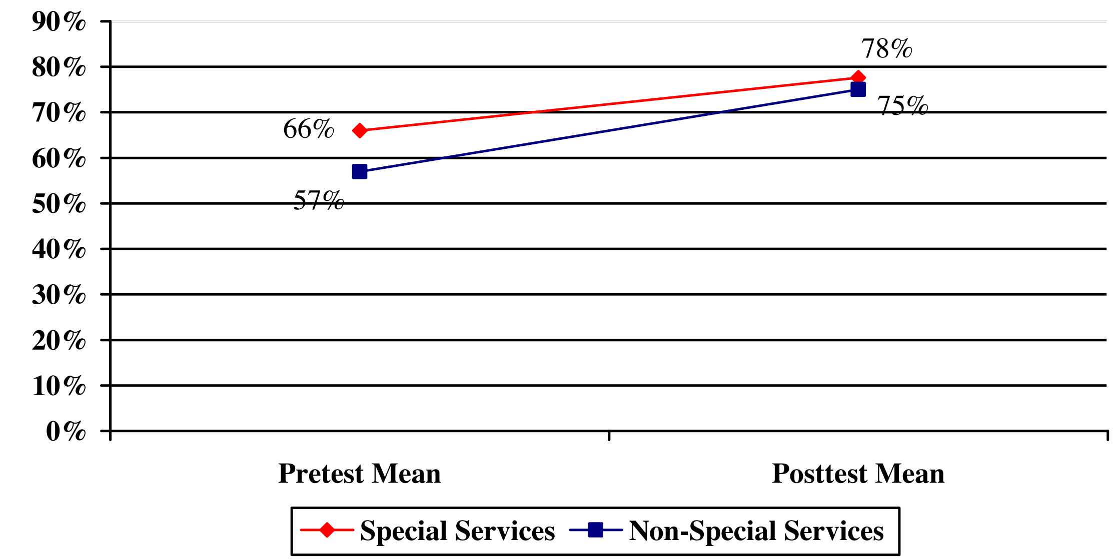
Figure 9 shows the percent of raw score increase for each of the special services groups.

Table 9
Paired *t*-test Comparison of Pretest/Posttest Scores
Vocabulary Study
Two Socio-Economic Groups
(N=101)

	Pretest Scores		*Posttest Scores*		*Analysis*	
Group (N)	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*	*t-test*	*Significance*
Special Services (44)	66.1	22.9	77.6	21.6	5.001	<.0001
Non-Special Services (57)	57.2	24.9	74.9	22.3	6.827	<.0001

Cohen's *d* statistic for the strength of relationship for the special services group was .5 and for the non-special services group the Cohen's *d* statistic was .7. A statistic of .8 indicates a large effect size and a statistic of .5 indicates a medium effect size. The results, therefore, indicate a medium effect size for both groups.

Figure 9
Comparison of Pretest and Posttest Percent Correct
Vocabulary Study
Special Services Students and Non-Special Services Students
(N=101)



English Proficiency Group Analysis

Teachers were asked to identify those students who were English proficient and those students who were not English proficient. Of the 101 students, teachers categorized 29 students as English proficient and 72 students as non-English proficient.

Table 10 and Figure 10 provide the results for each of these two groups. The students in both groups showed statistically significant (<.0001) improvement from pretest to posttest indicating that such a change would have occurred by chance fewer than once out of 10,000 times if the study were repeated.

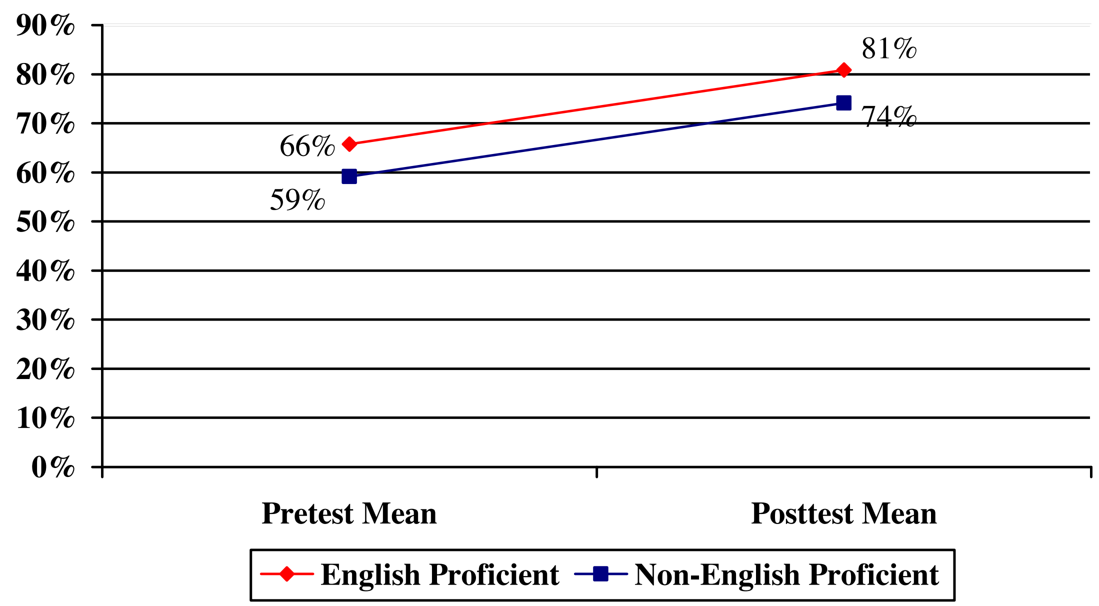
Figure 10 shows the percent of raw score increase for each of the English proficiency groups. The non-English proficient students started out with somewhat lower percentage correct scores. However, both groups improved approximately the same amount from pretesting to posttesting.

Table 10
Paired *t*-test Comparison of Pretest/Posttest Scores
Vocabulary Study
Two English Proficiency Groups
(N=101)

	Pretest Scores		*Posttest Scores*		*Analysis*	
Group (N)	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*	*t-test*	*Significance*
English Proficient (29)	65.8	22.8	80.9	21.0	6.267	<.0001
Non-English Proficient (72)	59.2	24.9	74.1	22.3	6.430	<.0001

Cohen's *d* statistic for the strength of relationship for the English proficient group and the non-English proficient group was .7. A statistic of .8 indicates a large effect size and a statistic of .5 indicates a medium effect size. The results, therefore, indicate a medium effect size for both the non-English proficient students and the English proficient group.

Figure 10
Comparison of Pretest and Posttest Percent Correct
Vocabulary Study
English Proficient and Non-English Proficient Students
(N=101)



Socio-Economic Group Analysis

To determine if the program favored higher socio-economic students over those who were categorized as lower socio-economic students, teachers were asked to categorize students as high or low socio-economic status. The scores of these two groups of students were then compared. Teachers identified 75 students as low socio-economic status and 26 students as high socio-economic status.

Table 11 and Figure 11 provide the results for each of these two groups. The students in both groups showed statistically significant (<.0001) improvement from pretest to posttest indicating that such a change would have occurred by chance fewer than once out of 10,000 times if the study were repeated.

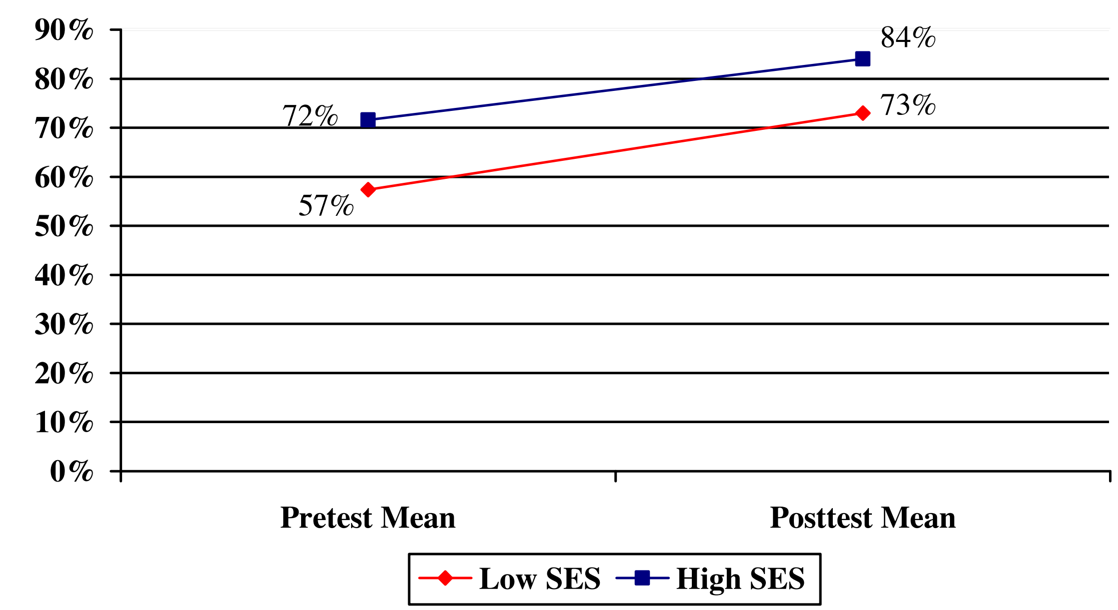
Figure 11 shows the percent of raw score increase for each of the socio-economic groups. The low socio-economic group started out with somewhat lower percentage correct scores. However, both groups improved approximately the same amount from pretesting to posttesting.

Table 11
Paired *t*-test Comparison of Pretest/Posttest Scores
Vocabulary Study
Two Socio-Economic Groups
(N=101)

	Pretest Scores		*Posttest Scores*		*Analysis*	
Group (N)	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*	*t-test*	*Significance*
Low Socio-Economic Status (75)	57.4	24.1	73.3	22.3	7.045	<.0001
High Socio-Economic Status (26)	71.6	22.3	84.0	19.6	5.068	<.0001

Cohen's *d* statistic for the strength of relationship for the low socio-economic group was .7 and for the high socio-economic group the Cohen's *d* statistic was .6. A statistic of .5 indicates a medium effect size. The results, therefore, indicate a medium effect size for both the low and high socio-economic groups.

Figure 11
Comparison of Pretest and Posttest Percent Correct
Vocabulary Study
Low and High Socio-Economic Students
(N=101)



Minority and Non-Minority Group Analysis

To determine if the program favored non-minority students over those who were categorized as minority, teachers were asked to categorize students as minority or non-minority. The scores of these two groups of students were then to be compared. However, there were questions regarding the identification of minority and non-minority students. Therefore, it was not possible to conduct any statistical analysis for this comparison.

CONCLUSIONS

The results of the various analyses were very positive for both the Concepts Study and the Vocabulary Study in demonstrating the effectiveness of increasing students' knowledge and understanding of math content, as represented by two sample chapters of the program. Table 12 shows that every statistical analysis was significant at <.0001 and the effect size was medium or large for every comparison.

Table 12
Summary of the Results
For Two Experimental Tryouts of
Concept Development or Vocabulary Development

Concepts Study		
Group Analyses	***Statistically Significant***	***Effect Size Using Cohen's d Statistic***
Total	Yes	Large
Achievement	Yes	All Groups: Large
Special Services	Yes	Special Services Group: Medium Non-Special Services Group: Large
English Proficiency	Yes	English Proficient: Medium Non-English Proficient: Large
Socio-Economic	Yes	Both Groups: Large
Minority	Yes	Non-Minority: Large Minority: Medium
Vocabulary Study		
Total	Yes	Large
Achievement	Yes	All Groups: Large
Special Services	Yes	Both Groups: Medium
English Proficiency	Yes	Both Groups: Medium
Socio-Economic	Yes	Both Groups: Medium
Minority	N/A	N/A

The results summarized in Table 12 support the conclusion that both the Concepts focus and the Vocabulary focus are successful in increasing student's understanding and achievement in mathematics. For both studies:

- The average total scores for the pretest/posttest comparison increased statistically significantly for the total group of students in both studies and the strengths of the effect were high.

- The average scores also increased statistically significantly pretest to posttest for three groups based on pretest achievement scores. All three groups in both studies showed a large effect size for the gains.

- The average scores also increased statistically significantly pretest to posttest for special services students as well as for non-special services students. The strength of the effect was shown to be medium for the special services group for both studies and large for the non-special services group in the Concepts Study and medium in the Vocabulary Study.

- The average scores also increased statistically significantly pretest to posttest for both English proficient and non-English proficient students. The strength of the effect was shown to be large for the non-English proficient group in the Concepts Study and medium for the English proficient group and for both groups in the Vocabulary Study.

- The average total scores also increased statistically significantly pretest to posttest for students identified as either low or high in terms of economic advantage. The strength of the effect was large for both the high SES group and the low SES group in the Concepts Study. In the Vocabulary Study, the effect size was medium for both SES groups.

- The average scores also increased statistically significantly pretest to posttest for minority and non-minority students in the Concepts Study. In the Concepts Study the strength of the effect was shown to be large for the non-minority group and medium for the minority group.

This study sought to determine concept development and vocabulary approaches evident in *Houghton Mifflin Harcourt GO Math!* are instructionally effective. The results of this efficacy study provide a very positive response to that question.

Experimental Efficacy Strategic Intervention

This report describes a control group/experimental group instructional efficacy study that was conducted to determine the impact of *Houghton Mifflin Harcourt GO Math!* Strategic Intervention materials on students' mathematical skills and strategy use.

Background

There has never been a greater need to ensure that the math programs that young students are using are optimally supporting them in developing the mathematical skills and strategies required for success in high school, college, and in the workplace. Because of the importance of determining the effectiveness of programs designed to support young children with mathematics instruction, Houghton Mifflin Harcourt contracted with the Educational Research Institute of America (ERIA) to study the effectiveness of the *Houghton Mifflin Harcourt GO Math!* Strategic Intervention materials. This report presents the findings from that study.

Design and Procedures of the Study

A quasi-experimental, control group pretest/posttest design was used for this study. Twelve grade 1 teachers from nine schools and ten grade 4 teachers from seven schools participated in the study. At both grades 1 and 4, six teachers participated in the experimental group. At grade 1, six teachers participated in the control group and at grade 4, four teachers participated in the control group. While the assignment to either the control group or the experimental group was not truly random, there was no known bias in the sampling and no known pattern to treatment group assignment—teachers were grouped in the order in which they volunteered to participate, allowing for similar sample sizes in the experimental and control groups.

At least one third of all students in each participating classroom in both the control group and the experimental group were working below grade level in math. However, according to the classroom teachers, no students in either group were working more than two years below grade level in math. The teachers in the experimental group were provided with directions and a schedule for participating in the study. These directions emphasized to teachers that they should teach the grade 1 or grade 4 chapter from their text and support students with Strategic Intervention materials.

According to the questionnaire results, at grade 1, an average of 54% of the students in each classroom were working up to two years below grade level in math and therefore received instruction that was supplemented by the use of the strategic intervention materials. At grade 4, an average of 56% of the students in each classroom used the strategic intervention materials. No fewer than one third of the students in any classroom used the strategic intervention materials. No classroom teacher used the strategic intervention materials with all students.

Executive Summary

Grade 1

Control Group/Experimental Group Posttest Analyses Researchers at ERIA conducted an Analysis of Variance (ANOVA) to determine if the differences in posttest scores between the control group and the experimental group at grade 1 were significantly different. The total test included 34 items (worth one point each) which was an adequate length to conduct an ANOVA. The .05 level of significance was used as the level at which differences would be considered statistically significant. For these analyses, 82 students were included in the experimental group and 104 students were included in the control group. In addition to the ANOVAs, effect-size analyses were computed for each of the comparisons. Cohen's *d* statistic was used to determine the effect size. This statistic provides an indication of the strength of the effect of the treatment regardless of the statistical significance. Cohen's *d* statistic is interpreted as follows:

.2 = small effect
.5 = medium effect
.8 = large effect

Table 1 presents the results of the ANOVA performed to determine if the difference in posttest scores between the control group and the experimental group at grade 1 was statistically significant. The average percent correct score on the posttest for the control group was 74.1% and for the experimental group was 80.6%, a difference that was statistically significant at the .0001 level. This level of significance indicates that such a difference would have occurred by chance less than once out of 10,000 repetitions. The effect size was medium.

Table 1
ANOVA Results Comparing the Total Test Percent Correct Scores of the Control Group and the Experimental Group on the Posttest
Grade 1

Test	*Group*	*Number of Students*	*Mean Score*	*SD*	F Test	*Significance*	*Effect Size*
Posttest	Control	104	74.1%	14.5%	8.653	<.0001	.51
Posttest	Experimental	82	80.6%	15.2%			

Figure 1 shows the percentage of the grade 1 control group students and experimental group students who scored below 70%, from 70% to 89%, and 90% or higher on the posttest. Almost ten percent more students in the control group than in the experimental group received posttest scores of below 70%. Conversely, nearly twenty percent more students in the experimental group than in the control group received posttest scores of 90% or higher.

Figure 1
Percentage of Control Group and Experimental Group Students Scoring at Various Levels on the Posttest
Grade 1

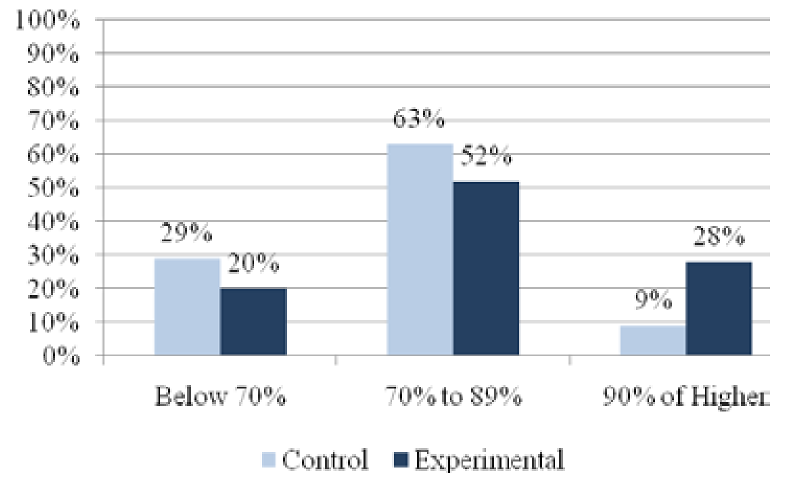


Figure 2 shows the percentage of students in the grade 1 strategic intervention group who scored below 70%, 70% to 89%, and 90% or higher on the pretest and on the posttest. All students in the grade 1 strategic intervention group scored below 70% on the pretest. However, on the posttest, 63% of the students in the group scored 70% or higher.

Figure 2
Percentage of Strategic Intervention Group Students Scoring at Various Levels on the Pretest and Posttest
Grade 1

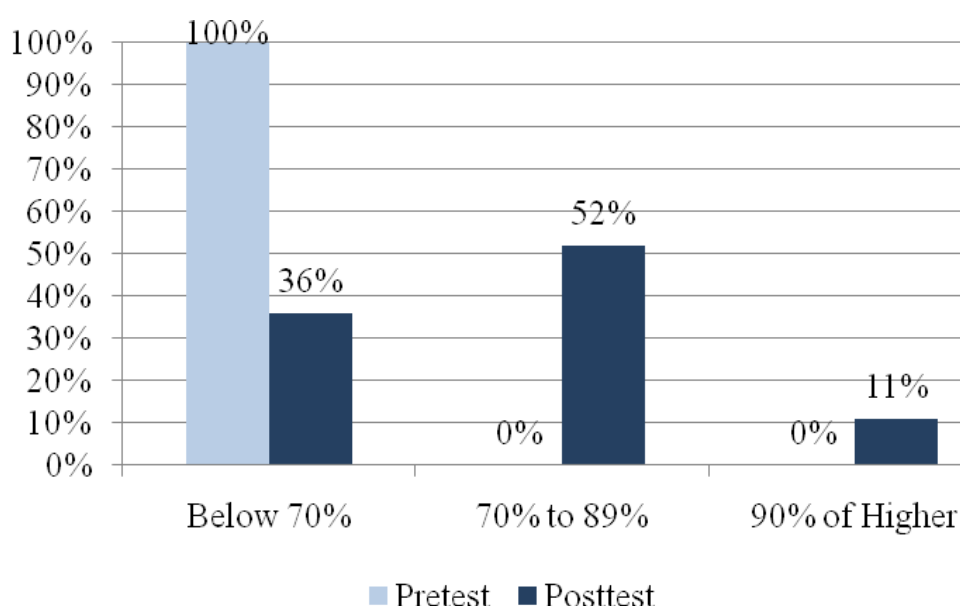
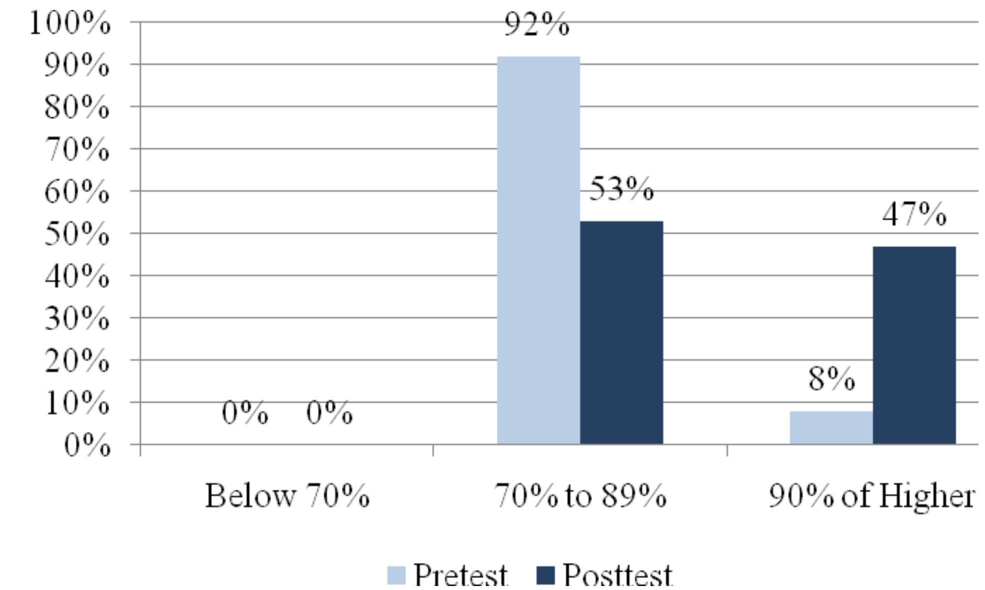


Figure 3 shows the percentage of students in the non-strategic intervention group who scored below 70%, 70% to 89%, and 90% or higher on the pretest and on the posttest. The percentage of students in the non-strategic intervention group receiving a score of 90% or higher increased from 8% on the pretest to 47% on the posttest.

Figure 3
Percentage of Non-Strategic Intervention Group Students Scoring at Various Levels on the Pretest and Posttest
Grade 1



Control Group/Experimental Group Posttest Analyses
Grade 4

Researchers at ERIA conducted an Analysis of Variance (ANOVA) to determine if the differences in posttest scores between the control group and the experimental group at grade 4 were significantly different. The total test included 32 items (worth one point each) which was an adequate length to conduct an ANOVA. The .05 level of significance was used as the level at which differences would be considered statistically significant. For these analyses, 101 students were included in the experimental group and 76 students were included in the control group. In addition to the ANOVAs, effect-size analyses were computed for each of the comparisons. Cohen's *d* statistic was used to determine the effect size. This statistic provides an indication of the strength of the effect of the treatment regardless of the statistical significance.

Cohen's *d* statistic is interpreted as follows:

.2 = small effect
.5 = medium effect
.8 = large effect

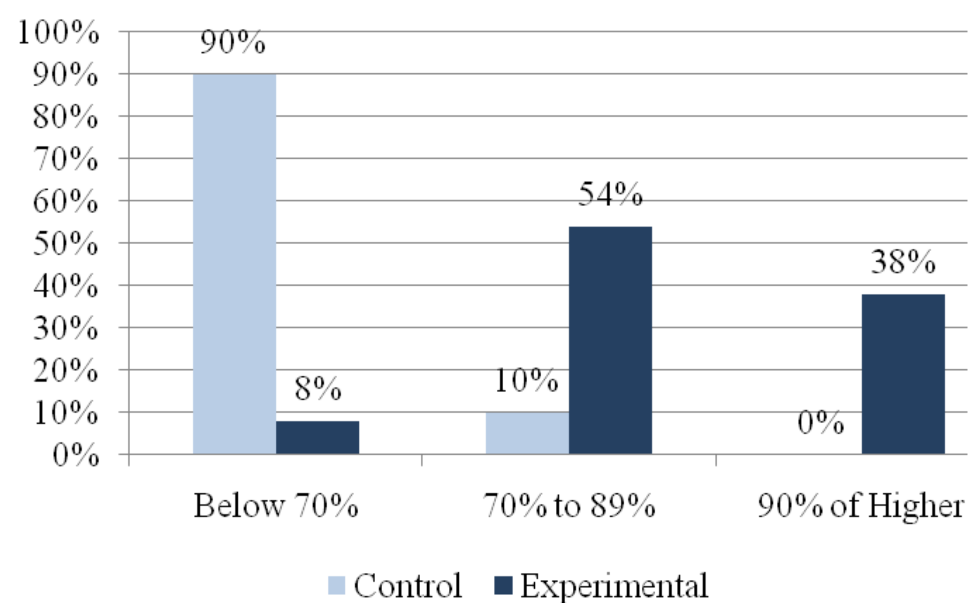
Table 2 presents the results of the ANOVA performed to determine if the difference in posttest scores between the control group and the experimental group at grade 4 was statistically significant. The average percent correct score on the posttest for the control group was 53.3% and for the experimental group was 84.3%, a difference that was statistically significant at the .0001 level. This level of significance indicates that such a difference would have occurred by chance less than once out of 10,000 repetitions. The effect size was large.

Table 2
ANOVA Results Comparing the Total Test Percent Correct Scores of the Control Group and the Experimental Group on the Posttest
Grade 4

Test	*Group*	*Number of Students*	*Mean Score*	*SD*	F Test	*Significance*	*Effect Size*
Posttest	Control	76	53.3%	13.3%	309.58	<.0001	2.59
Posttest	Experimental	101	84.3%	10.2%			

Figure 4 shows the percentage of the grade 4 control group students and experimental group students who scored below 70%, from 70% to 89%, and 90% or higher on the posttest. In the control group, 90% of the students scored below 70% on the posttest and none of them scored 90% or higher. In the experimental group, however, only 8% of the students scored below 70% on the posttest and more than one-third of the group scored 90% or higher.

Figure 4
Percentage of Control Group and Experimental Group Students Scoring at Various Levels on the Posttest
Grade 4



Total Experimental Group Pretest/Posttest Analyses

A paired comparison t-test was used to compare the pretest and posttest scores of the grade 4 experimental group. The .05 level of significance was used as the level at which increases would be considered statistically significant. A total of 101 students were included in these analyses.

Table 3 presents the results of the paired comparison t-test performed to determine if the difference between the pretest and the posttest total test percent correct scores at grade 4 was significant. The average percent correct score increased from 60.8% on the pretest to 84.3% on the posttest, a difference that was statistically significant at the .0001 level. This level of significance indicates that such a change would have occurred by chance less than once out of 10,000 repetitions. The effect size was large.

Table 3
Paired Comparison *t*-test Results Comparing the Experimental Group's Pretest and Posttest Total Test Percent Correct Scores
Grade 4

Test	*Group*	*Number of Students*	*Mean Score*	*SD*	*t-test*	*Significance*	*Effect Size*
Pretest	Total Experimental	101	60.8%	9.5%	38.389	<.0001	2.42
Posttest	Total Experimental	101	84.3%	10.2%			

Figure 5 shows the percentage of the grade 4 experimental group students who scored below 70%, from 70% to 89%, and 90% or higher on the pretest and on the posttest. The results provide a clear picture of the decline from pretest to posttest of below 70% correct scores and the large increase from pretest to posttest in the percentage of students scoring 90% or higher.

Figure 5
Percentage of Experimental Group Students Scoring at Various Levels on the Pretest and Posttest
Grade 4

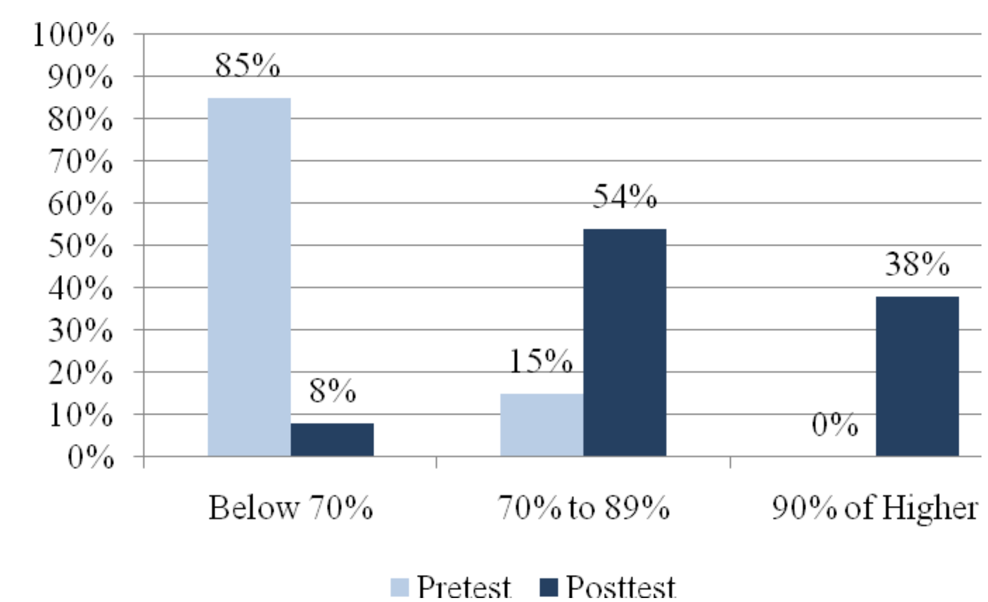


Figure 6 shows the percentage of grade 4 students in the strategic intervention group who scored below 70%, 70% to 89%, and 90% or higher on the pretest and on the posttest. All students in the grade 4 strategic intervention group scored below 70% on the pretest. However, on the posttest, 86% of the students in the group scored 70% or higher.

Figure 6
Percentage of Strategic Intervention Group Students Scoring at Various Levels on the Pretest and Posttest
Grade 4

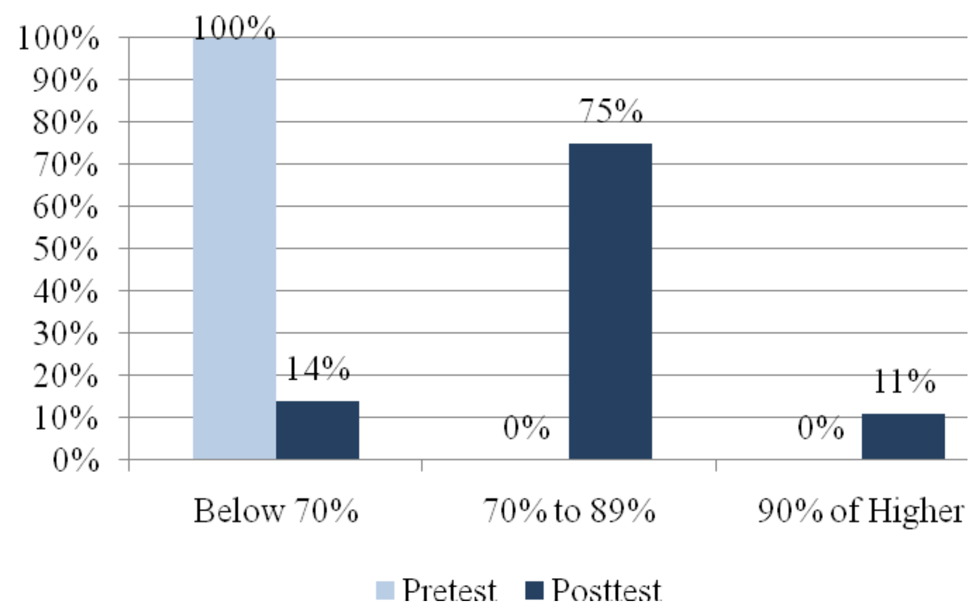
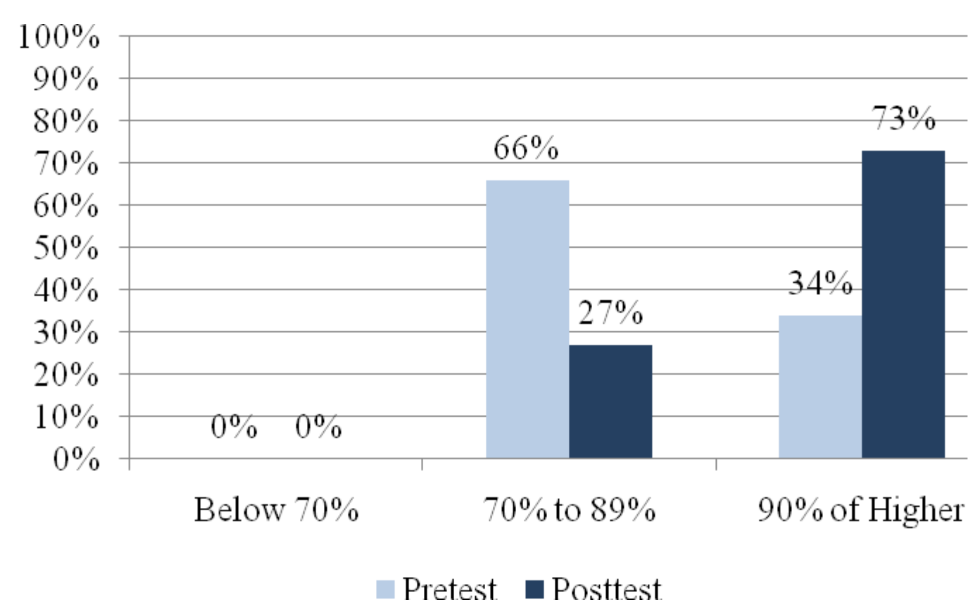


Figure 7 shows the percentage of grade 4 students in the non-strategic intervention group who scored below 70%, 70% to 89%, and 90% or higher on the pretest and on the posttest. The percentage of students in the non-strategic intervention group receiving a score of 90% or higher increased from 34% on the pretest to 73% on the posttest.

Figure 7
Percentage of Non-Strategic Intervention Group Students Scoring at Various Levels on the Pretest and Posttest
Grade 4



CONCLUSIONS

This study sought to determine the effect of the *Houghton Mifflin Harcourt GO Math!* Strategic Intervention materials on students' math skills and strategy use.

Table 4 summarizes the experimental group results showing the decreases from pretest to posttest in the percentages of students scoring at lower levels and the increases from pretest to posttest in the percentages of students scoring at higher levels.

Table 4
Summary of Changes from Pretest to Posttest of Percentage of Grade 1 and Grade 4 Experimental Group Students Scoring at Various Levels

Student Sample and Grade Level	*Below 70%*	*70% to 89%*	*90% or Higher*
Entire Sample			
Grade 1	-34%	+9%	+25%
Grade 4	-77%	+39%	+38%
Strategic Intervention Group			
Grade 1	-64%	+52%	+11%
Grade 4	-86%	+75%	+11%
Non-Strategic Intervention Group			
Grade 1	--	-39%	+39%
Grade 4	--	-39%	+39%

The mathematical skills and strategy use of students who were working up to two years below grade level in math and therefore received instruction that was supplemented by *Houghton Mifflin Harcourt GO Math!* Strategic Intervention increased in a way that was statistically significant.

Experimental Efficacy Intensive Intervention

This report describes a control group/experimental group instructional efficacy study that was conducted to determine the impact of the *Houghton Mifflin Harcourt GO Math!* Intensive Intervention Kit on students' mathematical skills and strategy use.

Background

Response to Intervention (RTI) is a federally prescribed alternative to the widely discredited aptitude-achievement discrepancy approach to the identification of students with learning disabilities. In 2004, when Congress reauthorized Individuals with Disabilities Education Act (IDEA), they changed the law about identifying children with specific learning disabilities. IDEA now allows educators to use the RTI framework to identify students with specific learning disabilities. RTI shifts the emphasis of the identification process toward providing support and intervention to struggling students early on. RTI typically includes three "tiers" of instruction, with more intensive help provided if a child does not respond at each tier. Most of the instruction is provided in general education, not in special education. Special education tends to be very expensive. Eliminating or significantly reducing special education would release resources that could be redistributed in general education, serving many more children (Hale, 2008).

RTI is a process that emphasizes how well students respond to changes in instruction. The essential elements of an RTI approach are: the provision of scientific, research-based instruction and interventions in general education; monitoring and measurement of student progress in response to the instruction and interventions; and use of these measures of student progress to shape instruction and make educational decisions (Klotz & Canter, 2006). RTI requires that instructional interventions be scientifically valid and systematically evaluated. Unfortunately, a major issue in today's schools is the widespread implementation of highly questionable, non-evidence-based instruction under the title RTI.

Because of the importance of determining the effectiveness of math programs in general and of programs designed to be implemented into the RTI framework in particular, Houghton Mifflin Harcourt contracted with the Educational Research Institute of America (ERIA) to study the effectiveness of the *Houghton Mifflin Harcourt GO Math!* Intensive Intervention Kit, one such RTI program. This report presents the findings from that study.

Research Questions

The following research questions guided the design of the study:

- Is the *Houghton Mifflin Harcourt GO Math!* Intensive Intervention Kit instructionally effective in improving students' mathematical skills and strategy use?
- Do students whose math instruction is supported by the *Houghton Mifflin Harcourt GO Math!* Intensive Intervention Kit show improvements in their mathematical skills and strategy use that are above those shown by students in a control group?

Design and Procedures of the Study

A quasi-experimental, control group pretest/posttest design was used for this study. Eleven grade 2 teachers from seven schools and nine grade 5 teachers from nine schools participated in the study. At grade 2, six teachers participated in the experimental group and five teachers participated in the control group. At grade 5, four teachers participated in the experimental group and five teachers participated in the control group. While the assignment to either the control group or the experimental group was not truly random, there was no known bias in the sampling and no known pattern to treatment group assignment—teachers were grouped in the order in which they volunteered to participate, allowing for similar sample sizes in the experimental and control groups. The ten teachers participating in the experimental group used the *Houghton Mifflin Harcourt GO Math!* Intensive Intervention Kit along with their primary math program. The teachers participating in the control group continued to use the math programs that they had been using prior to their involvement in the study and did not use the *Houghton Mifflin Harcourt GO Math!* Intensive Intervention Kit. The teachers in the experimental group were provided with directions and a schedule for participating in the study.

Executive Summary

Grade 2

Control Group/Experimental Group Posttest Analyses Researchers at ERIA conducted an Analysis of Variance (ANOVA) to determine if the differences in posttest scores between the control group and the experimental group at grade 2 were significantly different. The total test included 30 items (worth one point each) which was an adequate length to conduct an ANOVA. The .05 level of significance was used as the level at which differences would be considered statistically significant. For these analyses, 68 students were included in the experimental group and 93 students were included in the control group. In addition to the ANOVAs, effect-size analyses were computed for each of the comparisons. Cohen's *d* statistic was used to determine the effect size. This statistic provides an indication of the strength of the effect of the treatment regardless of the statistical significance. Cohen's *d* statistic is interpreted as follows:

.2 = small effect
.5 = medium effect
.8 = large effect

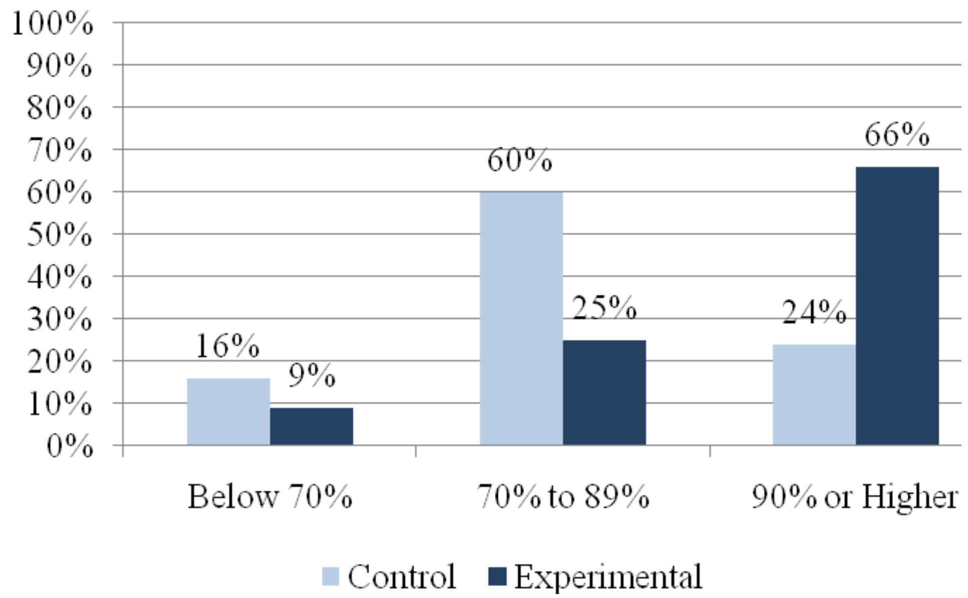
Table 1 presents the results of the ANOVA performed to determine if the difference in posttest scores between the control group and the experimental group at grade 2 was statistically significant. The average percent correct score on the posttest for the control group was 79.3% and for the experimental group was 89.8%, a difference that was statistically significant at the .0001 level. This level of significance indicates that such a difference would have occurred by chance less than once out of 10,000 repetitions. The effect size was large.

Table 1
ANOVA Results Comparing the Total Test Percent Correct Scores of the Control Group and the Experimental Group on the Posttest
Grade 2

Test	*Group*	*Number of Students*	*Mean Score*	*SD*	F Test	*Significance*	*Effect Size*
Posttest	Control	93	79.3%	11.4%	41.438	<.0001	1.06
Posttest	Experimental	68	89.8%	8.3%			

Figure 1 shows the percentage of the grade 2 control group students and experimental group students who scored below 70%, from 70% to 89%, and 90% or higher on the posttest. Over forty percent more students in the experimental group than in the control group received posttest scores of 90% or higher.

Figure 1
Percentage of Control Group and Experimental Group Students Scoring at Various Levels on the Posttest
Grade 2



Experimental Group Pretest/Posttest Analyses

A paired comparison t-test was used to compare the pretest and posttest scores of the grade 2 experimental group. The .05 level of significance was used as the level at which increases would be considered statistically significant. A total of 68 students were included in these analyses.

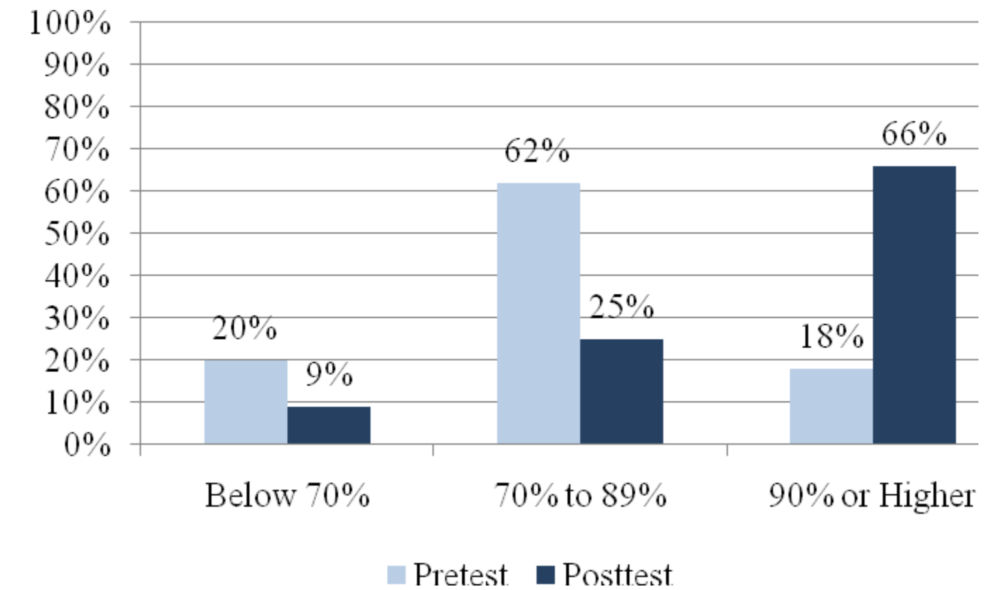
Table 2 presents the results of the paired comparison t-test performed to determine if the difference between the pretest and the posttest total test percent correct scores at grade 2 was significant. The average percent correct score increased from 77.9% on the pretest to 89.8% on the posttest, a difference that was statistically significant at the .0001 level. This level of significance indicates that such a change would have occurred by chance less than once out of 10,000 repetitions. The effect size was large.

Table 2
Paired Comparison *t*-test Results Comparing the Experimental Group's Pretest and Posttest Total Test Percent Correct Scores
Grade 2

Test	*Group*	*Number of Students*	*Mean Score*	*SD*	*t-test*	*Significance*	*Effect Size*
Pretest	Total Experimental	68	77.9%	13.2%	8.851	<.0001	1.27
Posttest	Total Experimental	68	89.8%	8.3%			

Figure 2 shows the percentage of the grade 2 experimental group students who scored below 70%, from 70% to 89%, and 90% or higher on the pretest and on the posttest. The results provide a clear picture of the decline from pretest to posttest of below 70% correct scores and the large increase from pretest to posttest in the percentage of students scoring 90% or higher.

Figure 2
Percentage of Experimental Group Students Scoring at Various Levels on Pretests and Posttests
Grade 2



Experimental Group Pretest/Posttest Analysis of Pretest Performance Groups

The experimental group was divided into two equal groups of 34 students based on their pretest scores. Paired comparison t-tests were conducted to determine if both groups made significant pretest to posttest gains.

Table 3 presents the results of the paired comparison t-test analysis of the student scores grouped by pretest performance. The average percent correct score for the lower scoring group increased from 68.2% to 86.3% and the average percent correct score for the higher scoring group increased from 87.6% to 93.3%. The difference for the lower scoring pretest group was statistically significant at the .001 level, indicating a change that would have occurred by chance less than once out of 1,000 repetitions. The difference for the higher scoring pretest group was statistically significant at the .0001 level. This level of significance indicates that such a change would have occurred by chance less than once out of 10,000 repetitions. The effect size was large for both groups.

Table 3
Paired Comparison *t*-test Results Comparing the Pretest/Posttest Total Test Percent Correct Scores for Students Grouped by Pretest Performance
Grade 2 Experimental Group

Test	*Number of Students*	*Mean Score*	*SD*	t-test	*Significance*	*Effect Size*
Lower Pretest Group						
Pretest	34	68.2%	12.2%	8.640	<.001	1.66
Posttest	34	86.3%	9.3%			
Higher Pretest Group						
Pretest	34	87.6%	3.8%	6.821	<.0001	1.28
Posttest	34	93.3%	5.1%			

Figure 3 shows the percentage of lower scoring students who scored below 70%, 70% to 89%, and 90% or higher on the pretest and on the posttest. While none of the students scored 90% or higher on the pretest, on the posttest, nearly half of the lower scoring students scored 90% or higher.

Figure 3
Percentage of Lower Scoring Students Scoring at Various Levels on the Pretest and Posttest
Grade 2 Experimental Group

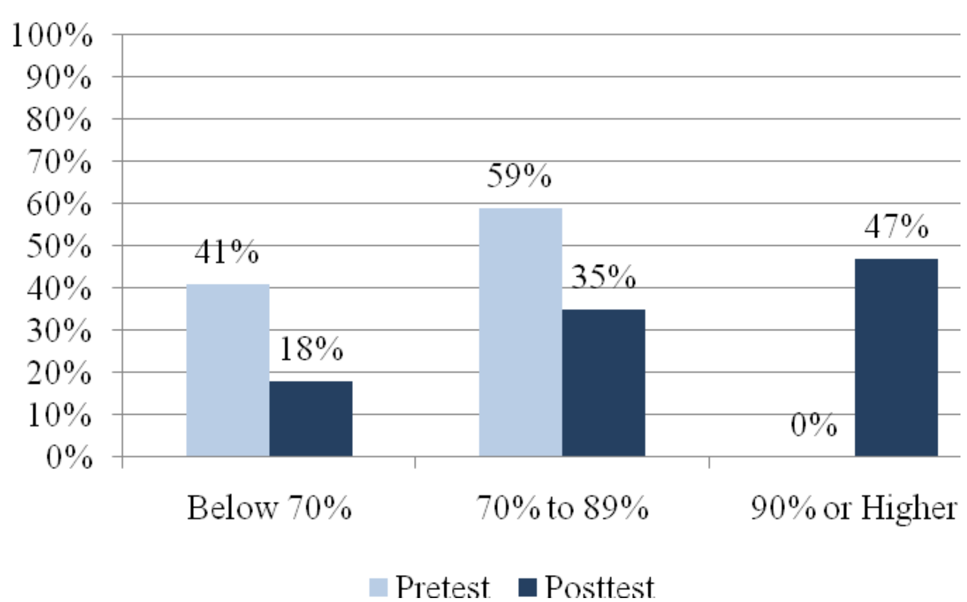
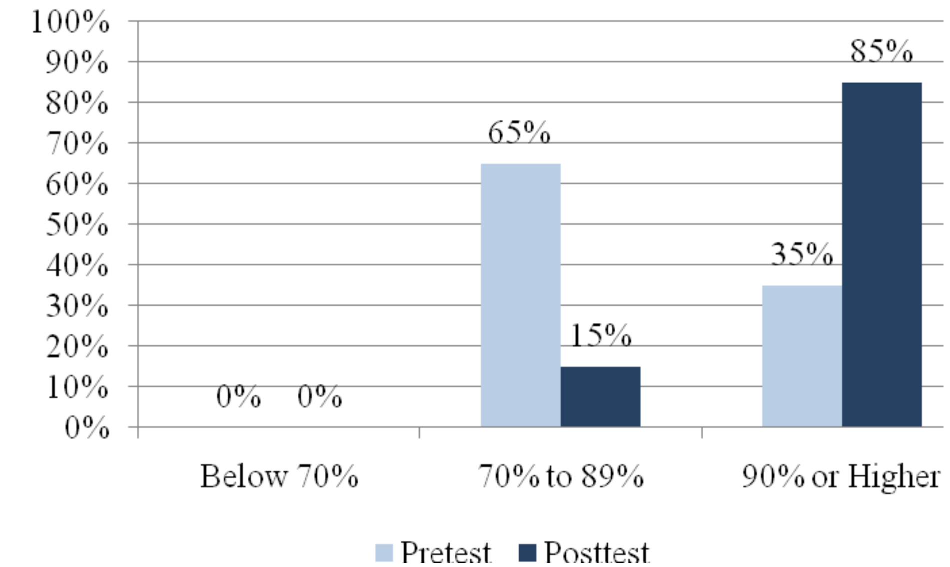


Figure 4 shows the percentage of higher scoring students who scored below 70%, 70% to 89%, and 90% or higher on the pretest and on the posttest. The percentage of students in the higher scoring group receiving a score of 90% or higher more than doubled from pretest to posttest, going from 35% on the pretest to 85% on the posttest.

Figure 4
Percentage of Higher Scoring Students Scoring at Various Levels on the Pretest and Posttest
Grade 2 Experimental Group



Control Group/Experimental Group Posttest Analyses

Grade 5

Researchers at ERIA conducted an Analysis of Variance (ANOVA) to determine if the differences in posttest scores between the control group and the experimental group at grade 5 were significantly different. The total test included 30 items (worth one point each) which was an adequate length to conduct an ANOVA. The .05 level of significance was used as the level at which differences would be considered statistically significant. For these analyses, 80 students were included in the experimental group and 86 students were included in the control group.

In addition to the ANOVAs, effect-size analyses were computed for each of the comparisons. Cohen's *d* statistic was used to determine the effect size. This statistic provides an indication of the strength of the effect of the treatment regardless of the statistical significance.
Cohen's *d* statistic is interpreted as follows:
.2 = small effect
.5 = medium effect
.8 = large effect

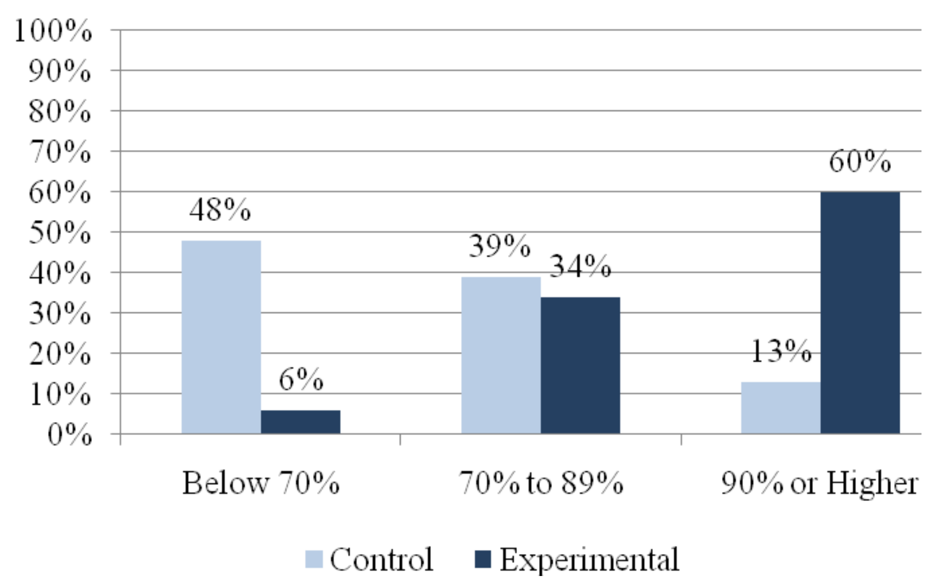
Table 4 presents the results of the ANOVA performed to determine if the difference in posttest scores between the control group and the experimental group at grade 5 was significant. The average percent correct score on the posttest for the control group was 66.5% and for the experimental group was 81.3%, a difference that was statistically significant at the .0001 level. This level of significance indicates that such a difference would have occurred by chance less than once out of 10,000 repetitions. The effect size was medium.

Table 4
ANOVA Results Comparing the Total Test Percent Correct Scores of the Control Group and the Experimental Group on the Posttest
Grade 5

Test	*Group*	*Number of Students*	*Mean Score*	*SD*	F Test	*Significance*	*Effect Size*
Posttest	Control	86	66.5%	25.0%	20.878	<.0001	.72
Posttest	Experimental	80	81.3%	14.9%			

Figure 5 shows the percentage of the grade 5 control group students and experimental group students who scored below 70%, from 70% to 89%, and 90% or higher on the posttest. The percentage of students scoring 90% or higher on the posttest was almost three times higher for the experimental group than the control group.

Figure 5
Percentage of Control Group and Experimental Group Students Scoring at Various Levels on the Posttest
Grade 5



Experimental Group Pretest/Posttest Analyses

A paired comparison t-test was used to compare the pretest and posttest scores of the grade 5 experimental group. The .05 level of significance was used as the level at which increases would be considered statistically significant. A total of 80 students was included in these analyses.

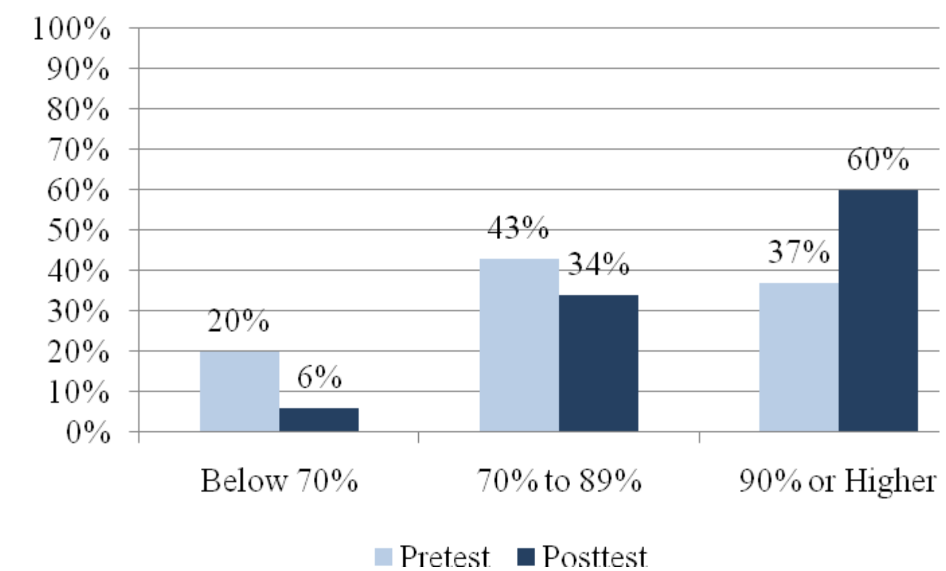
Table 5 presents the results of the paired comparison t-test performed to determine if the difference between the pretest and the posttest total test percent correct scores at grade 5 was significant. The average percent correct score increased from 71.3% on the pretest to 81.3% on the posttest, a difference that was statistically significant at the .0001 level. This level of significance indicates that such a change would have occurred by chance less than once out of 10,000 repetitions. The effect size was medium.

Table 5
Paired Comparison *t*-test Results Comparing the Experimental Group's Pretest and Posttest Total Test Percent Correct Scores
Grade 5

Test	*Group*	*Number of Students*	*Mean Score*	*SD*	*t-test*	*Significance*	*Effect Size*
Pretest	Total Experimental	80	71.3%	16.9%	8.814	<.0001	.63
Posttest	Total Experimental	80	81.3%	14.9%			

Figure 6 shows the percentage of the grade 5 experimental group students who scored below 70%, from 70% to 89%, and 90% or higher on the pretest and on the posttest. The results provide a clear picture of the decline from pretest to posttest of below 70% correct scores and the large increase from pretest to posttest in the percentage of students scoring 90% or higher.

Figure 6
Percentage of Experimental Group Students Scoring at Various Levels on the Pretest and Posttest
Grade 5



Experimental Group Pretest/Posttest Analysis of Pretest Performance Groups

The experimental group was divided into two equal groups of 40 students based on their pretest scores. Paired comparison t-tests were conducted to determine if both groups made significant pretest to posttest gains.

Table 6 presents the results of the paired comparison t-test analysis of the student scores grouped by pretest performance. The average percent correct score for the lower scoring group increased from 58.3% to 71.1% and the average percent correct score for the higher scoring group increased from 84.3% to 91.6%. The difference for the lower scoring pretest group was statistically significant at the .001 level, indicating a change that would have occurred by chance less than once out of 1,000 repetitions. The difference for the higher scoring pretest group was statistically significant at the .0001 level. This level of significance indicates that such a change would have occurred by chance less than once out of 10,000 repetitions. The effect size was large for both groups.

Table 6
Paired Comparison *t*-test Results Comparing the Pretest/Posttest Total Test Percent Correct Scores for Students Grouped by Pretest Performance
Grade 5 Experimental Group

Test	*Number of Students*	*Mean Score*	*SD*	*t-test*	*Significance*	*Effect Size*
Lower Pretest Group						
Pretest	40	58.3%	13.8%	6.626	<.001	.90
Posttest	40	71.1%	14.1%			
Higher Pretest Group						
Pretest	40	84.3%	6.7%	6.743	<.0001	1.12
Posttest	40	91.6%	6.2%			

Figure 7 shows the percentage of grade 5 students in the lower scoring pretest group who scored below 70%, 70% to 89%, and 90% or higher on the pretest and on the posttest. The percentage of lower scoring students scoring below 70% dropped by well over half from pretest to posttest.

Figure 7
Percentage of Students in the Lower Scoring Pretest Group Scoring at Various Levels on the Pretest and Posttest
Grade 5 Experimental Group

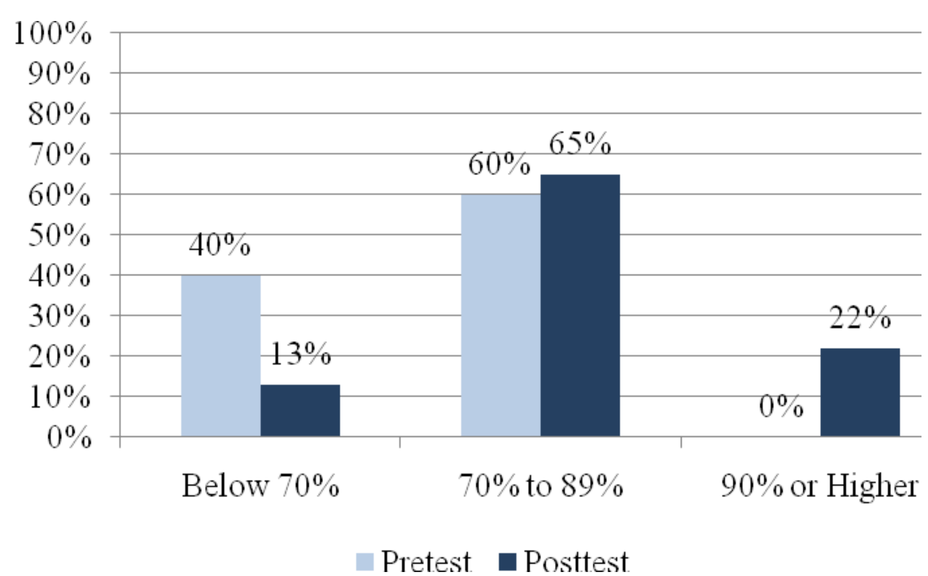
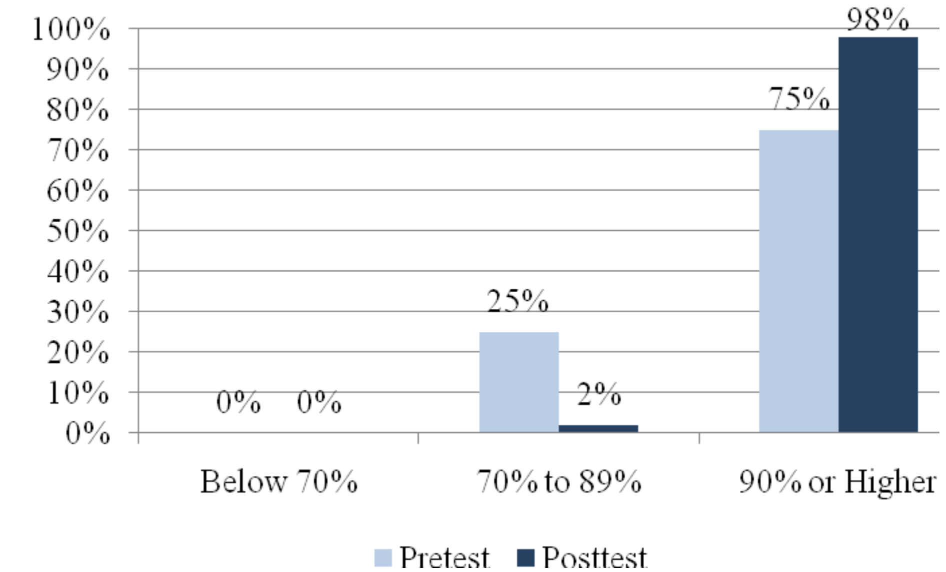


Figure 8 shows the percentage of grade 5 students in the higher scoring pretest group who scored below 70%, 70% to 89%, and 90% or higher on the pretest and on the posttest. The percentage of students in the lower scoring group receiving a score of 90% or higher increased by more than 20% from pretest to posttest.

Figure 8
Percentage of Students in the Higher Scoring Pretest Group Scoring at Various Levels on the Pretest and Posttest
Grade 5 Experimental Group



CONCLUSIONS

This study sought to determine the effect of the *Houghton Mifflin Harcourt GO Math!* Intensive Intervention Kit on students' math skills and strategy use. When comparing the experimental group with the control group at grade 2 and grade 5, statistically significant differences were found between the two groups' posttest scores for the total test, with the experimental group receiving higher scores at both grade levels. A summary of the results is provided in Table 7. The table indicates whether the differences were significant as well as the strength of each significant difference.

Table 7
Summary of the Control Group/Experimental Group Posttest Score Analyses at Grade 2 and Grade 5

Grade	*Difference Statistically Significant?*	*Effect Size*
Grade 2	Yes	Large
Grade 5	Yes	Medium

When comparing the pretest to posttest gains made by the experimental group, the group made statistically significant gains at both grade 2 and grade 5. In addition, significant gains were made by students who scored lower on the pretests as well as those who scored higher on the pretest. A summary of the results is provided in Table 8 below. The table indicates whether the gains were significant as well as the strength of each significant gain.

Table 8
Summary of the Experimental Group Pretest/Posttest Score Analyses at Grade 2 and Grade 5

	Grade 2		*Grade 5*	
Group	*Gain Statistically Significant?*	*Effect Size*	*Gain Statistically Significant?*	*Effect Size*
Total Group	Yes	Large	Yes	Medium
Lower Scorers on the Pretest	Yes	Large	Yes	Large
Higher Scorers on the Pretest	Yes	Large	Yes	Large

Table 9 summarizes the experimental group results showing the decreases from pretest to posttest in the percentages of students scoring at lower levels and the increases from pretest to posttest in the percentages of students scoring at higher levels.

Figure 9
Summary of Changes from Pretest to Posttest of Percentage of Grade 2 and Grade 5 Experimental Group Students Scoring at Various Levels

Student Sample and Grade Level	*Below 70%*	*70% to 89%*	*90% or Higher*
Entire Sample			
Grade 2	-11%	-37%	+48%
Grade 5	-14%	-9%	+23%
Lower Scoring Pretest Group			
Grade 2	-23%	-24%	+47%
Grade 5	-27%	+5%	+22%
Higher Scoring Pretest Group			
Grade 2	--	-50%	+50%
Grade 5	--	-23%	+23%

The conclusion based on the data from reliable and valuable assessments indicate grade 2 and grade 5 students whose instruction was supported by the *Houghton Mifflin Harcourt GO Math!* Intensive Intervention Kit increased their skills and strategy use in mathematics significantly more than grade 2 and grade 5 students in a control group.

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