Effective Instructional Practices For Students with Difficulties in Mathematics: Findings from a Research Synthesis

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Overview

- This presentation is a summary of major findings from three syntheses of research on effective practices for students with mathematics difficulties including over 50 studies.

- The practices are essential for developing interventions for students who require more than what typical classrooms can provide.
Who can benefit from these findings?

- Students who:
  - enter school with very limited knowledge of number concepts and counting procedures
  - receive inadequate instruction in previous years of schooling and fall behind their peers
  - regardless of motivation, quality of former mathematics instruction, and number knowledge and number sense when entering school still continue to experience problems
How were the effects of particular practices compared?

- These syntheses compared the relative effects of instructional practices using “effect sizes.” Effect sizes are a proportion of a standard deviation.

Effect sizes:
- <.20 extremely small/negligible
- .20 small
- .40 moderate
- ≥.80 large

Educationally Significant
Areas of Major Findings

- Visual and graphic depictions of problems
- Student think-alouds
- Explicit instruction
- Peer-assisted learning
- Formative assessment
### Effect Sizes for Instructional Variables

<table>
<thead>
<tr>
<th>Instructional Strategy</th>
<th>Effect Size For Special Education Students</th>
<th>Effect Size For Low Achieving Students</th>
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<tbody>
<tr>
<td>Visual and Graphic Depictions</td>
<td><code>.50 Moderate</code></td>
<td>NA</td>
</tr>
<tr>
<td>Systematic and Explicit Instruction</td>
<td><code>1.19 Large</code></td>
<td><code>.58 Moderate to Large</code></td>
</tr>
<tr>
<td>Student Think Alouds</td>
<td><code>.98 Large</code></td>
<td>NA</td>
</tr>
<tr>
<td>Use of structured peer-assisted learning activities involving heterogeneous-ability groupings</td>
<td><code>.42 Moderate</code></td>
<td><code>.62 Large</code></td>
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<tr>
<td>Formative Assessment Data Provided to <em>Teachers</em></td>
<td><code>.32 Small to Moderate</code></td>
<td><code>.51 Moderate to Large</code></td>
</tr>
<tr>
<td>Formative Assessment Data Provided Directly to <em>Students</em></td>
<td><code>.33 Small to Moderate</code></td>
<td><code>.57 Moderate to Large</code></td>
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</tbody>
</table>
Findings: Visuals and Graphic Depictions of Problems

- Graphic representations of problems and concepts are widely used in texts both in the U.S. and in nations that perform well in international comparisons.

- Teaching students to use graphic representations of the underlying concepts of a problem results in moderate effects.
Findings: Visuals and Graphic Depictions of Problems

- Effects were larger when teachers provided students with multiple opportunities to apply graphic representations to specific problems.

- Effects were also enhanced when teachers taught students to select appropriate graphic representation and why a particular representation was most suitable.

**Change Story Situation**
John had 47 baseball cards in his collection. He lost 15 of them when his family moved from Florida to New York. Now John has 32 baseball cards.

**Group Story Situation**
Tim has 54 fruit trees in his orchard. 39 are apple trees, and the remaining 15 are peach trees.

**Compare Story Situation**
Mitch has 43 CDs and Anne has 70. Anne has 27 more CDs than Mitch.

Findings: Visuals and Graphic Depictions of Problems

- When teachers used graphic representations to demonstrate problems, results were much less consistent.
- Visuals were not particularly useful unless students were provided opportunities to practice using them.
- Concrete-Representational-Abstract (CRA) approach seems promising based on 3 studies. Teachers model problems with concrete manipulatives to ensure students understand before moving to more abstract representations.
Findings: Student Think-Alouds

- Encouraging students to verbalize their thinking and talk about the steps they used in solving a problem – was consistently effective

- Verbalizing steps in problem solving was an important ingredient in addressing students’ impulsivity directly
Findings: Student Think-Alouds

- Verbalizing appeared to be most effective when multiple approaches to solving problems were demonstrated and students were encouraged to think-aloud as they solved multiple practice problems.
Findings: Explicit Instruction

- Explicit instruction consistently resulted in large effects both for learning single skills as well as multiple related skills in complex problem solving.

- These findings must be tempered by the fact that the measures on which the effect sizes were calculated were all researcher-developed.
Findings: Formative Assessment

- Formative assessment is the process of collecting data on a randomly selected array of relevant topics at regular intervals (e.g. once per week or twice a month).

- Evidence has shown that this approach is superior to the typical weekly or biweekly unit tests that appear in many texts.
Findings: Formative Assessment

- Formative assessment use has consistently lead to low or moderate effects on mathematics achievement.
- Feedback based on formative assessment coupled with specific suggestions for intervention strategies (e.g. problems for practice, alternate ways to explain a concept) improved effects.
- This type of feedback was consistently effective for special education teachers.
Findings: Feedback to Students about their Performance

- Providing students with feedback about their performance resulted in moderate effects.

- For students with disabilities, these effects were much smaller.
Findings: Peer-assisted learning

- Peer assisted learning provides extensive opportunities for students to practice solving math problems and to interact with peers about mathematics.
Findings: Peer assisted-learning

- Results have been consistently positive if:
  - Tutoring is provided by a proficient, trained peer
  - Student’s work in pairs and the activities have a clear structure.
  - The pairs include students at differing ability levels.
  - Both students play the role of tutor for some of the time.
  - Students are trained in the procedures necessary to assume the role of tutor.
Findings: Peer assisted-learning

- Peer assisted-learning appears to benefit both lower- and higher-performing learners because:
  - When serving as tutors, less proficient students attended to details of problems and the approaches their partner used to problem solve.
  - More proficient students solidified their conceptual understanding of mathematics by having to explain their problem solving to their peers.

- Ad hoc tutoring appears to be beneficial when a more experienced peer guides a novice in reinforcing previously learned material or in talking through problem solving.

- Though the number of studies is small, the effects of PALs for certified special education students remain unclear.
Summary

- Results of these research syntheses suggest that students who are struggling with mathematics benefit from:
  - Verbalizing and use of visuals for problem solving;
  - Explicit instruction in how to use specific skills and multi-step strategies;
  - Their teachers receiving feedback from formative assessment to modify instruction;
  - Peer-assisted learning opportunities in which they focus on problem details, observe models of proficient students’ problem solving, or are guided by more proficient peers.