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Research to Practice

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Mathematics Instruction for Students with Learning Disabilities: A Meta-Analysis of Instructional Components

Findings from special education studies at http://nichcy.org/research

This is a structured abstract of a meta-analysis conducted by Gersten, Chard, Jayanthi, Baker, Morphy, and Flojo, published in the Review of Educational Research. The full citation appears on page 6.

Abstract

This meta-analysis synthesized findings from 42 interventions on instructional approaches that enhance the mathematics proficiency of students with learning disabilities. The authors examined the impact of four categories of instructional components: (a) approaches to instruction and/or curriculum design; (b) formative assessment data and feedback to teachers on students' mathematics performance; (c) formative data and feedback to students with LD on their performance; and (d) peer-assisted mathematics instruction.

All instructional components except for student feedback with goal-setting and peer-assisted learning within a class resulted in significant mean effects ranging from 0.21 to 1.56. The authors also examined the effectiveness of these components when used individually or when combined with other intervention components. Two instructional components provided important increases in effect size both when used alone and when used in combination with other strategies—teaching students to use heuristics and explicit instruction. Limitations of the study, suggestions for future research, and applications for improvement of current practice are discussed.

Background

This meta-analysis synthesizes the results of mathematics interventions for students with learning disabilities in math, which are estimated to affect between 5% and 7% of school-age students.

The researchers divided the studies' interventions into four broad categories:

- approaches to instruction and/or curriculum;
- peer-assisted math instruction;
- providing teachers with ongoing formative assessment data and feedback on students' mathematics performance; and
- providing students with ongoing formative assessment data and feedback on their mathematics performance.

Research Questions

The purpose of this study was to synthesize the results of several studies on the effectiveness of different mathematics interventions for children with LD.

Research Subjects

The subjects participating in the research studies included in this meta-analysis were students with LD or mathematical disabilities (note that criteria for learning disabilities and/or mathematical disabilities can vary by state or country). Their age range was not always stated explicitly, but the description of the included studies implies that students were in elementary school and/or secondary school.

Research Design—Meta-analysis

Number of Studies—42

Years Spanned—1971-2007

Research Subjects—Students with LD or mathematical disabilities.

Age/Grade of Subjects—The age range of students in this meta-analysis was not always explicitly stated, but the description of the included studies implies that students were in elementary and/or secondary school.

Specified Disability
A specific learning disability or a mathematical disability.

Interventions
Interventions were placed in one of four categories: (a) approaches to instruction and/or curriculum; (b) peer-assisted math instruction; (c) providing teachers with ongoing formative assessment data and feedback on students' mathematics performance; or (d) providing students with ongoing formative assessment data and feedback on their mathematics performance.

Intervention

Interventions were placed in one of four categories:

1. **Approaches to instruction and/or curriculum design**

a. Explicit instruction: The requirements for an intervention to be considered explicit or systematic instruction were: "(a) The teacher demonstrated a step-by-step plan (strategy) for solving the problem; (b) the step-by-step plan was for a specific set of problems (as opposed to a general problem-solving heuristic strategy); and (c) students were asked to use the same procedure/steps demonstrated by the teacher to solve the problem" (p. 1210).

b. Use of heuristics: For this meta-analysis, a "heuristic" was defined as a method or strategy that exemplified a generic approach for solving a problem. Unlike explicit instruction, a strategy was only considered to use heuristics if it was not used for a specific set of problems but involved a generic method or strategy that could be applied to a variety of problems. For example, a heuristic strategy could include steps such as "Read the problem. Highlight the key words. Solve the problem. Check your work." (p. 1210).

c. Student verbalizations of their mathematical reasoning: This category included self-instruction, verbalizing solution steps, and thinking aloud.

d. Use of visual representations while solving problems: A strategy was considered a visual representation both when teachers used visual representations in demonstrating mathematical concepts and when students were required to use visual representations to solve problems.

e. Range and sequence of examples: A *range* of examples referred to examples that varied systematically (for example, teaching only proper fractions vs. initially teaching proper and improper fractions together). A *sequence* of examples was any designated pattern in how examples were provided, such as easy to hard, or concrete to abstract.

f. Other instructional variables: If a study used instructional or curricular components that did not fit into one of the other five categories, it was placed in this one.

2. Peer-assisted math instruction | Two types of peer tutoring were included in this category. The first was cross-age peer tutoring, where an older student was paired with a younger student to teach the younger student a concept. The second form of peer-assisted instruction was within-classroom peer tutoring, where two students from the same class worked together taking turns in the role of the tutor.

3. Providing ongoing formative assessment data and feedback to teachers on students' mathematics performance | To be classified in this category, the intervention had to include the teacher receiving data on student progress. This information could consist simply of feedback on student progress or could include instructional recommendations or other options for addressing students' needs (e.g., skill analysis).

4. Providing ongoing formative assessment data and feedback to students on their mathematics performance | Assessment data and feedback were provided to students on their performance or effort by teachers, peers, or computer software programs.

Duration of Intervention

Duration was not specified for most of the interventions. However, the interventions in the category of "Providing teachers with feedback on student progress" were reported to range from 15 weeks to 2 school years.

Effect Size

Effect size is a statistical calculation that indicates how much of an impact an intervention had on the children who received it. In this synthesis, effect size measured the impact that components of various interventions had on children with LD. The researchers used a conservative measure of effect size called Hedge's *g* in combination with several other meta-analytic techniques to conduct their analyses.

An effect size of less than 0.20 suggests that a treatment did not have a significant effect on the sample population. Larger effect sizes indicate that the treatment had some impact. The larger the effect size, the larger the impact of the intervention on student learning. For example, an effect size of 0.21 would indicate that the intervention had a significant impact, while an effect size of 1.21 would indicate a much stronger and more significant impact.

The mean effect sizes for the various instructional components examined in this meta-analysis were as follows:

Explicit instruction = 1.22

Use of heuristics = 1.56

Student verbalizations = 1.04

Visuals for teacher and student = 0.46

Visuals for teacher only = 0.41

Sequence and/or range of examples = 0.82

Teacher feedback = 0.21

Teacher feedback plus options = 0.34

Teacher feedback combined = 0.23

Student feedback = 0.23

Student feedback with goal setting = 0.17

Student feedback combined = 0.21

Cross-age tutoring = 1.02

Peer-assisted learning within a class = 0.14

All effect sizes for the instructional components were statistically significant with two exceptions:(a) asking students to set a goal and measure attainment of that goal (0.17), and (b) peer-assisted learning within a class (0.14).

Findings

1. Approaches to instruction and/or curriculum design

a. Explicit instruction: Mean effect size of 1.22. Overall, explicit instruction was very effective. However, the effectiveness in the 11 studies that examined explicit instruction varied widely. The study that displayed the lowest level of effectiveness only included students working through steps to solve problems but not being shown how to do calculations. The study with the highest effect size used explicit instruction to teach students a strategic process used by mathematics experts to solve math problems.

b. Use of heuristics: Mean effect size of 1.56. Two of the most effective interventions in this category involved teachers instructing students in multiple heuristics that could be used to solve a particular type of problem, then discussing which strategy would be best for various sample problems, and finally practicing the steps to solve the problems.

c. Student verbalizations of their mathematical reasoning: Mean effect size of 1.04. Different types, levels of specificity, and amounts of verbalizations were encouraged in the 8 reviewed studies in this category. Student verbalizations of their mathematical reasoning were found to be an effective way to help students improve math performance.

d. Use of visual representations while solving problems: Mean effect sizes of 0.46 when both the students and teacher used visual representations, 0.41 when visual representations were used by the teacher only. Visual representations included pictures provided to students and student-drawn visualizations. Popular topics for using visual representations included fractions and teaching quantities. While the mean overall effect size for visual representations was small to moderate, certain studies had large effects. In one case, the researchers suggested that a large effect might have been tied to the fact that the task students were learning was simple and discreet. In other cases, the positive impact of using visual representations was increased when combined with other effective instructional components.

e. Range and sequence of examples: Mean effect size of 0.82. Using either a range or sequence of examples proved to be effective for teaching mathematics to students with LD. Some of the successful ways this strategy was implemented were: (a) highlighting distinctive features of a given problem type; (b) systematically progressing from easy to more complex and difficult examples; (c) using a CRA (concrete-representational-abstract) instructional sequence to ensure that students actually understood visual representations of mathematics concepts before using them as a means to illustrate those concepts; and (d) carefully selecting and sequencing instructional examples to illustrate contrasts, build indepth knowledge of mathematical processes, and highlight common features in seemingly disparate word problems.

f. Other instructional variables: One study used enhanced anchored instruction (EAI), which did not fit into any of the other categories, but was found to be a promising practice (effect size of 0.80). EAI intends to provide students with opportunities to apply mathematical principles and processes that focus on real-world problems. The idea behind EAI is that, if students are asked to solve engaging real-world problems (e.g., build a skateboard ramp) using concepts like fractions and other computation skills they learned previously, then they will be more motivated and more likely to increase their engagement in the learning task. EAI problems can be presented using traditional paper-and-pencil tasks or via video or CD.

2. Peer-assisted math instruction | The two types of peer tutoring were included in this category yielded very different results. The first, cross-age peer tutoring, where an older student is paired with a younger student to teach the younger student a concept, was an effective intervention method (large mean effect size of 1.02). The second form of peer-assisted instruction, within-classroom peer tutoring, was not found to be effective (mean effect size of 0.14). One possible reason for the greater success of cross-age peer tutoring is that students leading cross-age peer tutoring were typically given either a protocol to follow or explicit training on how to tutor.

3. Providing ongoing formative assessment data and feedback to teachers on students' mathematics performance | Mean effect sizes were as follows: for teacher feedback alone, 0.21; for teacher feedback plus options for addressing instructional needs, 0.34; for teacher feedback overall, 0.23. Providing teachers with data on student progress was found to be an effective strategy; its efficacy was increased slightly when combined with instructional recommendations or other options for addressing students' needs (e.g., skill analysis).

4. Providing ongoing formative assessment data and feedback to students on their mathematics performance | Mean effect size for student feedback alone, 0.23; for student feedback with goal setting, 0.17; for student feedback combined, 0.21 (all small or non-significant impacts). Providing students with assessment data and feedback on their performance or effort had a positive but modest effect. However, involving students in instructional goal setting in addition to providing them with data or feedback did not have a significant effect.

Conclusions

What sets this meta-analysis apart from most others is that, instead of compiling multiple studies that all examine the same type of intervention, the researchers examined studies specifically on mathematics interventions for students with LD, divided each of the interventions into its various instructional components, and then examined the effectiveness of each instructional component separately. This approach allowed the researchers not only to identify the most effective components of mathematics instruction for students with LD, but also to determine which components were effective when used individually and which ones needed to be combined with other instructional strategies to be effective.

Two interventions were effective whether used as the sole strategy for teaching mathematics to students with LD or when paired with other strategies: explicit instruction and the use of heuristics. The remaining instructional components examined in this meta-analysis were effective when used in combination with one or more other techniques but did not make a significant impact on student learning on their own. For example, explicit instruction was effective whether used exclusively or combined with other techniques. On the other hand, while student verbalizations were effective in combination with explicit instruction or the use of heuristics (two strategies in which student verbalizations are almost always encouraged), they did not make a unique contribution to effectiveness on their own.

Recommendations for Future Research

The authors suggest that further research should be conducted with respect to two strategies:

- the use of heuristics, and
- peer-assisted mathematics instruction.

In the case of use of heuristics, a highly successful but not widely studied strategy, the researchers suggest it should be studied further to determine what aspect of the strategy makes it effective, "whether it involves teaching a multistep strategy or teaching multiple skills that can be employed to derive the solution to a problem" (p. 1232), and how well students can generalize and transfer heuristics to new types of problems. Peer-assisted instruction should be studied further to determine if linking peer-assisted instruction with explicit instruction could make it a more effective strategy for students with LD.

Research Connections

Looking for more information on mathematical interventions for children with LD? We're pleased to point you to these additional resources, all available in the research section of our website.

Effective Mathematics Instruction
Steedly, K., Dragoo, K.E., Arefeh, S., & Luke, S.D.
http://nichcy.org/research/ee/math

Effects of Instruction in Solving Mathematical Word Problems for Students with Learning Problems: A Meta-Analysis
Xin, Y.P., & Jitendra, A.K.
http://nichcy.org/research/summaries/abstract9

Mathematics Interventions for Children with Special Needs
Kroesbergen, E.H., & Van Luit, J.E.H.
http://nichcy.org/research/summaries/abstract25

Here are meta-analyses on mathematics instruction that included children with other disabilities:

Synthesis of Empirical Research on Teaching Mathematics to Low Achieving Students
Baker, S., Gersten, R., & Lee, D.
http://nichcy.org/research/summaries/abstract16

Meta-Analysis on Teaching Mathematics to Students With Significant Cognitive Disabilities
Browder, D.M., Spooner, F., Ahlgrim-Delzell, L., Harris, A., & Wakeman, S.Y.
http://nichcy.org/research/summaries/abstract79

And finally, here are summaries of meta-analyses on some of the same strategies reviewed in this research summary.

Do Special Education Interventions Improve Learning of Secondary Content? A Meta-Analysis
Scruggs, T.E., Mastropieri, M.A., Berkeley, S., & Graetz, J.E.
http://nichcy.org/research/summaries/abstract80

Using What Works
The above meta-analysis comes with the companion page *Using What Works*, which links you with resources on how to use the research-based strategies discussed in the meta-analysis.
http://nichcy.org/schoolage/effective-practices/meta80resources

The Power of Strategy Instruction
Luke, S.D.
http://nichcy.org/research/ee/learning-strategies

Searching for the Best Model for Instructing Students with Learning Disabilities
Swanson, H.L.
http://nichcy.org/research/summaries/abstract35

Full citation of the meta-analysis discussed in this structured abstract

Gersten, R., Chard, D.J., Jayanthi, M., Baker, S.K., Morphy, P., & Flojo, J. (2009). Mathematics instruction for students with learning disabilities: A meta-analysis of instructional components. *Review of Educational Research, 79*(3), 1202-1242.

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