Office of Special Services

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Research You Can Use

"We educators stand at a special point in time. This is not because a new decade, century, and millennium have begun (although this phenomenon certainly brings new opportunities and complexities). Rather, it is because the "art" of teaching is rapidly becoming the "science" of teaching and this is a relatively new phenomenon."
Marzano et al., 2000

No Child Left Behind Act of 2001 Update

TITLE II, PART A
Improving Teacher Quality State Grants

The Eisenhower Professional Development State Grants and Class-Size Reduction programs have been combined into one program that focuses on preparing, training, and recruiting high-quality teachers. Title II, Part A provides LEAs increased flexibility to allocate funds among professional development, class-size reduction, and other teacher quality activities, without the requirements of the previous law. Furthermore, it eliminates the Eisenhower priority for professional development in mathematics and science and creates a separate Math and Science Partnerships competitive grant program. Beyond traditional professional development, the dollars may be used for teacher and principal recruitment and retention initiatives, signing bonuses and other financial incentives, teacher and principal mentoring, reforming tenure systems, merit pay, teacher testing, and pay differentiation initiatives. Title II, Part A also allows LEAs to use program funds to reduce class size, and does not limit the use of program funds for class-size reduction activities in grades 1 through 3, as the current law does.

TITLE II, PART B
Mathematics and Science Partnerships

Title II, Part B is a new program authorizing $450 million for competitive 3-year grants to partnerships for activities to improve the academic achievement of students in the areas of mathematics and science. If awarded the grant**,** grantees may use funds to: (1) develop or redesign more rigorous math and science curricula; (2) provide professional development for teachers designed to improve their subject knowledge; (3) promote strong teaching skills that include those based on scientific research and technology-based teaching methods; (4) operate summer workshops or institutes; (5) recruit math, science, and engineering majors into teaching; (6) establish distance learning programs; (7) design programs to prepare teachers to mentor other teachers; (8) operate programs to bring math and science teachers into contact with working scientists, mathematicians, and engineers; (9) design programs to identify and develop exemplary math and science teachers in grades K-8; and (10) develop programs to encourage young women and other underrepresented groups to pursue careers in math, science, engineering, and technology.

For further information, please refer to the No Child Left Behind Act of 2001 which can be found at http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=107_cong_bills&docid=f:h1enr.txt.pdf

What is "scientifically based research"?

According to The No Child Left Behind Act of 2001, federal funds must be spent on activities that reflect "scientifically based research." Simply, the research must be conducted using a systematic, empirical methodology that has produced results that are reliable across multiple observations, has been evaluated using an experimental or quasi-experimental design and using control groups or control conditions, and has been accepted by a peer-reviewed journal or evaluated through a comparably rigorous process (SEC. 9101 (37)).

Some of the questions that should be considered when determining if research on mathematics instruction is creditable are:

- Who did the research?
- What are the assumptions or basis of knowledge?
- What is the methodology or type of research (anecdotal or data driven)?
- What was the sample (size and randomness)?
- When was the research done?
- What's the replicability?

The following are resources available for up-to-date research on mathematics.

National Council of Teachers of Mathematics (NCTM), www.nctm.org
Mathematical Association of America (MAA), www.maa.org
Mathematical Sciences Education Board (MSEB), www7.nationalacademies.org/mseb/
The Association for Supervision and Curriculum Development (ASCD), www.ascd.org
National Education Association (NEA), www.nea.org

In their article entitled Improving Student Achievement in Mathematics, Grouws and Cebulla identified ten practices that were associated with student success in mathematics.

1. **Opportunity to Learn** (OTL)
   - OTL includes the scope of the mathematics presented, how the mathematics is taught, and the match between students' entry skills and new material.
   - Research found a positive relationship between total time allocated to math and general math achievement.
   - Researchers found that several math textbook series had a lack of attention to new material and heavy emphasis on review. This was particularly true at the elementary and middle school levels.
   - Suggestions for the classroom included:
     - Allocating sufficient time for mathematics instruction at every grade level.
     - Providing instruction with textbooks that devote major attention to review and that address little new content each year should be avoided or their use should be heavily supplement in appropriate ways.
     - Providing all students the opportunity to learn problem solving and higher-order thinking abilities regardless of their level.

2. **Focus on meaning**
   - Investigations have consistently shown that an emphasis on teaching for meaning has positive effects on student learning including better initial learning, greater retention and an increased likelihood that ideas will be used in new situations.
   - Suggestions for the classroom included:
     - Emphasizing the mathematical meanings of ideas, including how the idea, concept or skill is connected in multiple ways to other mathematical ideas. For example when teaching subtraction, teachers need to emphasize the inverse or 'undoing' relationship between it and addition.
     - Relating mathematical concepts to real-life situations. The mathematics taught and learned must seem reasonable to students and make sense to them. Hence, teachers should pay close attention to their students' interest and backgrounds.
     - Making explicit the connections between mathematics and other subjects. For example, when teaching data-gathering or data representation skills, relate it to public opinion polling in social studies.

3. **Learning new concepts and skills while solving problems**
   - Research suggests that students who develop conceptual understanding early perform best on procedural knowledge later. Students with good conceptual understanding are able to transfer knowledge and to develop procedures and skills they have not been taught.
   - Suggestions for the classroom included:
     - Development of more sophisticated mathematical skills can be approached by treating their attainment of skills as a problem for students to solve. Instruction can begin with an example for which students intuitively know the answer. From there, students can explore and develop their own algorithm. For instance, most students understand that if you have four pizzas and then eat a half of one pizza you will have

three and half pizzas left. Teachers can use this knowledge to help students develop an understanding of subtraction of fractions.
    - The teaching of skills and problem solving do not need to be done independently. Both can be done together.

4. **Opportunities for both invention and practice**
    - Data from the Third International Mathematics and Science Study (TIMSS) video study showed that over 90% of mathematics class time in United States eighth grade classrooms is spent practicing routine procedures, with the remainder of the time generally spent applying procedures in new situations. Virtually no time is spent inventing new procedures and analyzing unfamiliar situations. In contrast students at the same grade level in typical Japanese classrooms spend approximately 40% of instructional time practicing routine procedures, 15% applying procedures in new situations, and 45% inventing new procedures and analyzing new situations.
    - Furthermore, studies have found that when students discover mathematical ideas and invent mathematical procedures, they have a stronger conceptual understanding of connections between mathematical ideas.
    - Implications for the classroom included:
        - Giving students the opportunity to both practice routine procedures and invent and discover new ideas. Teachers must strive to ensure that both activities are included in appropriate proportions and in appropriate ways.

5. **Openness to student solution methods and student interaction**
    - American studies clearly demonstrate that student achievement and understanding are significantly improved when teachers are aware of how students construct knowledge, are familiar with the intuitive solution methods that students use when they solve problems, and utilize this knowledge when planning and conducting instruction in mathematics.
    - Research has demonstrated that when students have opportunities to develop their own solution methods, they are better able to apply mathematical knowledge in new problem situations.
    - Implications for the classroom included:
        - Encouraging students to find their own solution methods and giving them opportunities to share and compare their solution methods and answers. One way to organize such instruction is to have students work in small groups initially and then share ideas and solutions in a whole-class discussion.
        - Or teachers could assign a problem for the students to solve and then move about the room as they work, keeping track of which students are using which strategies. This technique provides teachers an opportunity to better understand how each student processes knowledge.

6. **Small group learning**
    - In a study that reviewed eighty different studies that compared student achievement in small-group settings with traditional whole-class instruction, it was found in 40% of these studies, students in the classes using small group approaches significantly outscored control students on measures of student performance.
    - Suggestions for the classroom included:
        - Selecting tasks that are appropriate for group work.
        - Having students initially work individually on a task and then follow this with group work where students share and build on their individual ideas.

- Emphasizing expectations, group goals and individual accountability.
- Using flexible grouping rather than thinking of small groups as something that must always be used or never be used. Small-group instruction should be thought of as an instructional practice that is appropriate for certain learning objectives.

7. **Whole-class discussion**
   - Research suggests that whole-class discussion can be effective when it is used for sharing and explaining the variety of solutions by which individual students have solved problems. It allows students to see the many ways of examining a situation and the variety of appropriate and acceptable solutions.
   - Students should be expected to be active listeners who participate in the discussion and feel a sense of responsibility for each other's understanding.
   - Suggestions for the classroom included:
     - Following whole-class instruction with individual work. It can be a time when key ideas are brought to the surface by having students present and discuss their individual solution methods.
     - Using whole-class discussion as an effective diagnostic tool for determining the depth of student understanding and identifying misconceptions.

8. **Number sense**
   - 'Number sense' relates to having an intuitive feel for number size and combinations.
   - It involves being able to use mentally computing, estimating, sensing number magnitudes, moving between representation systems for numbers, and judging the reasonableness of numerical results in problem situations in order to make sound decision and reasonable judgments.
   - Suggestions for the classroom included:
     - Moving beyond teaching single skills in isolation to a more integrated approach that encourages the development of number sense in all classroom activities, from the development of computational procedures to mathematical problem solving.

9. **Concrete materials**
   - Many studies show that the use of concrete materials can produce meaningful use of notational systems and increase student concept development.
   - Although successful teaching requires teachers to carefully choose their procedures on the basis of the context which they will be used, available research suggest that teachers should use manipulative materials in mathematics instruction more regularly in order to give students hands-on experience that helps them construct useful meanings for the mathematical ideas they are learning.
   - Recommendations for the classroom included:
     - Using the same material to teach multiple ideas over the course of schooling. This will lessen the amount of time it takes to introduce the material and also helps students to see connections between ideas.
     - Using of concrete material beyond just demonstrations. It is essential that children use materials in meaningful ways rather than in a rigid and prescribed way that focuses on remembering rather than on thinking.
     - Helping students come to see the two-way relationship between concrete embodiments of a mathematical concept and the notational system used to represent it.

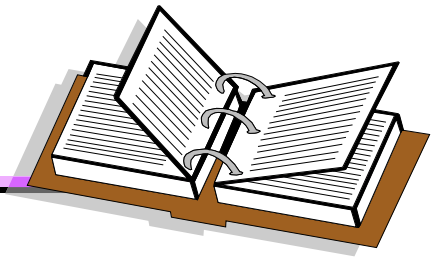
10. **Students' use of calculators**
    - The many studies conducted regarding calculators has consistently shown that thoughtful use of calculators in mathematics classes improves student mathematics achievement and attitudes towards mathematics.
    - Recommendations for the classroom included
        - Emphasizing calculators as a tool for exploration and discovery in problem-solving situations and when introducing new mathematical content. By reducing computation time and providing immediate feedback, calculators help students focus on understanding their work and justifying their methods and results.

Upcoming Events

March 22	Title I Directors Meeting – Four Points Sheraton, Denver
April 2	Consolidated Federal Programs Workshop, Durango
April 3	Consolidated Federal Programs Workshop, Alamosa
April 9	Consolidated Federal Programs Workshop, Greeley
April 10	Consolidated Federal Programs Workshop, Denver
April 12	Consolidated Federal Programs Workshop, Glenwood Springs
April 16	Consolidated Federal Programs Workshop, Pueblo
April 21-24	National Council of Teachers of Mathematics (NCTM) 80th Annual Meeting, Las Vegas
April 28-May 2	International Reading Association (IRA) Conference, San Francisco

FUTURE ISSUES:

March – Parent Involvement
April – Ensuring highly qualified staff in every school
May – Reauthorization



Resources

Groouws, D. & Cebulla, K. (2000). *Improving Student Achievement In Mathematics*. International Academy of Education, Educational Practices Series-4, p 1-47. Available at www.ibe.unesco.org

Marzano, R., Pickering, D. & Pollock, J. (2001). Classroom Instruction That Works, Research-Based Strategies For Increasing Student Achievement. Alexandria, VA.

U.S. Department of Education, www.ed.gov