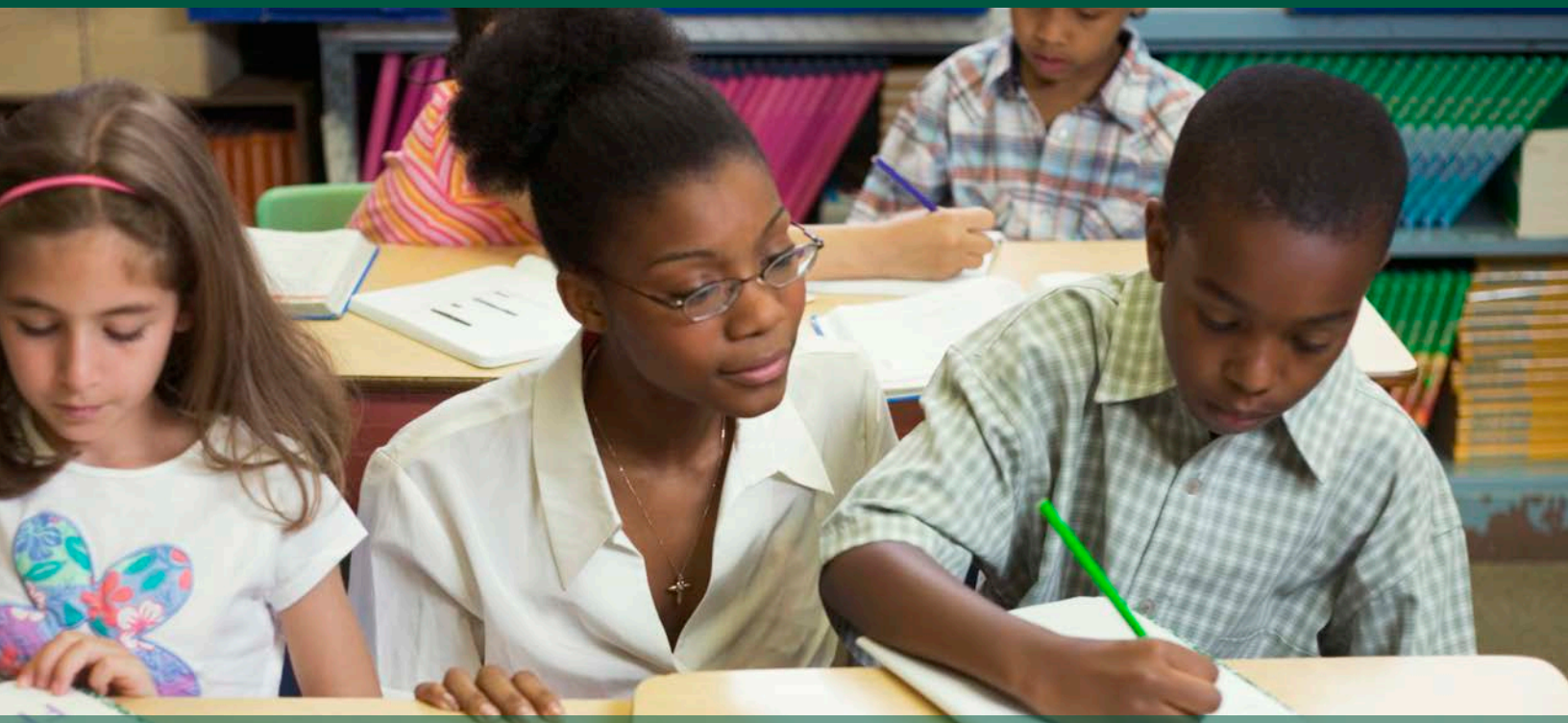
Improving Mathematical Problem Solving in Grades 4 Through 8

Summary of Evidence for Instructional Tips Based on the Educator's Practice Guide



Summary of evidence on instructional tips for:

- **Assisting Students in Monitoring and Reflecting on the Problem-Solving Process**
- **Teaching Students to Use Visual Representations to Solve Problems**
- **Helping Students Make Sense of Algebraic Notation**

About the Summary of Evidence for WWC Instructional Tips

Instructional tips help educators carry out recommendations contained in IES Educator's Practice Guides. This summary of evidence describes the research evidence that supports the use of the instructional tips in classrooms and is based on a practice guide authored by *Sybilla Beckmann, Mark Driscoll, Megan Franke, Patricia Herzig, Asha Jitendra, Kenneth R. Koedinger, Philip Ogbuehi,* and *John Woodward.*

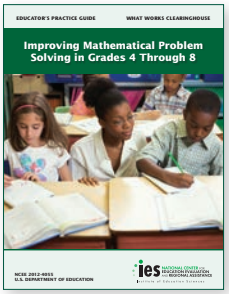
What Works Clearinghouse™

ies NATIONAL CENTER FOR EDUCATION EVALUATION AND REGIONAL ASSISTANCE
Institute of Education Sciences

About the Evidence

The evidence supporting the three mathematical problem solving instructional tips is drawn from research that meets What Works Clearinghouse (WWC) design standards and is summarized below.

To learn more about the research evidence, read the practice guide ***Improving Mathematical Problem Solving in Grades 4 Through 8***.



Evidence on

Assisting Students in Monitoring and Reflecting on the Problem-Solving Process *(Recommendation 2, Steps 1 and 2)*

Supported by **nine studies** that meet WWC Group Design Standards and **three supplemental studies**

Several studies with diverse student samples directly tested the effectiveness of monitoring and reflecting on the problem-solving process, and consistently found positive effects on student achievement.

- In two studies, students were provided with a **task list that identified specific steps to solving problems**.[1]
- In two other studies, students received a **checklist with questions to ask themselves while problem solving (self-questioning)**, coupled with visual aids.[2] These studies found that this instructional approach improved student achievement; however, since the intervention combined multiple components, the panel could not attribute the positive results solely to the checklist.
- Additionally, five studies found that student performance improved when **teachers modeled a self-questioning process** and then asked students to practice it.[3]
  - For example, in two studies, teachers guided the self-questioning process by including questions in students' practice workbooks, and then asking students to answer the questions verbally and in writing.[4]
  - In two studies, teachers modeled self-questioning by asking and answering questions derived from a problem-solving model.[5]

Supplemental evidence comes from three single-case design studies.

- The first study found that teacher modeling of a self-questioning approach improved achievement for students with learning disabilities or mild intellectual disabilities.[6]
- The second study evaluated the effectiveness of teaching middle school students with learning disabilities a seven-step self-questioning process and found no evidence of positive effects.[7]
- The final study found that teaching students to use a task list had no evidence of positive effects on the achievement of students with learning disabilities.[8]

Evidence on

Teaching Students to Use Visual Representations to Solve Problems

(Recommendation 3, Steps 1 and 2)

Supported by **six studies** that meet WWC Group Design Standards and **two supplemental studies**

Six studies with middle school student samples consistently found that using visual representations improved achievement.[9]

- One study involved introducing an **alternative problem-solving approach integrated with visual representations** for multiplication and division problems.[10]
- In four studies, students were **taught to differentiate between types of math problems and then to implement an appropriate diagram** for the relevant type.[11]
  - For example, in one of these studies, middle school students received papers listing the prominent features of different kinds of problems.[12] Students then used type-specific diagrams to represent these problems.
  - In another study, students practiced identifying different problem types and then mapping the features of each on a schematic diagram.[13]
- Finally, one study showed that teachers **helping students design, develop, and improve their own visual representations** improved student achievement more than students simply using teacher- or textbook-developed visuals.[14]

Supplemental evidence comes from one single-case design study in which students were taught how to use visual representations; the study found no evidence of an effect.[15]

Evidence on

Helping Students Make Sense of Algebraic Notation

(Recommendation 5, Step 3)

Supported by **two studies** that meet WWC Group Design Standards

Two studies tested the effects of helping students make sense of algebraic notation, and both found positive effects on student achievement.[16]

- One study found that **providing students with intermediate arithmetic problems** before asking them to understand the algebraic notation for a different problem significantly improved achievement.[17]
- Another study found that **having students practice symbolic algebraic problems** (substituting one expression into another) improved performance on two-step word problems more than practicing with one-step word problems.[18]

Although the panel of experts believes students should also explain each component of an algebraic equation, no study directly tested the importance of this.

Notes

[1] Hohn and Frey (2002); Verschaffel et al. (1999).
[2] Jitendra et al. (2009); Jitendra et al. (2010).
[3] Cardelle-Elawar (1990); Cardelle-Elawar (1995); King (1991); Kramarski and Mevarech (2003); Mevarech and Kramarski (2003).
[4] Kramarski and Mevarech (2003); Mevarech and Kramarski (2003).
[5] Cardelle-Elawar (1990); Cardelle-Elawar (1995).
[6] Cassel and Reid (1996).
[7] Montague (1992).
[8] Case et al. (1992).
[9] Jitendra et al. (1998); Jitendra et al. (2009); Jitendra et al. (2010); Terwel et al. (2009); Selke et al. (1991); Xin et al. (2005).
[10] Selke et al. (1991).
[11] Jitendra et al. (1998); Jitendra et al. (2009); Jitendra et al. (2010); Xin et al. (2005).
[12] Xin et al. (2005, p. 185). Note: teachers in the comparison condition also modeled how to use representations to represent information in problems.
[13] Jitendra et al. (1998).
[14] Terwel et al. (2009).
[15] Jitendra et al. (1999)
[16] Koedinger and Anderson (1998); Koedinger and McLaughlin (2010).
[17] Koedinger and Anderson (1998).
[18] Koedinger and McLaughlin (2010).