



# The Effectiveness of Computer-Aided Mathematics Instruction in the New Era of STEM Education



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*“In the 21<sup>st</sup> century, schools can’t be throw-backs to the state of education fifty, twenty, or even ten years ago. The content they provide, the learning experiences they offer, the teaching methods they employ, and the assessments they use, must all keep pace with this century.”*

**Arne Duncan**  
U.S. Secretary of  
Education

## A Math Problem

A strong mathematical foundation is a cornerstone of every child’s education, helping them to move on to higher learning and increasing their chances of success in science, technology, engineering, and mathematics intensive (STEM) professional careers. Funding programs such as Race to the Top recognize this by holding schools accountable for student achievement as measured by the Common Core State Standards. The related next generation assessments, under development, will likewise be raising the bar for higher measures of achievement. Yet, despite the clear opportunities and legislative requirements that a strong mathematics education offers, it remains an incredibly difficult subject area to staff, and the achievement gap for at-risk students persists (Institute of Educational Sciences, 2009). Educators seek creative ways to teach mathematics more effectively to close such gaps and to better prepare students for the new standards and assessments, but they face numerous challenges.

## A Tough Road

Challenges faced by districts include the following:

- Resources are not equitably allocated.
- Chronic teacher shortages necessitate teachers teaching “out of field” in areas where they lack adequate professional development.
- The achievement gap between economically disadvantaged students and their peers creates a need to “raise the floor” to put all students on an equal footing.
- Educators need to understand how to teach less material than is usually found in America’s overcrowded curriculum and to teach it at deeper levels than ever before.
- The expectation is that all children are to be comfortable functioning within a technology-rich environment.

Major strides need to be taken to ensure that these needs are met. With increased federal attention and so much expected of districts within a short timeframe, educators are feeling ever more pressure to show results.

## A Math Solution

The International Center for Leadership in Education's Rigor/Relevance Framework® fits well with the new demands and education reform parameters set forth by the STEM initiatives. It is based on traditional elements of education, yet encourages movement to the application of knowledge, instead of maintaining an exclusive focus on the acquisition of knowledge. Consequently, this tool aligns with the new Common Core State Standards, with their emphasis on deep knowledge applied to real-world situations.

At the same time, computer-aided instruction (CAI) has long been considered a method for addressing school improvement (U.S. Department of Education, 2009). CAI offers advantages over traditional instruction, including one-on-one interaction, multimedia capabilities that enrich the lesson presentations, self-pacing, and instantaneous feedback. Such advantages have in the past been offset by an overreliance on media tools, a learning curve for classroom management systems on the administrative side, and a lack of available proven programs. This last point is underscored by the fact that most CAI programs are tutorial or serve in a supplemental capacity.

One program, however, serves as a complete, full curriculum Instructional Improvement System (IIS): The I CAN Learn® Program. The name is an acronym for Interactive Computer Aided Natural Learning. The self-contained curricula are delivered on a one-to-one basis. Multimedia supports and underscores the lesson objectives, but the pedagogy itself is founded on real-world teaching methodology and is concerned with the practical application of knowledge gained; thus, it is in tandem with Quadrant B of the Rigor/Relevance Framework, where students design solutions and solve real-world problems.

### "Positive Effects"

The What Works Clearinghouse awarded the I CAN Learn® Program its highest rating of "Positive Effects." No other program has as much research proving its effectiveness. This CAI program has proved successful in equipping students, especially at-risk and minority students, with the skills they need to meet district, state, and core curriculum mathematics standards.

In the I CAN Learn® Program, students learn at their own pace through a lesson order coordinated to state and district standards. Faster learners move ahead without feeling constrained, and slower learners proceed without the fear of slowing up the rest of the class. Teachers monitor student progress through an intuitive Class Management System, using the data to drive instruction. They identify, in real time, students who need help and then work with them directly, keeping them on track without holding up the rest of the class and making the most of their valuable classroom time.

The I CAN Learn® Program has been proven to work at scale in independent scientifically based research studies, and has a demonstrated ability to address the aforementioned concerns and challenges (Barrow, L., Markman, L., and Rouse, C.E., 2009). Studies on the program have been reviewed by the U.S. Department of Education's What Works Clearinghouse (WWC), a central and trusted source for evaluating which programs truly work in education. The WWC has recognized the program with its highest rating of "Positive Effects" for helping raise state-required ESEA high-stakes test scores and for the statistically

significant improvements this intervention had on scores for high-stakes tests such as the California Standards Test (CST). This is the only middle school mathematics intervention to receive this recognition from the WWC. Additionally, the program has been adopted as a textbook in California, Oklahoma, and Tennessee.

## Addressing School Challenges

The I CAN Learn® Program is already helping districts nationwide address these challenges:

- The program elevates and standardizes the quality of instruction in line with state and Common Core State Standards, delivering the same content and a consistent level of instruction to all students, regardless of social or economic status. All teachers have access to the same quality materials and courseware.
- As a full-curriculum software solution, it serves as an out-of-the-box option for teachers scrambling to teach out of field. The self-contained lessons feature classroom-tested mathematics pedagogy delivered to students via interactive courseware.
- The program has been scientifically proven to close achievement gaps for at-risk students (Barrow, L., Markman, L, and Rouse, C.E., 2009). Custom curriculum alignments ensure that additional subgroups, including English language learners (ELLs) and students with disabilities (SWDs), are accommodated, as are any others requiring Response to Intervention (RTI) programs.
- The courseware is delivered through the computer, immersing students in a technology-rich environment. This also frees teachers to focus their attention on the individual students who need help the most. In addition, teachers can use a modified online version of the program, offered through the National Education Association (NEA) Academy for online professional development, to earn CEU credits. By its very nature, this program introduces technology into the classroom as a means of CAI.

### Key Findings from Technology's Edge

- The at-scale RCT involved 3,541 at-risk and minority students in three states, 17 schools, and 152 classes.
- The program produced an additional half-year of increased mastery of pre-algebra/algebra content in one year of use.
- It closed the achievement gap related to race and ethnicity by approximately one-third on the National Assessment of Educational Progress (NAEP).
- The expense was less than the cost of reducing class size from 25 to 15 students.

### Findings from Technology's Edge: The Educational Benefits of Computer-Aided Instruction

The I CAN Learn® Program has demonstrated a significant impact in raising student achievement and closing mathematics achievement gaps. A recent large-scale randomized control trial (RCT) with a population of over 3,500 students was conducted by researchers from Princeton University, led by Cecilia Rouse, a member of President Obama's Council of Economic Advisors

(Barrow, L., Markman, L, and Rouse, C.E., 2009). The program was assessed using a test designed to target pre-algebra and algebra skills. Students randomly assigned to computer-aided instruction scored significantly higher than students randomly assigned to traditional instruction. Not only does the I CAN Learn® Program introduce technology into the classroom, but also it is an effective (and cost-effective) alternative to reducing class size. The complete peer-reviewed study may be viewed online.

## How the Instructional Improvement System Works

### Curricula

- Fundamentals of Mathematics
- Pre-Algebra
- Geometry Core
- Algebra

The program is a data-driven Instructional Improvement System delivering standards-based mathematics instruction. It can be installed on existing hardware in multiple configurations and scaled up as needed to meet district needs. Custom curriculum alignment to state, district, and school standards prepares students for high-stakes testing. This is accomplished by selecting from the program's lesson database, which contains over 500 lessons. The curricula are aligned to the new Common Core State Standards.

### Student Courseware

There are two primary components of the program. The first is the Student Courseware, which delivers instruction to students on a one-to-one basis. Lessons are comprised of multimedia presentations incorporating audio, video, Flash animation, and interactivity using on-screen buttons, cursor-manipulated tools, and navigation, along with text entry through the proprietary interface. Students work at their own pace through a lesson strand correlated to state objectives, NCTM Focal Points, and Common Core State Standards. The Courseware teaches students how to make sense of problems and persevere in solving them (Practice Standard 1 of the Common Core State Standards).

### Student Courseware Sections

- Pretest
- Warm-Up
- Lesson Presentation
- Tutor
- Independent Practice
- Journal
- Problem Set of the Day
- Lesson Quiz

The epistemology goes beyond just showing steps and solutions; lessons teach students how to reason abstractly as they reach the pinnacle of Quadrant D of the Rigor/Relevance Framework, where they are challenged to move to abstract, unpredictable situations (Practice Standard 2 of the Common Core State Standards). An example of this capability is the program's Tutor section with its dynamic hints system, which offers suggestions based on the actual nature of the student's error. Additionally, many lessons feature Modeling with Mathematics (Practice Standard 4 of the Common Core State Standards) as an objective (using "cups and counters" as well as geometrical shapes,

among other methods). Because it is CAI, the content can be presented with a clarity that would not be feasible without the use of technology. For example, ideas involving the manipulation and analysis of three-dimensional objects are expressed graphically, providing a sophisticated visual model that conveys the concept effectively.

## Classroom Explorer® CMS

The second component is the Classroom Explorer® Class Management System (CMS), used exclusively by the teacher for data-driven instruction and to monitor progress, generate reports, and handle administrative tasks. Its management tools identify students who need help the most, allowing teachers to focus their attention where it is most beneficial.

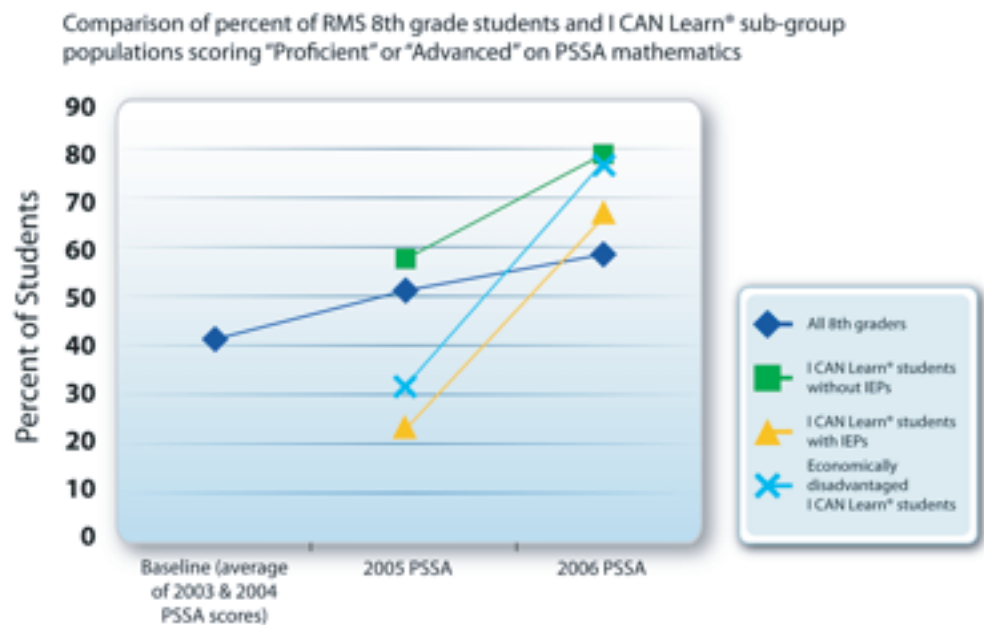
### Classroom Explorer® CMS

Delivers real-time formative and summative assessments of all aspects of classroom management. This system includes the following components and capabilities:

- Data-Driven Assessments
- GradeBook
- On-Demand Reports

## Impact on Special Needs Students

The I CAN Learn® Program has demonstrated its ability to help districts meet their Adequate Yearly Progress (AYP) goals for SWDs and economically disadvantaged students (EDs). In a Williamsport Area School District study in Pennsylvania, the program increased student achievement (as measured by the Pennsylvania System of School Assessment - PSSA) with EDs and students requiring Individualized Education Plans (IEPs). The ED group improved from just 32% scoring “proficient or above” in 2005 to 78% scoring “proficient or above” in 2006, a gain of 46% in just one year. And it wasn’t just with these subgroups — all groups of students using this program outperformed their traditionally taught peers. The following chart chronicles the program’s success with these subgroups:



## Program Impact: LAUSD

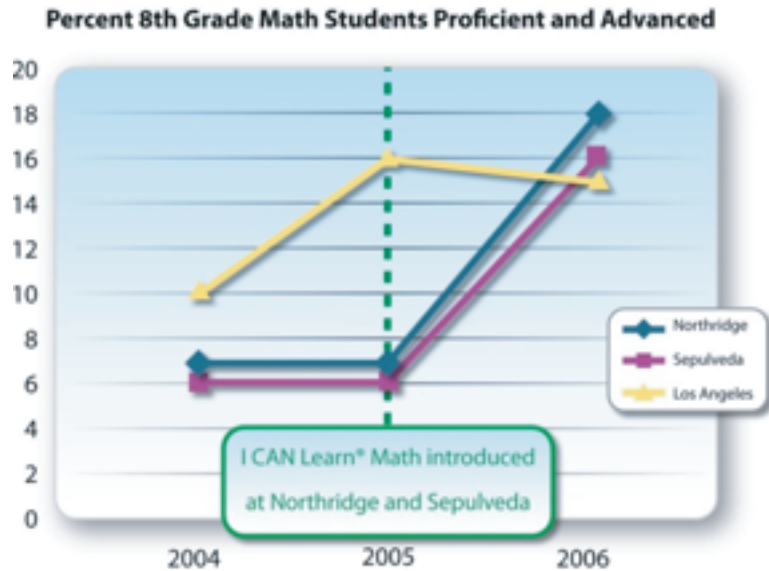
In 2005, the Los Angeles Unified School District (LAUSD) implemented the I CAN Learn® Program. After just one year of use, two middle schools (Sepulveda Middle School and Northridge Middle School) that previously performed



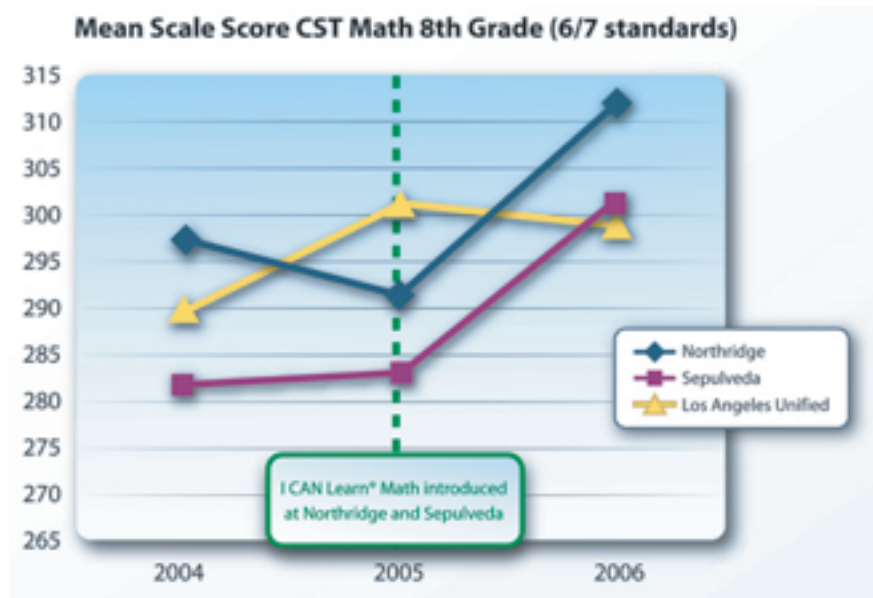
*“This program helps students become better at math and teachers become better teachers. Because of the success we’ve had, our entire school uses it. It helps our teachers reach students who have previously not done well in math, ensures that gifted students can continue working without being held back by the need for multiple explanations and pushes the average student to always do better.”*

**Debbie Henderson**  
Principal  
Indiantown Middle School  
Martin County Schools  
Florida

below district averages nearly tripled the percentage of students scoring in Proficient and Advanced categories of the CST, allowing them to finish well above district averages. Note how these two schools compared with the overall performance of the LAUSD (the yellow bar):



After one year of use, Northridge Middle School’s mean scores for mathematics for 8<sup>th</sup> grade students had jumped by 20.4 scale points, surpassing the LAUSD average score by 13 points. This helped Northridge to finish well above district averages for mathematics. Furthermore, this increase reversed a downward trend in Northridge test scores. Mean CST test scores for Sepulveda also increased by approximately 20 points, helping the school to finish just above district averages. At the same time, overall CST scores for the LAUSD experienced a slight decline.





## Data-Driven Instruction

CAI not only provides benefits to students using the system; the very architecture of such systems allows for longitudinal data collection and analytical tools on the backend, configured to almost any specification by programmers. In the case of the I CAN Learn® Program, this system has a complete suite of tools built into the software, which makes it capable of collecting data and then using it to drive instruction, as well as using it for formative and summative assessments and accountability studies.

The program also provides effective support to teachers and principals. The teacher trainings are motivational and structured to provide ongoing pedagogical support along with curriculum alignment. The NEA Academy currently offers three online courses using the I CAN Learn® Curriculum. Teachers report that the program has been effective in working with their ELL, special education, and low-income students. The program also features a diagnostic placement tool, called the Universal Math Assessment (UMA), which measures content knowledge as well as foundational math skills and pinpoints the key concepts that have not been mastered, making this program effective for use in RTI programs.


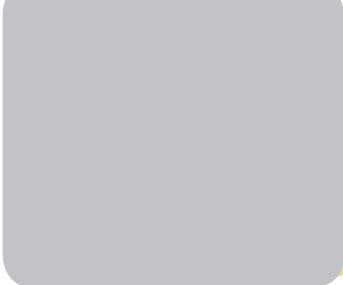
The program has a long history of turning around the lowest-achieving schools. The Princeton study found that it is also a cost-effective method of doing so, as it costs less than reducing a classroom size from 25 to 15 students. The program was initially envisioned as a way to reach the most struggling and at-risk students, and while the program's scope has increased greatly since its inception, at its roots it remains deeply committed to helping to teach at-risk students the mathematics they need to succeed in education, thereby moving them on to professional STEM careers.

## Reaching a Higher Level of Performance

A strong mathematics program in the era of the Common Core State Standards will require a new kind of teaching. These new standards are at a higher level than most state standards, and the skills and information they contain will have to be applied on the assessments to real-life situations, not merely learned. The International Center's Rigor/Relevance Framework is well suited to this challenge. The Framework illustrates how to teach so that students function at levels of higher order thinking, while applying their knowledge and skills to complex, open-ended, real-world problems, whether across the STEM disciplines or any other disciplines.

Regarding the importance of mathematics, President Obama has stated, "Our nation's success depends on strengthening America's role as the world's engine of discovery and innovation. That leadership tomorrow depends on how we educate our students today — especially in science, technology, engineering, and math."





The phrase, “all students deserve equity in education” is expressed so often it has become cliché. However, CAI offers a way to true equity, as it is capable of leveling the playing field, provided that the instruction itself is scientifically proven to be an effective means of teaching. The I CAN Learn® Program has demonstrated that it is capable of this. It addresses the need for highly effective teachers as it accommodates teachers teaching out of field. The result: improved high-stakes test scores and the closing of achievement gaps for economically disadvantaged students and students with disabilities. Schools and districts seeking to achieve such goals should keep this research in mind when assessing their CAI mathematics and algebra options.

### Further Reading, Studies, and Sources

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## Press Release Archive

[www.icanlearn.com/blog/category/press-releases/](http://www.icanlearn.com/blog/category/press-releases/)

"I CAN Learn® Instructional Improvement System Named an Approved Professional Development Provider for Race to the Top in Tennessee"

"Federal What Works Clearinghouse Database Results Show I CAN Learn® Instructional Improvement System is Only Middle School Math Intervention Program with Positive Effects"

"The NEA Academy Partners with I CAN Learn® Instructional Improvement System to Offer Online Professional Development Courses"

"I CAN Learn® Instructional Improvement System Helps States Compete for Race to the Top Grants"

"Hispanic Math Students Show More Than Fifty Percent Gain in Scores in Florida"

"I CAN Learn® Program adopted as Oklahoma textbook"