Scaffolding Young Math Learners to Be Effective Spatial Problem Solvers

Background

This program of research, funded by the NSF, has shown that individual differences in early spatial skills are important factors, both in students' early acquisition of arithmetic and their later math reasoning skills. Spatial skills consist of the ability to use mental pictures for solutions to problems—such as interpreting graphs, charts, and maps, and understanding geometry and measurement problems. It is particularly important to study the relation between spatial skills and math performance in girls, because on average, males tend to do better than females on key types of spatial tasks even in children as young as ages 3 and 4. In older students, higher spatial skills have also been shown to predict math achievement and choice of STEM majors and careers, particularly in fields where women are underrepresented. Research has clearly shown that spatial skills can be improved through training. This research has focused on understanding individual differences in early acquisition of spatial skills and the supportive strategies and methods that can be employed to scaffold these skills by teachers and parents.

Through another NSF grant, the researchers developed instructional materials for children in PreK–2nd grade, with a focus on teaching spatially based math content—covering measurement, geometry, spatial and numerical patterning, block building, and data analysis and graphing. The resulting materials consist of a six-book early childhood storytelling/math series entitled *Round the Rug Math: Adventures in Problem Solving*, for PreK–2nd grade, published by McGraw-Hill in 2002. The books were designed to develop math problem-solving skills through the medium of storytelling. The project included a series of research studies showing the effectiveness of using a storytelling approach to scaffold young children's learning of mathematics, and developed assessment tools for evaluating changes in children's block building and puzzle skills.

For the next step in this NSF-funded research on early learners, the researchers focused on young girls. The goal was to understand first-grade girls' individual differences in early spatial and arithmetic skills within the context of their home environments. The researchers examined multiple factors simultaneously, starting with (1) socio-economic factors (such as income level, mothers' education, and financial stress), moving to (2) the general environmental conditions within the home (such as parental investment of time and material resources), and finally examining (3) the types of specific math and spatial activities experienced by these young girls. Then, the researchers more closely examined factors within the home environment by studying videotaped mother-child interactions when solving a joint origami problem-solving task to determine what types of maternal scaffolding were related to effective spatial and arithmetic skills. Finally, in the most recent NSF grant, they have followed the first-grade girls into fifth grade to determine the relative importance of early spatial, arithmetic, and verbal skills in predicting fifth-grade math reasoning skills.

Documented Results

Below is a summarization of some of the research findings relating to learners' early acquisition of spatial and arithmetic skills.

- The research evaluation of the storytelling/math books showed that for both geometry and block building, kindergartners improved more when taught within a storytelling context than in a non-story context.

- The first-grade girls with good spatial skills were able to use more-advanced mental arithmetic strategies (rather than using their fingers or counters) when solving both the addition and subtraction problems.
- Mothers who were effective at supporting their daughters' spatial problem solving on the origami task had daughters who performed better on other spatial tasks.
- These girls' spatial skills in turn predicted their arithmetic performance.
- First-grade girls' spatial skills were a stronger predictor of their fifth-grade math reasoning skills than either their first-grade arithmetic or verbal skills.

Potential Applications

What is striking about all of our research findings is the strong predictive power of spatial skills on students' math skills. The present results support the hypothesis that spatial skills are an important underpinning of students' math abilities. However, the problem is that within the educational system at all levels, from preschool to college, the teaching of spatial skills is not a major focus. Instead, those with good spatial skills simply rise to the top in math and science. Yet, for boys as well as girls, spatial skills have been found to be important for success in STEM. This program of research documents the critical role of spatial skills for mathematics learning in students as young as kindergartners and first graders. It is encouraging, therefore, that both boys and girls can be effectively taught how to think and solve problems spatially. Based on this research, the goal is to help educators better understand developmental changes in spatial skills and how these skills relate to early mathematics. Most important, a key goal is to help educators understand how to intervene to enable young learners to be more effective spatial problem solvers.

For More Information

Casey, B. (2009). Applying developmental approaches to math. In O. A. Barbarin, & B. Wasik, *The handbook of child development and early education: Research to practice.* New York: Guilford Press.