Applying Research-Based Principles for Effective Teaching to Algebra Classrooms

California Algebra Forum II
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James Hiebert
Begin With Two Facts About Teaching and Learning

1. Teaching matters
   - All educational resources (including curricula) reach students through teaching
     - Unless teaching changes, students won’t know the difference
     - By teaching, I mean the way teachers interact with students about content
   - Teaching is not the same as teachers
The Second Fact About Teaching and Learning

2. Effective methods of teaching depend on what we want students to learn

- All discussions about research-based findings of effective classroom practices must begin with learning goals
- Learning goals are value judgments
  - This inevitably leads to debates, but eventual agreement is essential to improve teaching
A Statement of Learning Goals

- Consensus statement of learning goals in 2001 National Research Council report *Adding It Up*, confirmed by the National Math Panel.
An Ambitious Learning Goal: Mathematical Proficiency

Adding It Up, p. 117
Two Research-Based Features of Teaching for Mathematical Proficiency

- Make conceptual relationships clear
  - Attend explicitly, in some way, to relationships among facts, procedures, representations, ideas, etc.
  - T. Carpenter: Engage in relational thinking (Is $57 + 38 = 56 + 39$ true or false?)
  - C. Kieran: See the underlying similarity in different forms (Teacher B: increasingly easy ways to solve the chewing gum problem)
Two Research-Based Features of Teaching For Mathematical Proficiency

- Allow students to do some of the important mathematical work
  - Teachers pose challenging problems (just beyond the familiar) and allow time for students to work
  - Problems should engage more than one strand of proficiency
    - See T. Carpenter and C. Kieran for many examples
  - Major threat is teachers jumping in too quickly and telling students how to find the answer
How Are We Doing?

- Does math teaching in the U.S. include the two features that help students achieve mathematical proficiency?
- The TIMSS 1999 Video Study helps answer this question
  - The study examined about 100 8th-grade math lessons in each of 6 higher achieving countries and the U.S. (Australia, Czech Republic, Hong Kong, Japan, Netherlands, Switzerland)
  - Videotapes of a random sample of lessons gathered across the year in each country
Types of Problems Presented to Students

- **Stating Concepts**: recalling or applying definitions or conventions

- **Using Procedures**: applying learned procedures

- **Making Connections**: constructing relationships among ideas, facts, or procedures
Types of Problems Presented

- AU: 61% Using procedures, 15% Making connections
- CZ: 77% Using procedures, 16% Making connections
- HK: 84% Using procedures, 13% Making connections
- JP: 41% Using procedures, 54% Making connections
- NL: 57% Using procedures, 24% Making connections
- US: 69% Using procedures, 17% Making connections
Types of Problems Presented AND Worked On During the Lesson

- Each problem was coded a second time based on how it was worked on and discussed during the lesson.

- This is where teaching really matters.
  - Problems can be transformed
Again: Types of Problems Presented

<table>
<thead>
<tr>
<th>Country</th>
<th>Using procedures</th>
<th>Making connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>AU</td>
<td>61</td>
<td>15</td>
</tr>
<tr>
<td>CZ</td>
<td>77</td>
<td>16</td>
</tr>
<tr>
<td>HK</td>
<td>84</td>
<td>13</td>
</tr>
<tr>
<td>JP</td>
<td>41</td>
<td>54</td>
</tr>
<tr>
<td>NL</td>
<td>57</td>
<td>24</td>
</tr>
<tr>
<td>US</td>
<td>69</td>
<td>17</td>
</tr>
</tbody>
</table>
How Making Connections Problems Are Worked On During the Lesson

The chart shows the percent of Making Connections Problems worked on by students in different countries, comparing the use of procedures and making connections.

- **AU**: Using procedures (31%), Making connections (8%)
- **CZ**: Using procedures (52%), Making connections (16%)
- **HK**: Using procedures (46%), Making connections (18%)
- **JP**: Using procedures (48%), Making connections (20%)
- **NL**: Using procedures (37%), Making connections (19%)
- **US**: Using procedures (59%), Making connections (0%)

Legend:
- **Using procedures**
- **Making connections**
Lessons Learned from Research

- Two features of teaching help students become mathematically proficient
  - attending to mathematical relationships
  - allowing students to wrestle with key ideas
- These are two features shared by many higher achieving countries but absent in typical 8th grade classrooms in the U.S. (Not a new finding)
- A preferred curriculum is not enough; teaching transforms curricula.
Teaching Is Hard To Change, But It Is Easier When We Have a Clear Target

- If we want students to develop mathematical proficiency, then
- Teaching needs to incorporate
  - more direct attention to relationships among concepts, procedures, and facts; and,
  - more opportunities for students to wrestle with the important mathematical ideas.
How Does Teaching Change?

- By being clear about what changes are needed (learning goals for teachers)
- By providing learning opportunities that align with the goals (just as in providing aligned opportunities for students). For teachers’ learning, this means
  - Not prescribing rules for better teaching and asking teachers to memorize them
  - But rather allowing teachers to wrestle with the key ideas involved in teaching for Mathematical Proficiency
- By marshalling the leadership needed to create and sustain these opportunities
Learning Environments Needed To Make Ambitious Changes To Teaching

- Teachers must work together to study teaching
- Studying teaching must become part of the routine and culture of the school
- Studying algebra teaching means studying the details of how problems are presented and worked on with students

How does this look, in practice?
The Practice Of Studying Teaching

**Cycle of Teaching**

- Planning
- Reflecting On Practice
- Classroom Practice
- Slowing down the cycle...
  ... and attending to the planning and reflecting phases
Planning and Reflecting On Teaching

- Begin by designing a few lessons with great care
- Specify the learning goals clearly and precisely
- Include some algebra problems that challenge students
- Predict students’ responses to these problems in order to decide beforehand how to sustain the goal of the problems
- Gather evidence on lesson’s effectiveness by assessing students’ thinking against the learning goals
- Use the evidence to improve the lesson a little for next time
Won’t This Approach Take Years?

- Yes
- The alternatives tried for the past 100 years do not show great promise
- Maybe it’s time to take seriously the importance of improving teaching and to recognize the hard, relentless work required to do so
Final Words

- When you improve a little each day, eventually big things occur . . . . Not tomorrow, not the next day, but eventually a big gain is made. Don’t look for the big, quick improvement. Seek the small improvement one day at a time. That’s the only way it happens—and when it happens, it lasts.

  John Wooden, UCLA