Research in Brief:
Effective practices for teaching math in middle and secondary schools

Achievement in mathematics is a growing concern among educators as EQAO math scores have been declining across the province of Ontario in recent years. Research in effective math instruction may guide educators to develop effective teaching strategies.

Secondary school mathematic success is a significant indicator of long-term economic potential. Research in this area has focused on the effects of textbooks, technology, and instructional process have on increasing student aptitude in mathematic.

<u>What are effective programs and strategies in teaching middle and high school mathematics?</u>
A recent systematic review by Slavin et al. examined the impact of 3 types of mathematic instruction programs for middle and high schools.

- Mathematics curricula – programs that focused on using textbook-based instruction to teach strands of mathematics curricula.
- Computer assisted instruction (CAI) - programs that utilize technology to deliver mathematics instruction.
- Instructional process – programs which rely primarily on professional development to give teachers effective strategies for teaching mathematics.

Key findings of the current review indicate that programs designed to change daily teaching practices have larger impacts on student achievement than programs that emphasize textbooks or technology alone. In particular, the use of cooperative learning which encourages student interactions has the greatest impact.

What is a systematic review?
The purpose of a systematic review is to summarize the best available research to a specific question. This is done by bringing together the results of several studies. Studies included in a review are screened for quality, so that the findings of a large number of studies can be combined.

What did the researchers do?
Slavin and colleagues conducted a search of several major bibliographic databases (i.e. ERIC, JSTOR, EBSCO, PsychInfo, Dissertation Abstracts), web-based repositories, and education publishers' websites. The following criteria qualified a study for inclusion in the review: 1) programs designed and implemented with students from middle or high school mathematics, 2) world-wide studies published in English in 1970 or later, 3) studies had a treatment/control design including the following: randomized experiments, randomized quasi-experiments, matched studies or matched post-hoc, 4) pretest data was provided and no indication of initial inequality, 5) mathematics performance measures were quantitative, and 6) a minimum duration of 12 weeks.

Key Points

⇒ *Research tells us that improving instructional process is key to helping students to increase achievement in math.*

⇒ *Teachers can significantly enhance mathematics learning at middle and secondary school levels by adopting cooperative learning.*

⇒ *The evidence does not support the idea that curricula alone produces different outcomes for mathematics achievement.*

⇒ *There is very little evidence in middle and high schools that computer assisted instruction (CAI) math programs, when used alone, are effective in improving student achievement.*

For an in-depth look at effective mathematics instruction see: Slavin, R. E., Lake, C., & Groff, C. (2010). What Works in Teaching Math? Educator's Guide. *Center for Research and Reform in Education*.

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A total of 100 studies were included in the review: 46 studies evaluated math curricula, 38 studies evaluated CAI, and 22 studies evaluated instructional process programs.

What did they learn?

Math Curricula

Programs involving math curricula evaluated for this review fell into 3 categories:

- Strategies based on problem-solving, alternative solutions, and conceptual understanding
- Traditional commercial textbooks that are balanced between algorithms, concepts, and problem solving
- Back-to-basics textbooks that emphasizes a step-by-step approach to mathematics

A total of 46 studies evaluating various mathematics curricula were examined. The effect size was quite low at only +0.03. These findings indicate that programs which use textbook based instruction alone may not have a significant improvement on student achievement.

Computer Assisted Instruction (CAI)

Programs explored for this review, fell into three different applications of CAI:

- Supplemental CAI programs in which students work on computer 10-15 minutes per day, primarily to fill in gaps in their prior knowledge.
- Core CAI approaches in which the computer largely replaces the teacher, providing core instruction opportunities for practice, assessment, and prescription, all tailored to the needs of each student.
- Computer-managed learning systems, using computers to assess students, print out individualized assignments, score assignments, and provide feedback to teachers on students' progress for use their class lessons.

Findings from 38 qualifying studies, which evaluated various forms of CAI, were explored. The median effect size for programs involving CAI on student achievement was +0.10.

This effect size, similar to programs focusing on mathematics curricula, is quite low. Researchers noted that no program stood out as having significant and replicated effects in any of the 38 qualifying studies. These findings suggest that CAI programs on their own do not have a significant positive impact on student achievement.

Instructional Process Programs

Programs focusing on instructional processes to deliver mathematics instruction often emphasize professional development to help teachers use effective teaching strategies. These programs typically keep certain elements of mathematics instruction constant (e.g., textbooks, content, and objectives); while changing the teaching methods used to deliver the mathematics concepts.

Instructional process programs explored in this review were divided into five subcategories:

- *Cooperative learning-* students work in pairs or small groups to help each other master academic content
- *Metacognitive strategy instruction-* students are taught to ask themselves questions aloud of comprehension, connections and similarities/differences with previous problems, appropriate strategies, and self-reflection
- *Individualized instruction-* students choose their own learning experiences to meet teacher-established objectives, with the teacher providing a great deal of individualized assistance to students
- *Mastery learning-* is an approach to instruction intended to bring all students to a pre-established level of mastery (i.e., 80% correct) on a set of instructional objectives. Students are taught to well-defined standards, formatively assessed, given corrective instruction if needed, and then summatively assessed.
- *Comprehensive school reform (CSR)-* are whole school models that include extensive professional development in instructional methods, curriculum, school organization, classroom management, parent involvement, and other issues.

A total of 22 studies focusing on instructional process programs were included in this review. With an effect size of +0.18, instructional process programs had the highest impact on positive gains in student achievement.

When the five types of instructional process programs were considered separately, studies on cooperative learning programs (n=7) showed that a much higher mean effect size (+0.46) on positive gains in student achievement.

Overall, the authors conclude that the three types of approaches to mathematics instruction (Mathematics Curricula, CAI, Instructional Process Programs) do not conflict with each other and may have additive effects if used together.

This summary is taken from Slavin, R. E., Lake, C., & Groff, C. (2009). Effective programs in middle and high school mathematics: A best-evidence synthesis. *Review of Educational Research*, *79*(2), 839-911

Please see the original document for full details. In the case of any disagreement between this summary and the original document, the original document should be seen as authoritative.