Research-Based Practices that Increase Students' Achievement—

and Practical Suggestions for Implementing Them in Your Classroom

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Challenge

- Essential for all students to succeed at high levels in mathematics.
- How can we:
  - Increase the effectiveness of our mathematics curriculum and instruction;
  - Ensure that all students are achieving at high levels.

Research-Informed Actions

Instructional practice should be informed by high-quality research, when available, and by the best professional judgment and experience of accomplished classroom teachers.

National Math Panel, 2008

Relevant Research

- How people learn;
- How students learn mathematics;
- Particular challenges in learning specific mathematics content;
- Established principles of mathematics learning and instruction;
- New approaches to knowing what students know;
- Effective instruction for special needs students;
- Student motivation;
- Teacher supports;
- Language and literacy related to mathematics learning.

Reactions to Research

- Doesn't address my concerns or questions
- Doesn't apply to "my kids"
- "Some things are so obvious that they don't require research."
  - The earth is flat.
  - The sun moves around the earth.

"Wisdom of practice" can/should inform research, but it is not a substitute for research.

Realistic Expectations

- Research is most useful when it provides an understanding of why a particular strategy, intervention, approach or program works (Hiebert 2003).
- Research on general learning principles can provide a basis for effective instructional practices.

Research Results

- *How People Learn*, NRC, 1999, 2005
- *Adding It Up: Helping Children Learn Mathematics*, NRC, 2001
- *Knowing What Students Know: The Science and Design of Educational Assessment,* NRC, 2001
- *Foundations for Success*, National Mathematics Advisory Panel, 2008
- *Educational Researcher*, Response to NMAP Report, December 2008
- QUASAR project
- TIMSS, 1999

Fact or Fiction?

1. Children cannot solve word problems until they know their basic facts/computational procedures.
2. Cooperative learning is more effective than direct instruction.
3. Children's math knowledge when entering kindergarten is strongly predictive of their achievement in elementary, middle and high school.
4. Solving linear equations is easier than solving linear function word problems.
5. There is little teachers can do to increase students' motivation and effort.
6. Focused, intense practice helps students learn and remember concepts and skills.

What Happened?

Which of the following are even numbers?

a. 89

b. 138

c. 150

d. 245

Examples of Well-Established Research Results

- On-going cumulative distributed practice improves learning and retention.

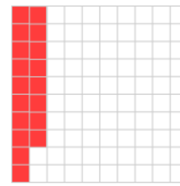
Ongoing Review and Practice

1. If it rained 3 days out of 20 days, what percent of the days did it rain?

   Answer:

   Evidence for answer:

2. If the large square represents one whole, what fraction is represented by the shaded area?



   Answer:

   Evidence for answer:

3. Which symbol (<, >, *or* =) correctly describes the relationship between these two numbers.

   $\frac{9}{16}$ ☐ 0.5625

   Evidence for answer:

4. There are 6 boys to every 9 girls in the 6th grade at Ripple River School. There are a total of 75 students in the 6th grade. How many boys are there in the 6th grade?

   Answer:

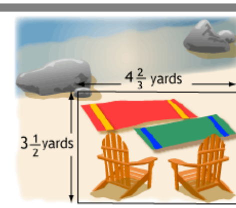
   Evidence for answer:

5. Meghan works at an ice cream shop and makes $8.25 per hour. Lucas works for a landscaper and makes $6.50 per hour. How much more does Meghan make each hour?

   Answer:

   Evidence for answer:

6. How long of a piece of rope do the girls need to totally enclose their space at the beach?



   Answer:

   Evidence for answer:

Examples of Well-Established Research Results

- On-going cumulative distributed practice improves learning and retention.
- An individual's prior knowledge significantly influences what is learned in a particular situation.

Connect New Learning with Prior Knowledge

Cue students about knowledge to access

- Preview
- Openers

Algebra 1 Example: Day 1 Activity

Shape Equations #5

Clue 1 ◇ x △ = ⬡	**Clue 2** 2 x △ = 12
Clue 3 ◇ + ◇ = △	**Clue 4** 2 ◇ + 2 △ = ⬡

△ = ____ ◇ = ____ ⬡ = ____

Your thinking:

Substitution Method for Solving Systems: Opener

1. Consider the following algebra problem from earlier in the course.

   Evaluate $ab + 2c$ when $a = -2$, $b = 3$, and $c = 5$.

   a. Solve the problem.

   b. Explain how the mathematical idea of "substitution" is used in solving this problem.

2. Use the clues as a set in the Shape Equation below to find the values for the shapes. [The value for each shape remains constant for each equation.] Then explain your reasoning.

   ● + ■ + ▲ = 15

   3 • ▲ = 12

   ■ – ▲ = 2

   Answer:

   ● = ____

   ■ = ____

   ▲ = ____

   a. Here is how I figured out the answer:

   b. Here is how I know that my answer is correct:

   c. Explain how the mathematical idea of "substitution" is used in solving this problem.

Prior Knowledge Includes Informal Knowledge

1. Mike has 8 pennies. Sam has 3 pennies. How many altogether?
2. Mike has 8 pennies. Sam gives him 3 more. How many does Mike have now?
3. Mike has 8 pennies. He loses 3. How many does he have now?
4. Mike has 8 pennies. Sam gives him some more. Now he has 11. How many did he get from Sam?
5. Mike has 11 pennies. He loses some. How he has 8 pennies. How many did he lose?
6. Mike has some pennies. He gets 3 more. Now he has 11. How many did he have at the beginning?
7. Mike has some pennies. He loses 3. Now he has 8. How many did he have at the beginning.

Extending to Algebra

U.S. Shirts charges $12 per shirt plus $10 set-up charge for custom printing.

- What is the total cost of an order for 3 shirts?
- What is the total cost of an order for 10 shirts?
- What is the total cost of an order for 100 shirts?
- A customer spends $70 on T-shirts. How many shirts did the customer buy?

$y = 12x + 10$

- Solve for y when x = 3, 10, 100.
- Solve $70 = 12x + 10$

Connect New Learning with Prior Knowledge

- Cue students about knowledge to access
  - Preview
  - Openers
- Informal knowledge
- Directly assess prior knowledge

Expose and Discuss Common Misconceptions

Table 1

x	y
1	1
4	7
6	11
7	13

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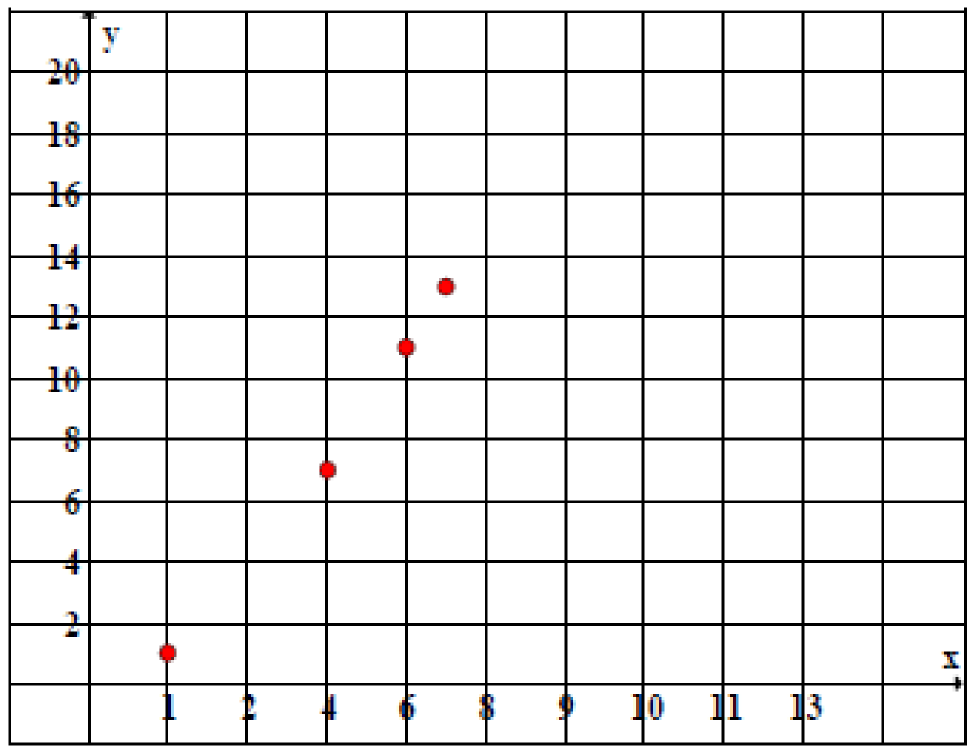
Graph 1



Analyzing Graphs

1. What's wrong with Graph 1?

Table 1

x	y
1	1
4	7
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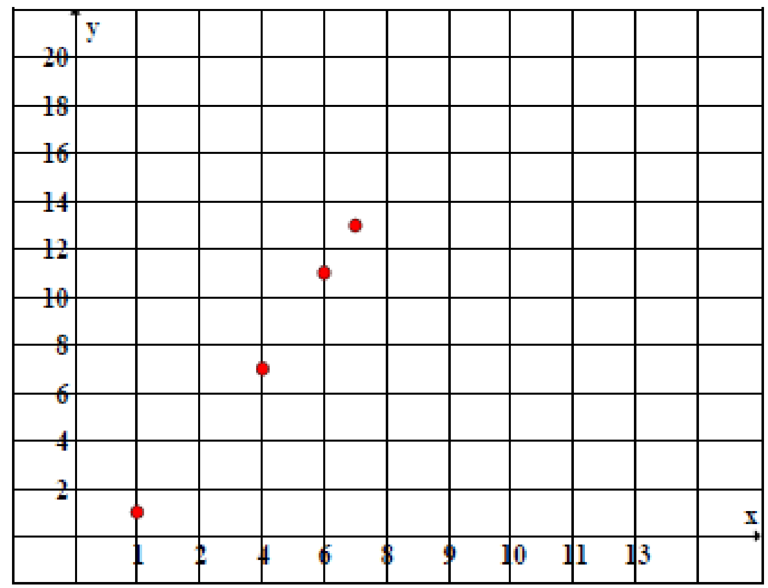
Graph 1



2. Use the data in Table 1 to draw a correct graph.

The meaning of "="

- 6 + 9 = _____
- 6 + 9 = 15
- 15 = 6 + 9
- 6 + 9 = 8 + 7
- 15 = 15

Foundations for Algebra

8

8, 7, 3, 9, 2

$8 + 9 = 17 - 7 = 10 \div 2 = 5 + 3 = 8$

$8 + 9 = 8$

Think about

- How do you use, model the use of "="?
- What opportunities are you providing for students to use "=" to denote equality?

Connect New Learning with Prior Knowledge

- Cue students about knowledge to access
  - Preview
  - Openers
- Informal knowledge
- Directly assess prior knowledge
- Avoid promoting misconceptions, explicitly or implicitly

Examples of Well-Established Research Results

- On-going cumulative distributed practice improves learning and retention.
- Accessing prior knowledge and addressing students' misconceptions improves learning.
- Engage with challenging tasks that involve active meaning-making.

Learners should

- Engage with challenging tasks that involve active meaning-making.
- Acquire conceptual knowledge as well as skills to enable them to organize their knowledge, transfer knowledge to new situations, and acquire new knowledge.

What Are Mathematical Tasks?

Mathematical tasks are a set of problems or a single complex problem the purpose of which is to focus students' attention on a particular mathematical idea.

Why Focus on Mathematical Tasks?

- Tasks form the basis for students' opportunities to learn what mathematics is and how one does it;
- Tasks influence learners by directing their attention to particular aspects of content and by specifying ways to process information;
- The level and kind of thinking required by mathematical instructional tasks influences what students learn; and
- Differences in the level and kind of thinking of tasks used by different teachers, schools, and districts, is a major source of inequity in students' opportunities to learn mathematics.

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The QUASAR Project

- Assisted schools in economically disadvantaged communities to develop instructional programs that emphasize thinking, reasoning and problem solving in mathematics.
- Worked with lowest achieving middle schools in six urban sites.
- Studied the impact of high quality curricula and professional development upon student achievement.

Comparing Two Mathematical Tasks

Martha was re-carpeting her bedroom which was 15 feet long and 10 feet wide. How many square feet of carpeting will she need to purchase?

Stein, Smith, Henningsen, & Silver, 2000, p. 1

Comparing Two Mathematical Tasks

Ms. Brown's class will raise rabbits for their spring science fair. They have 24 feet of fencing with which to build a rectangular rabbit pen in which to keep the rabbits.

1. **If Ms. Brown's students want their rabbits to have as much room as possible, how long would each of the sides of the pen be?**

2. **How long would each of the sides of the pen be if they had only 16 feet of fencing?**

3. **How would you go about determining the pen with the most room for any amount of fencing? Organize your work so that someone else who reads it will understand it.**

Stein, Smith, Henningsen, & Silver, 2000, p. 2

Compare the Two Tasks

Discuss:

- How are Martha's Carpeting Task and the Fencing Task the same and how are they different?

Cognitive Level of Tasks

- Lower-Level Tasks
  - memorization
  - procedures without connections (e.g., Martha's Carpeting Task)
- Higher-Level Tasks
  - procedures with connections
  - doing mathematics (e.g., The Fencing Task)

Lower-Level Tasks

- Memorization
  - What are the decimal equivalents for the fractions ½ and ¼?
- Procedures without connections
  - Convert the fraction 3/8 to a decimal.

Higher-Level Tasks

- Procedures with connections
  - Using a 10 x 10 grid, identify the decimal and percent equivalents of 3/5.
- Doing mathematics
  - Shade 6 small squares in a 4 x 10 rectangle. Using the rectangle, explain how to determine:
    a) The decimal part of area that is shaded;
    b) The fractional part of area that is shaded.

"Not all tasks are created equal, and *different tasks will provoke different levels and kinds of student thinking*."

Stein, Smith, Henningsen, & Silver, 2000

"The level and kind of thinking in which students engage determines what they will learn."

Hiebert et al., 1997

Opportunities for *all* students to engage in high-level tasks?

- Examine tasks in your instructional materials:
  - Higher level?
  - Lower level?
- Where are the higher-level tasks?
- Do *all* students have the opportunity to do higher-level tasks?

The Mathematical Tasks Framework

TASKS as they appear in curricular/ instructional materials → **TASKS** as set up by the teachers → **TASKS** as implemented by students → **Student Learning**

Key Question:

Who
is doing
the thinking?

LSC Evaluation Study

While teachers were using the materials more extensively in their classrooms, there was a wide variation in how well they were implementing these materials. Teachers were often content to omit rich activities, skip over steps and jump to higher level concepts, or leave little time for students to ‘make sense’ of the lessons.

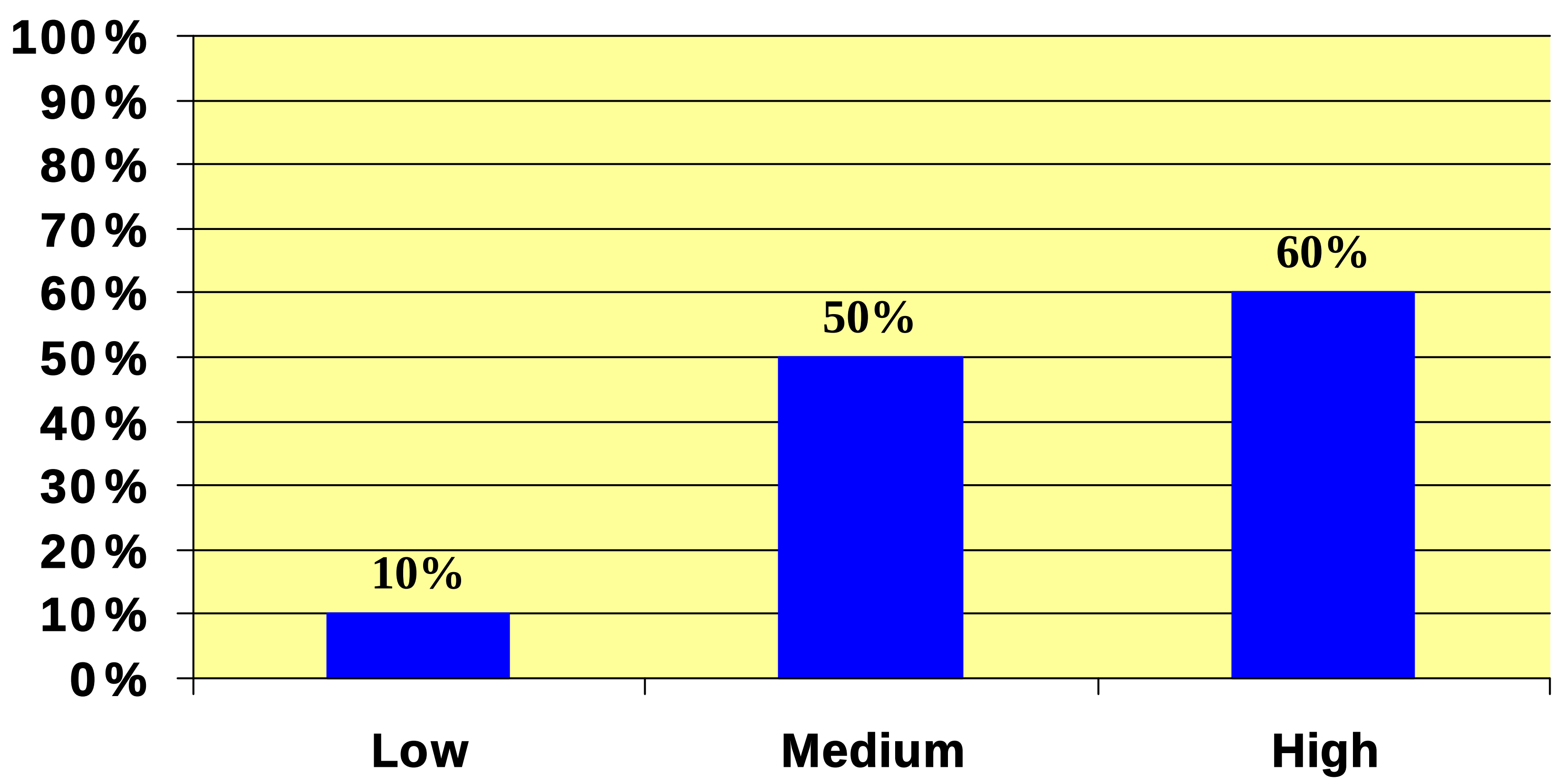
Weiss, et al, 2006

LSC Evaluation Study

In fact, classroom observations indicated that the lessons taught as the developers intended were more likely to provide students with learning opportunities than those that were "adapted."

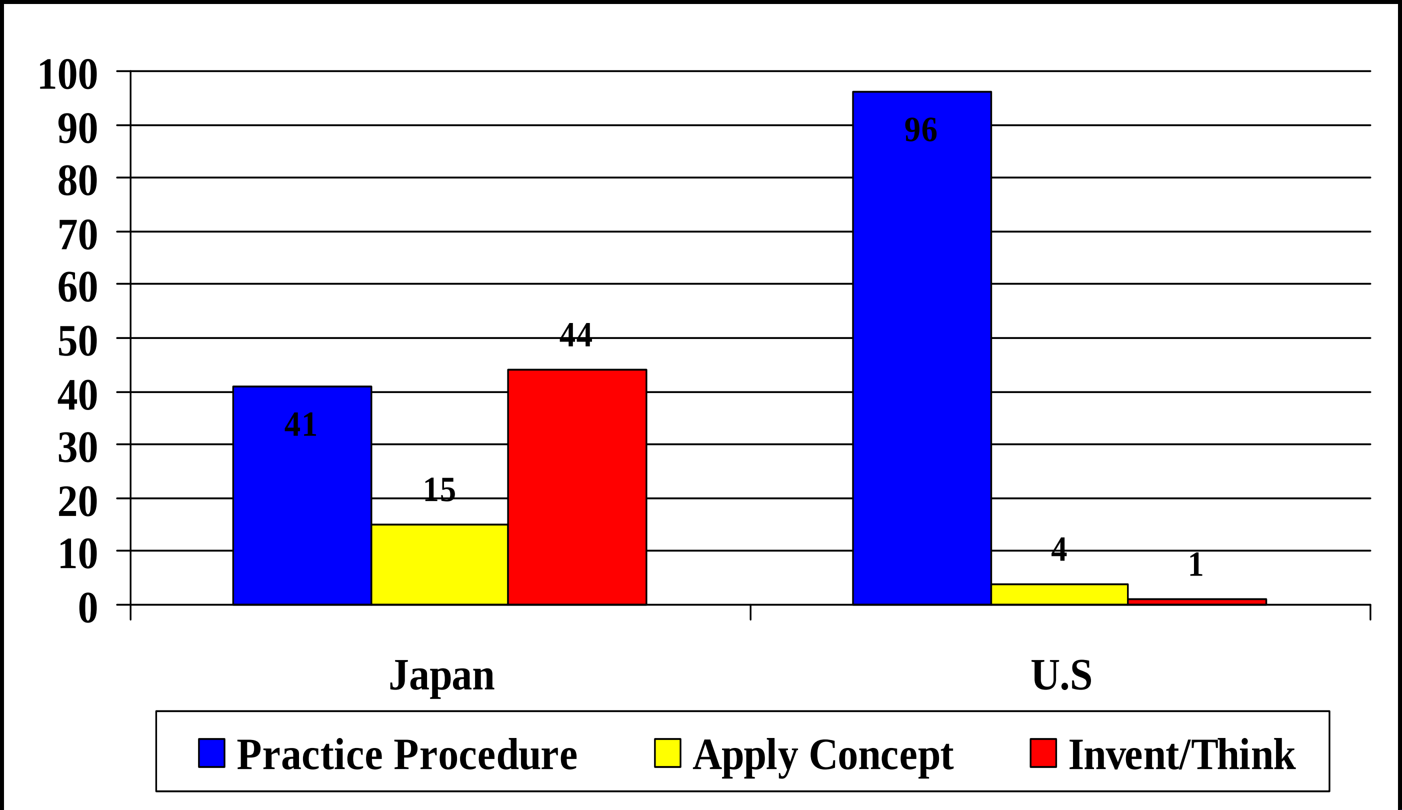
Weiss, et al, 2006

Highly-Rated Lessons by Adherence to Standards-Based Materials



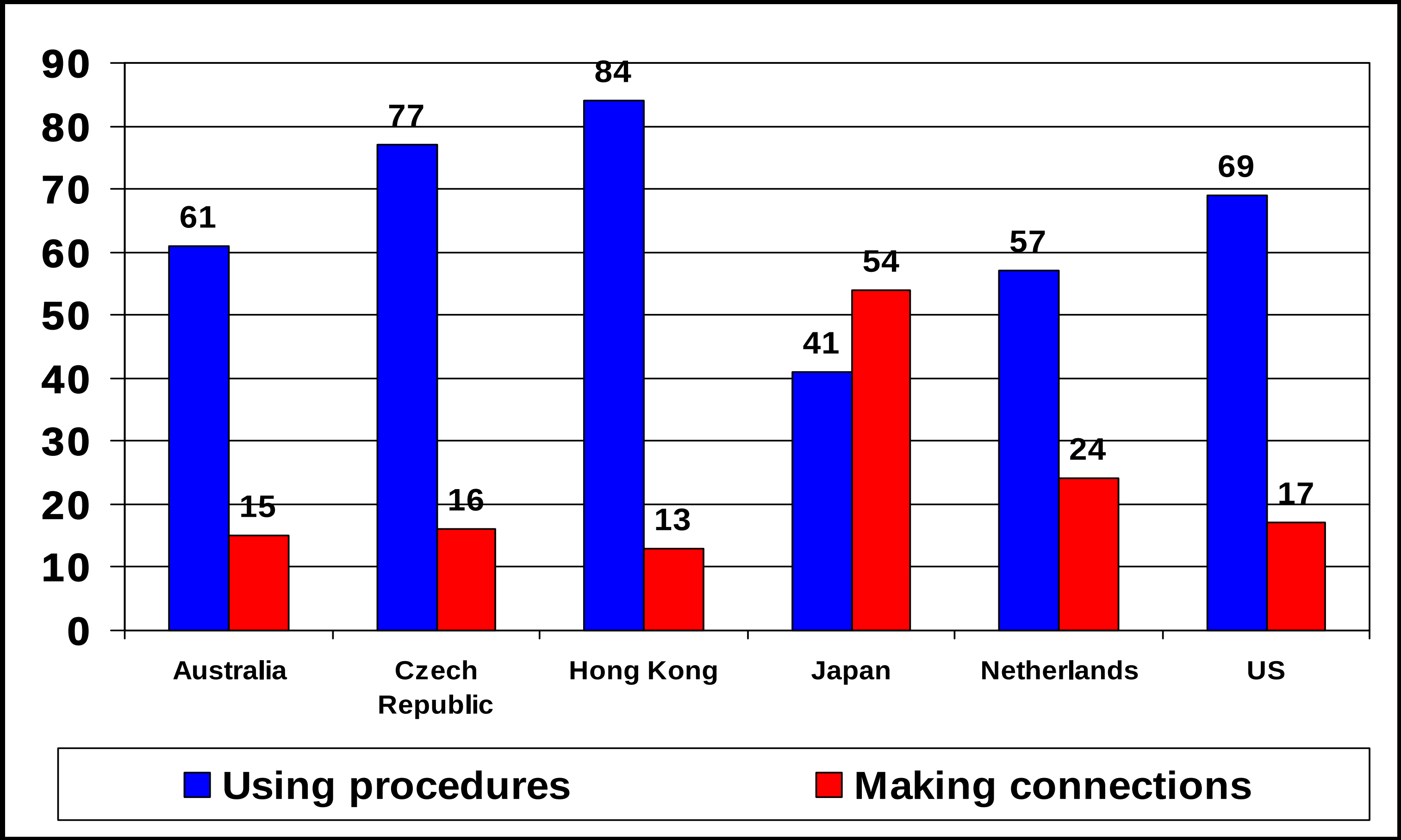
TIMSS Video Studies

Average Percentage of Seatwork Time in Each Country Spent Working on Three Kinds of Tasks



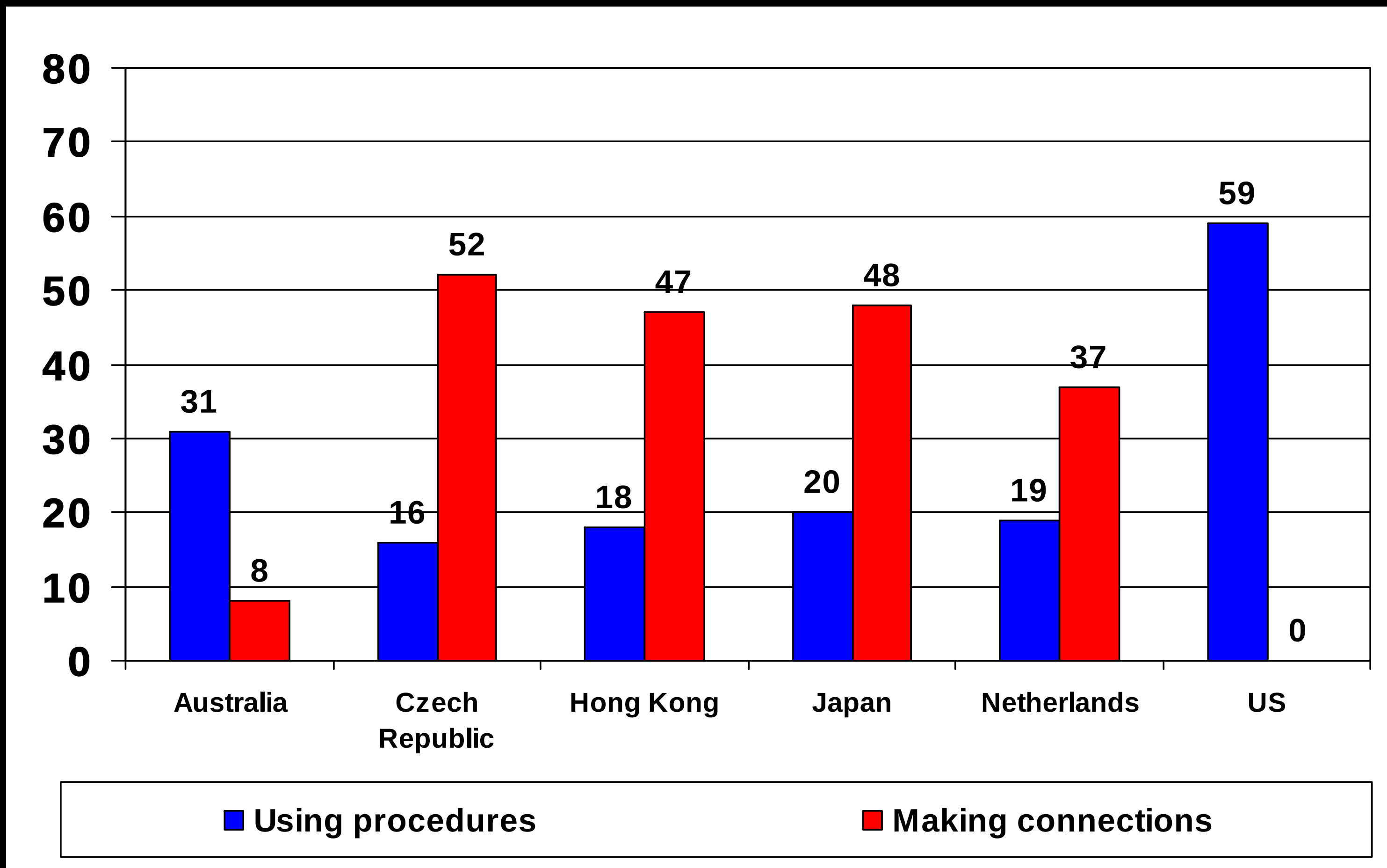
Types of Math Problems Presented

1999 TIMSS Video Study



LEADERSHIP IN MATHEMATICS EDUCATION
NCSM
NETWORK
COMMUNICATE
SUPPORT
MOTIVATE

How Teachers Implemented *Making Connections* Math Problems



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Effect on student achievement

	Task Set-Up	Task Implementation	Student Learning
A.	High →	High →	High
	Low →	Low →	Low
C.	High →	Low →	Moderate

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- Accessing prior knowledge and addressing students' misconceptions increases learning.
- Engaging students with challenging tasks that involve active meaning-making increases learning.
- Promoting learners' beliefs about their own intelligence can increase their motivation and effort to learn mathematics.

Students' Beliefs about Their Intelligence Affect Their Academic Achievement

- Fixed mindset:
  - Avoid learning situations if they might make mistakes
  - Try to hide, rather than fix, mistakes or deficiencies
  - Decrease effort when confronted with challenge
- Growth mindset:
  - Work to correct mistakes and deficiencies
  - View effort as positive; increase effort when challenged

Students' Beliefs about Their Intelligence Affect Their Academic Achievement

When confronted with challenging school transitions or courses, students with growth mindsets outperform those with fixed mindsets, even when they enter with equal skills and knowledge.

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Students Can Develop Growth Mindsets

- Explicit instruction about the brain, its function, and that intellectual development is the result of effort and learning has increased students' achievement in middle school mathematics.
- Teacher praise influences mindsets
  - Fixed: Praise refers to intelligence
  - Growth: Praise refers to effort, engagement, perseverance

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Examples of Well-Established Research Results

- Formative assessment increases students' learning.
- Clear, meaningful, specific, timely feedback improves learning.
- Playing number board games can promote development of number sense.
- Professional collaboration around instructional issues increases student achievement.

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Thank You!