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RESEARCH-BASED STRATEGIES FOR IMPROVING STUDENT ACHIEVEMENT: MATHEMATICS

Educational Research Service (ERS) has published a report designed to promote research-based decision making in schools. The report, entitled *Handbook of Research on Improving Student Achievement*, provides research findings and classroom implications for each of the major disciplines taught in elementary and secondary schools. Scholars who contributed to the handbook conducted extensive searches of the literature, evaluated the quality of the research, and prepared the syntheses that are included in the handbook. The handbook contains a combination of emerging strategies and "tried and true" practices. By offering comprehensive, research-based strategies for use in the classroom, the handbook can assist educators in the selection and implementation of effective instructional practices. Although research cannot identify the best way to teach in every classroom, it can point to the instructional practices that are most likely to achieve the desired results.

This information capsule is the second in a series that summarizes research-based teaching strategies in reading and writing, mathematics, and science. Following are strategies and practices that have been successfully implemented in mathematics.

Opportunity to learn. Many research studies have documented a strong relationship between students' opportunity to learn and their mathematics performance. Studies have found a positive association between total time allocated to mathematics and general mathematics achievement. When the length of mathematics classes is increased at every grade level, students are provided with more instructional time in important mathematics content and skills. Textbooks are also related to students' opportunity to learn. Teachers should use textbooks as one instructional tool among many and avoid using books that place a heavy emphasis on review and address little new content.

Focus on meaning. Focusing instruction on the meaningful development of important mathematical ideas increases student learning. Studies show that an emphasis on teaching for meaning has a positive effect on student learning, including better initial learning, greater retention,

and increased likelihood that ideas will be used in new situations. There is evidence that students can learn mathematics in contexts that are both closely connected to real-life situations and those that are purely mathematical, but the abstractness of the learning environment must be carefully chosen and monitored. When incorporating teaching for meaning into their classroom practices, teachers should:

- emphasize the mathematical meanings of ideas, including how the ideas being taught are connected to other mathematical ideas;
- consider students' interests and backgrounds;
- build on students' unique conceptualizations and methods when designing and implementing instruction; and
- stress the connection between mathematics and other subjects.

Learning new concepts and skills while solving problems. There is evidence that students can learn new mathematical concepts and skills while they are working out solutions to problems. It is not necessary for teachers to focus first on problem solving. Students can learn and solve simultaneously. Studies have shown that if students are initially drilled too much on isolated skills, they have a harder time making sense of them later. Research suggests that students who develop conceptual understanding early perform best on procedural knowledge later. Students with good conceptual understanding are able to develop skills they have not been taught. Students with lower levels of conceptual understanding need more practice to acquire procedural knowledge. Acquisition of sophisticated mathematics skills can be approached by treating their development as a problem for students to solve. By solving carefully chosen non-routine problems, students can gain an understanding of many important mathematical ideas.

Opportunities for invention and practice. It has been documented that giving students the opportunity to discover and invent new knowledge, as well as the time to practice what they have learned, improves student achievement. A balance is needed between the time students spend practicing routine mathematics procedures and the time devoted to inventing and discovering new knowledge. Too often, classroom instruction overemphasizes skill work. To increase opportunities for discovery and invention, teachers should frequently use non-routine problems, introduce lessons by presenting the new skill as a problem to be solved, and allow students to build new knowledge based on their use of intuitive knowledge and informal procedures.

Openness to student solution methods and student interaction. Teaching that incorporates students' intuitive solution methods can increase student learning, especially when combined with opportunities for student interaction and discussion. When students have opportunities to develop their own solution methods, they are better able to apply mathematical knowledge in new problem situations. Teachers should provide opportunities for students to interact in problem-rich situations and encourage students to find their own solution methods. Students can work in small groups and then share ideas and solutions in a whole class discussion so they are able to compare solution methods and answers.

Small group learning. Research shows that students' levels of mathematical achievement can increase when they work on activities, problems, and assignments in small groups. The small group approach, where both group goals and individual accountability are emphasized, can also lead to improvements in students' abilities to communicate, resolve differences, and get along with others.

Whole class discussion. Research has shown that whole class discussion, following individual and small group work on problem-solving activities, improves student achievement. Whole class discussion can help teachers determine areas of student progress and identify any difficulties students may be having. The class discussion should be a summary of individual work and include an exchange of students' ideas. This can be accomplished by asking students to present and discuss their individual solution methods, or through any other approach that brings closure to problem-solving activities, led by the teacher, the students, or both.

Number sense. Studies have found that teaching mathematics with a focus on number sense encourages students to become problem solvers in a wide variety of situations and to view mathematics as a discipline where thinking is important. In order to make sound decisions and reasonable judgments, students must learn to have an intuitive feel for number size and combinations and to work flexibly with numbers in a variety of problem situations. Teachers should consider moving beyond a unit-skills approach (i.e., focusing exclusively on a single skill) to a more integrated approach that encourages the development of number sense in all classroom activities, from computational procedures to mathematical problem solving.

Concrete materials. Long-term use of concrete materials is positively related to increases in student mathematical achievement and improved attitudes toward mathematics. Frequent use of manipulatives gives students hands-on experience that helps them apply meaning to the mathematical ideas they are learning. The use of the same manipulatives to teach multiple ideas shortens the amount of time needed to introduce new material and helps students see the connections between mathematical ideas.

Calculators. Studies have found that student use of calculators can result in increases in their problem-solving abilities and improved attitudes. Calculators allow students to focus on understanding their work by reducing computation time and providing them with immediate feedback. They should be used as a tool for exploration and discovery in problem-solving situations and when new mathematical content is being introduced.

Summary

A review of general, research-based teaching strategies and practices in mathematics has been provided, based on ERS' *Handbook of Research on Improving Student Achievement*. ERS' full report presents effective practices for improving student learning in all of the major elementary and secondary subject areas. The strategies contained in the report were developed to help educators use accurate, comprehensive research in their instructional practices. A future information capsule will examine research-based strategies that can be implemented in science classrooms.

Source: Cawelti, Gordon (editor). *Handbook of Research on Improving Student Achievement, Third Edition*. Arlington, VA: Educational Research Service, 2004.