Teaching actions and examples accompany three evidence-based recommendations for student success in algebra.

Rose Mary Zbiek and Matthew R. Larson
Improving student learning is the primary goal of every teacher of algebra. We seek strategies to help all students learn important algebra content and develop mathematical practices. The new Institute of Education Sciences [IES] practice guide, Teaching Strategies for Improving Algebra Knowledge in Middle and High School Students (Star et al. 2015), provides teachers with specific, evidence-based recommendations that address the challenges of teaching algebra to secondary school students. The guide synthesizes the best available research, according to rigorous What Works Clearinghouse design standards (information about these standards is available at http://whatworks.ed.gov), and offers a list of actionable recommendations based on that evidence.

We present three recommendations from the IES guide and associated actions. We add our view of the recommendations in terms of specific ways to use student work and examples, to capitalize on multiple representations and structure, and to engage students in alternative solutions. Whether they are implementing the Common Core State Standards or their own state standards and regardless of their adopted curriculum, teachers of algebra can benefit from collaborative instructional planning that uses these recommendations and actions. In addition, incorporating these ideas into teacher education programs can better prepare prospective teachers for their initial classroom experiences, which often are in algebra settings.

EVIDENCE-BASED INSTRUCTIONAL STRATEGIES

The three recommendations and corresponding actions summarized in figure 1 inform instructional strategies. Each recommendation or action might be introduced and enacted separately over time, making it possible to enhance instruction gradually and to integrate the ideas into most local professional development programs. We value how the recommendations add research-based depth to general classroom practices that are commonly emphasized in professional development and teacher education. In particular, we see how the recommendations inform analysis and discussion of student work, use of multiple representations, and alternative strategies—teaching practices that offer important opportunities for all algebra students.

Recommendation 1

Teachers know the value of analyzing student work. For example, teachers suspect that students can benefit from looking at correctly and incorrectly worked examples of how to solve equations or inequalities. A challenging question is how best to use those worked examples, including when to introduce them and what to ask students to do with them. Implementation of action 1 allows teachers to have students identify and distinguish between strategic errors (using an inappropriate strategy or reasoning incorrectly) and procedural errors (making mistakes in carrying out a procedure or mathematical operation).

Recommendation 2

Use of multiple representations in algebra is critical. Teachers connect representations to the mathematical practice of attending to structure. Actions that teachers can take include drawing attention to the structure of expressions and the use of mathematical language to describe structures. Students
Recommendation 1
*Use solved problems to engage students in analyzing algebraic reasoning and strategies.*

**Actions**
1. Have students discuss solved problem structures and solutions to make connections among strategies and reasoning.
2. Select solved problems that reflect the lesson’s instructional aim, including problems that illustrate common errors.
3. Use whole-class discussions, small-group work, and independent practice activities to introduce, elaborate on, and practice working with solved problems.

Recommendation 2
*Teach students to use the structure of algebraic representations.*

**Actions**
1. Promote the use of language that reflects mathematical structure.
2. Encourage students to use reflective questioning to notice structure as they solve problems.
3. Teach students that different algebraic representations can convey different information about an algebra problem.

Recommendation 3
*Teach students to intentionally choose from alternative algebraic strategies when solving problems.*

**Actions**
1. Teach students to recognize and generate strategies for solving problems.
2. Encourage students to articulate the reasoning behind their choice of strategy and the mathematical validity of their strategy when solving problems.
3. Have students evaluate and compare different strategies for solving problems.

Adapted from *Teaching Strategies for Improving Algebra Knowledge in Middle and High School Students* (Star et al. 2015).

**Fig. 1** Actions are associated with each of the three recommendations.

Alternative strategies are valuable for many reasons. Although action 1 might seem obvious as stated, an exploration of the research supporting it can lead us to see the importance of students asking reflective questions as they analyze, select, or develop different strategies. For example, students might ask whether they could apply the steps they used in a different order or what first steps would be possible. Questions such as these can help students understand and value alternative approaches.

The three research-based recommendations are useful tools for teachers of algebra to refine their classroom strategies involving student work and examples, multiple representations and structure, and alternative solutions.

**POTENTIAL ROADBLOCKS AND SUGGESTED APPROACHES**

New instructional strategies such as those suggested by these recommendations are often met with resistance. Early adopters are quick to implement new strategies, whereas others are quick to point out why a new strategy might not work. We turn to the guide for approaches and a rationale to overcome each roadblock.

For example, concerning recommendation 3, action 3, some teachers will be worried that they will confuse their students by teaching multiple strategies for solving a problem. Students “have a hard enough time learning one strategy! Isn’t it easier for them to master one strategy for solving algebra problems?” (Star et al. 2015, p. 36). The goal of teaching alternative strategies is not mastery of all strategies by all students but the individual student’s mastery of the strategies that he or she chooses to use.

Teachers might be concerned that a buffet of strategies can overwhelm students. Multiple approaches to a problem are not new to students. They naturally see alternative approaches when other students share their ideas about how to solve a problem. Introduction of alternative strategies one at a time gives students time to become sufficiently familiar with the strategies to compare them. Students learn how to evaluate alternatives as they move beyond rote memorization and have more than one way to think about a problem. Struggling students can choose from strategies with which they are comfortable, and they have other options if they forget a particular strategy.

The suggestions on how to overcome common roadblocks to implementing the recommendations and the rationale for the recommendations can support teachers in implementing the strategies; in addition, they can make excellent discussion starters for teachers within their professional learning communities. The rationales and suggestions can
inform conversations with the larger school community, including parents. For prospective teachers, the rationales impart that reasoning professionally remains at the heart of informed teaching and decision making.

**TAKING ACTION TO IMPROVE STUDENT LEARNING**

The Professionalism Principle set forth in *Principles to Actions* (NCTM 2014) recommends, in part, that teachers should collaborate within professional learning communities to “discuss, select, and implement common research-informed instructional strategies and plans” (p. 104). For teachers and teacher educators who want to focus and extend teaching practices related to student work, multiple representations, and alternative strategies for use in algebra classrooms, the recommendations, examples, and solutions to challenges in *Teaching Strategies for Improving Algebra Knowledge in Middle and High School Students* are a key resource when planning evidence-based instruction to support student success in algebra.

**REFERENCES**


---

**Fig. 2** Specific examples help teachers and students distinguish between imprecise and precise language.

<table>
<thead>
<tr>
<th>Imprecise Language</th>
<th>Precise Mathematical Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take out the $x$.</td>
<td>Factor $x$ from the expression. Divide both sides of the equation by $x$, with a caution about the possibility of dividing by 0.</td>
</tr>
<tr>
<td>Move the 5 over.</td>
<td>Subtract 5 from both sides of the equation.</td>
</tr>
<tr>
<td>Use the rainbow method. Use FOIL.</td>
<td>Use the distributive property.</td>
</tr>
<tr>
<td>Solve an expression.</td>
<td>Solve an equation. Rewrite an expression.</td>
</tr>
<tr>
<td>$A$ is apples.</td>
<td>Let $a$ represent the number of apples. Let $a$ represent the cost of the apples in dollars. Let $a$ represent the weight of the apples in pounds.</td>
</tr>
<tr>
<td>Plug in the 2.</td>
<td>Substitute 2 for $x$.</td>
</tr>
<tr>
<td>To simplify, flip it and multiply. To divide a fraction, invert and multiply.</td>
<td>To simplify, multiply both sides by the reciprocal. To divide fractions, multiply by the reciprocal.</td>
</tr>
<tr>
<td>Do the opposite to each side.</td>
<td>Use inverse operations. Add the opposite to each side.</td>
</tr>
<tr>
<td>The numbers cancel out.</td>
<td>The numbers add to zero. The numbers divide to one.</td>
</tr>
<tr>
<td>Plug it into the expression.</td>
<td>Evaluate the expression.</td>
</tr>
</tbody>
</table>

Source: *Teaching Strategies for Improving Algebra Knowledge in Middle and High School Students* (Star et al. 2015, p. 18).