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Assessing Mathematics Assessment Policies and Practices: Lessons Learned and Actions to Move Forward

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In this session we will

- Examine NCTM recommendations through the years that have influenced our understanding of effective mathematics assessment practices and policies;
- Highlight essential features of effective mathematics assessment practices and policies that should be part of our current practices and policies.

Why Assessment?

"What is inspected is expected.
What is evaluated is valued.
What gets counted, counts."

Assessment Standards for School Mathematics, NCTM, 1995

"I am inclined to think that most teachers believe they should teach principles rather than facts, that they should aim at mental power rather than knowledge of details. At the same time, many teachers seem to think that they are compelled by one circumstance or another to sacrifice their ideals and best judgment . . . That examinations covering certain ground await their students at the end of a given time; that their success is measured by the percentage of students who pass the examinations . . .

Examinations will be ever with us, though it is to be hoped that they will not always continue to be quite so much of a bug-bear as now.

W.H. Metzler, Editor

The Mathematics Teacher, Issue 1, September 1908

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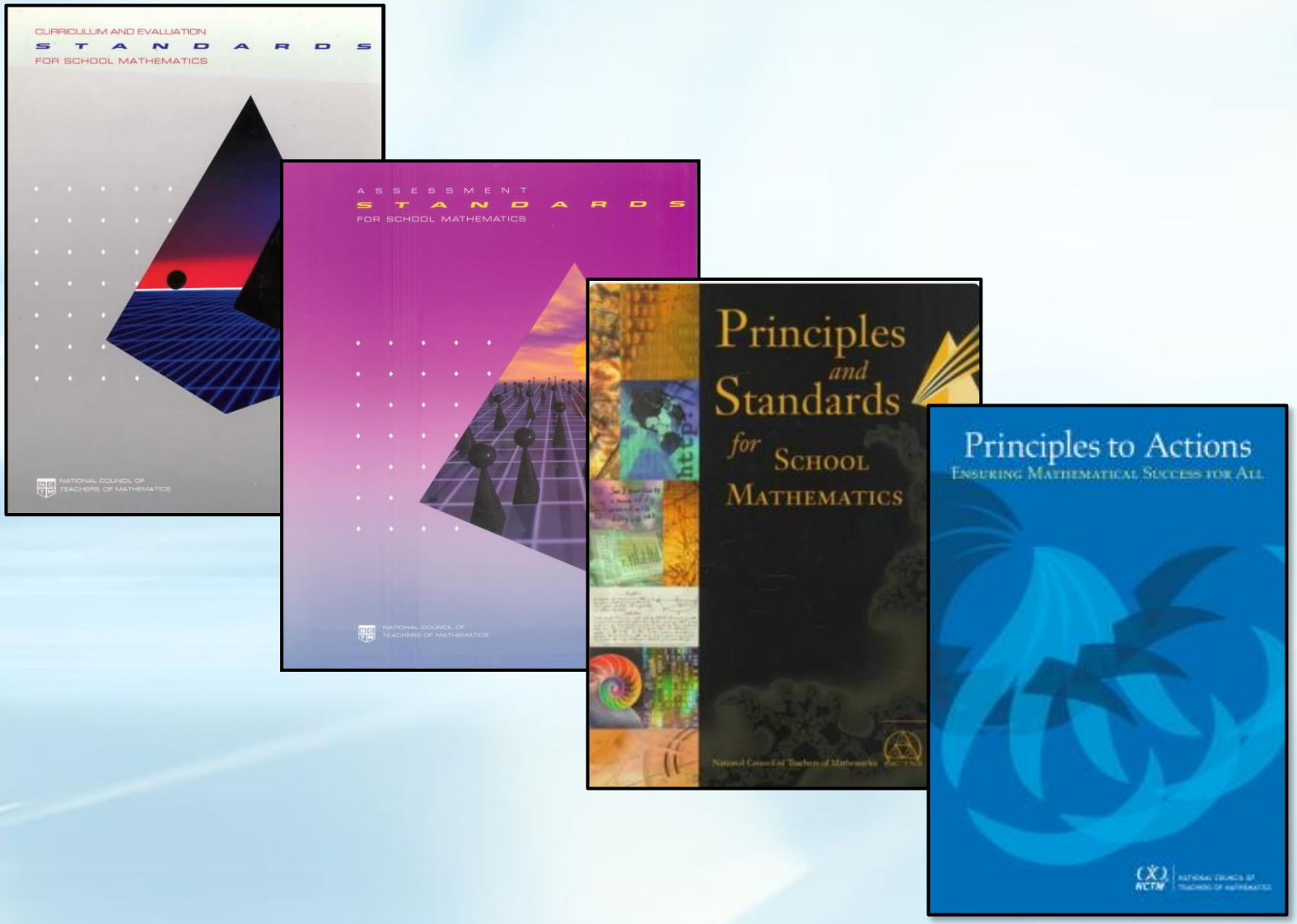


1970's & 1980's

Mandated Testing

- District or State-level achievement tests or both (70%)
- Tests were norm-referenced. Most widely used tests:

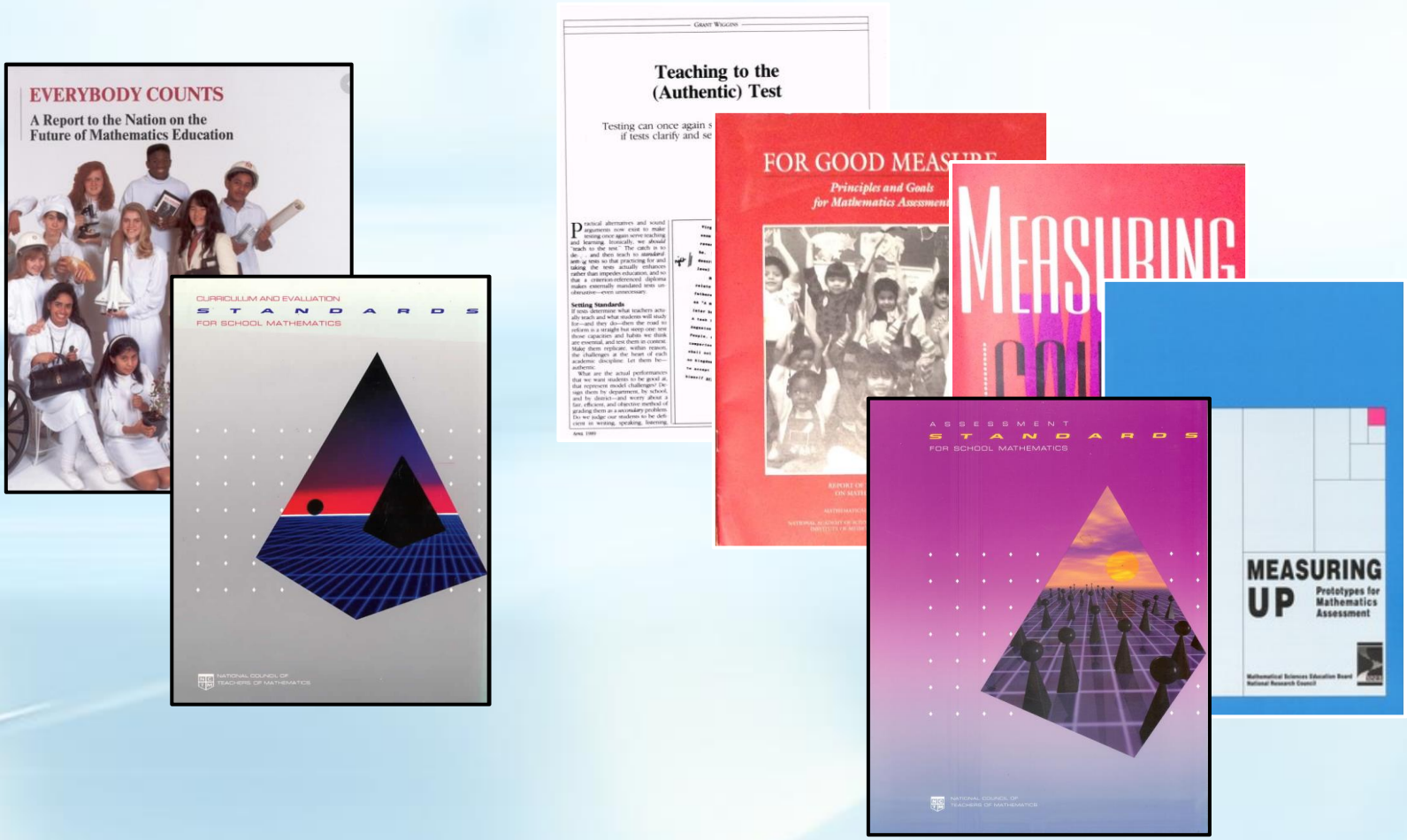
  CAT MAT SAT SRA CTBS ITBS

"Most teachers make changes in their teaching to reflect [the form and character of the tests their students take]"

Romberg, Wilson & Khaketla, 1989

Late 1980s & 1990s

Assessment reform to address equity issues



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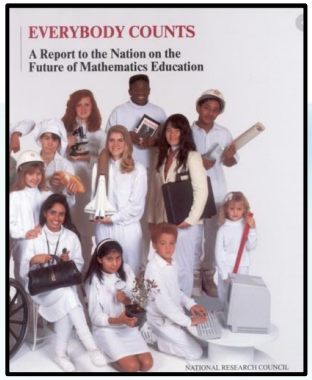
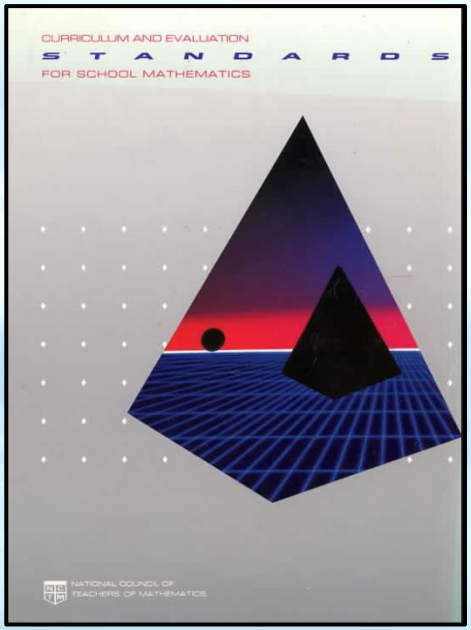


“We must ensure that tests measure what is of value, not just what is easy to test. What is tested is what gets taught. Tests must measure what is most important."

Everybody Counts: A report to the Nation on the Future of Mathematics Education

National Research Council, 1989

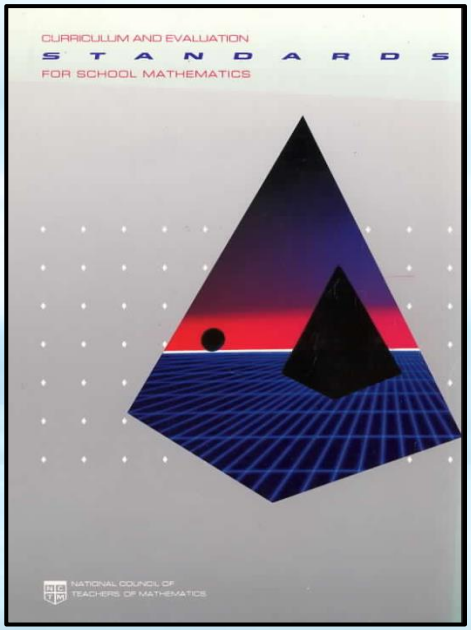
Curriculum and Evaluation Standards for School Mathematics



1989

"Evaluation is fundamental to the process of making the Standards a reality. The Evaluation Standards propose changes in the processes and methods by which information is collected . . .to increase and improve the gathering of relevant, useful information."

Curriculum and Evaluation Standards for School Mathematics



1989

The Evaluation Standards propose that—

- *Student assessment be integral to instruction;*
- *Multiple means of assessment methods be used;*
- *All aspects of mathematical knowledge and it's connections be assessed; and*
- *Instruction and curriculum be considered equally in judging the quality of a program.*

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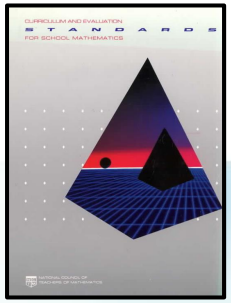

Evaluation Standards

Decreased Attention

- Assessing what students do not know
- Having assessment be simply counting correct answers on tests for the sole purpose of assigning grades
- Focusing on a large number of specific or isolated skilled organized by a content-behavior matrix.
- Using exercises or word problems requiring only one or two skills.

Increased Attention

- Assessing what students know and how they think about mathematics
- Having assessment be an integral part of teaching
- Focusing on a broad range of mathematical tasks and taking a holistic view of mathematics
- Developing problem situations that require the applications of a number of mathematical ideas.

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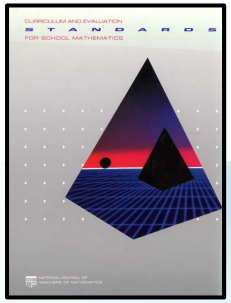

Evaluation Standards

Decreased Attention

- Using only written tests
- Excluding calculators, computers, and manipulatives from the assessment process.
- Evaluating the program only on the basis of test scores
- Using standardized achievement tests as the only indicator of program outcomes.

Increased Attention

- Using multiple assessment techniques, including written, oral, and demonstration formats.
- Using calculators, computers, and manipulatives in assessment
- Evaluating the program by systematically collecting information on outcomes, curriculum, and instruction.
- Using standardized achievement tests as only one of many indicators of program outcomes.

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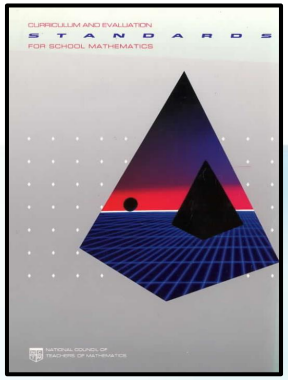

Evaluation Standards

General Assessment

1. Alignment

Of methods and tasks with the curriculum's goals, objectives and mathematical content; relative emphases given to various topics and processes and their relationships; instructional approaches and activities, including the use of calculators, computers, and manipulatives.

2. Multiple Sources of Information

Decisions concerning students' learning should be made on the basis of a convergence of information from a variety of sources, encompassing tasks that demand different kinds of mathematical thinking; present the same concept or procedure in different contexts, formats and problem situations.

3. Appropriate Assessment Methods and Uses

Assessment methods and instruments should be selected on the basis of the type of information sought; the use to which the information will be put; and the developmental level and maturity of the student. The use of assessment data for purposes other than those intended is inappropriate.

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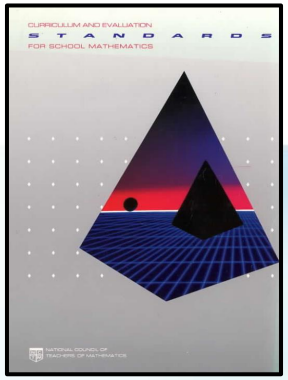

Evaluation Standards

Student Assessment

4. **Mathematical Power**
5. **Problem Solving**

   Assessment should provide evidence that students can **formulate** problems, apply a variety of **strategies** to solve problems; **solve** problems; **verify** and **interpret** results; **generalize** solutions.

6. **Communication**
7. **Reasoning**
8. **Mathematical Concepts**
9. **Mathematical Procedures**
10. **Mathematical Disposition**

    Assessment should seek information about their **confidence** in using mathematics to solve problems, to communicate ideas, and to reason; **flexibility** in exploring mathematical ideas and trying alternative methods in solving problems; willingness to **persevere** in mathematical tasks; **interest, curiosity and inventiveness** in doing mathematics; inclination to **monitor and reflect** on their own thinking and performance; **valuing** of the application of mathematics to situations arising in other disciplines and everyday experiences; **appreciation** of the role of mathematics in our culture and its value as a tool and as a language.

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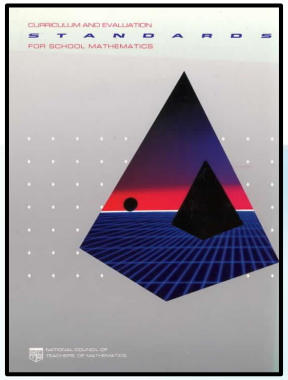


Evaluation Standards

Program Evaluation

11. Indicators for Program Evaluation

Indicators of a program's consistency with the Standards should include student outcomes, program expectations and support; **equity** for all students; curriculum review and change.

12. Curriculum and Instructional Resources

Evaluation of a program's consistency with the Curriculum Standards should focus on goals, objectives and mathematical content; relative emphases of various topics and processes and their relationships; instructional approaches and activities; articulation across grades; assessment methods and instruments; availability of technological tools and support materials.

13. Instruction

In evaluating a program's consistency with the Curriculum Standards, instruction and the environment in which it takes place should be examined with special attention to mathematical content and its treatment; relative emphases assigned to various topics and processes and the relationships among them; **opportunities to learn**, instructional resources and classroom climate; assessment methods and instruments; **the articulation of instruction across grades**.

14. Evaluation Team

1990's & Early 2000's

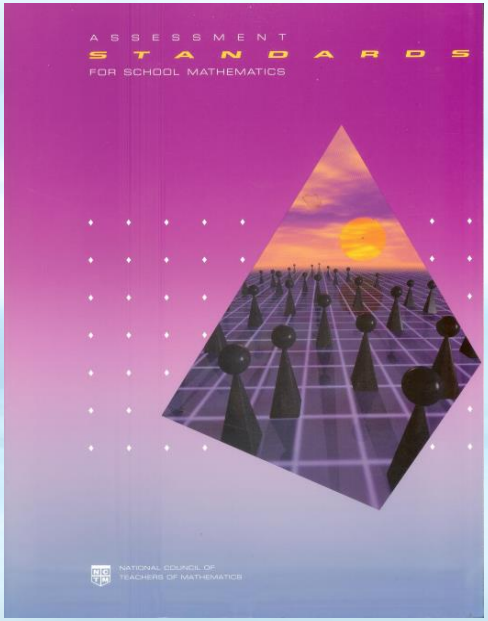
Assessment Development Projects

- Balanced Assessment Project
- Mathematics Assessment Resource Service (MARS)
- New Standards Project

Performance Assessments Part of Mandated Tests

- CA, CT, MA, MD, MI
- New Standards Reference Examination
- Portfolio Assessment--VT, KY
- Common assessments across states, NECAP

Assessment Standards for School Mathematics



The assessment standards provide criteria for judging the quality of mathematics assessments.

1995

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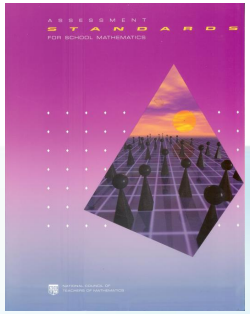
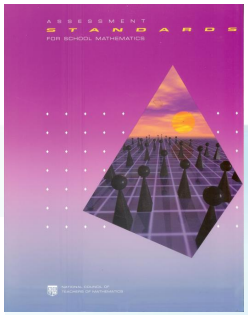
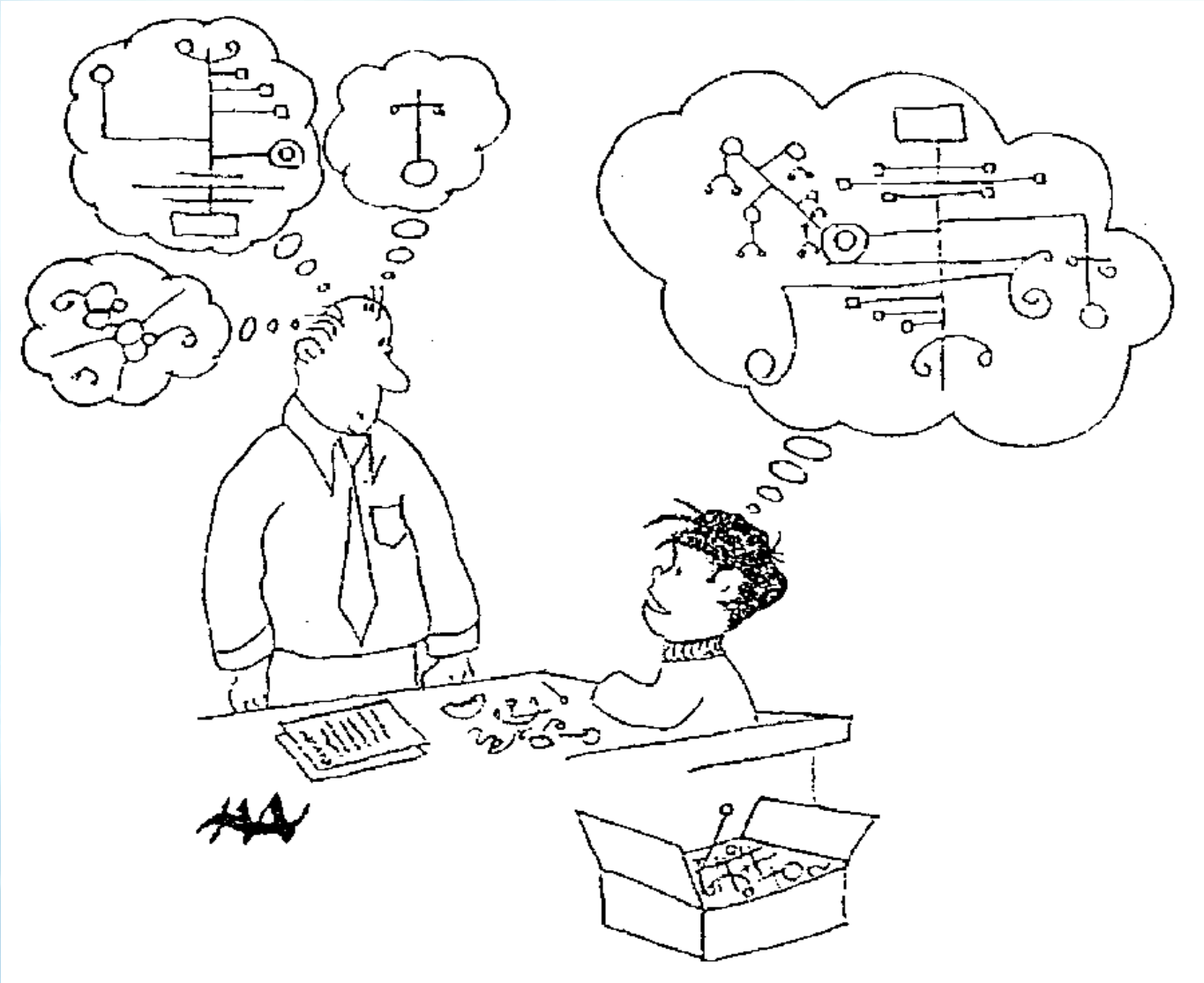


What is Assessment?

Assessment is the process of gathering evidence about student's knowledge of, ability to use, and disposition towards mathematics and of making inferences based on that evidence for a variety of purposes.

Assessment Standards for School Mathematics, NCTM, 1995.


ASSESSMENT
STANDARDS
FOR SCHOOL MATHEMATICS



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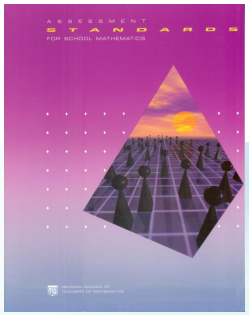
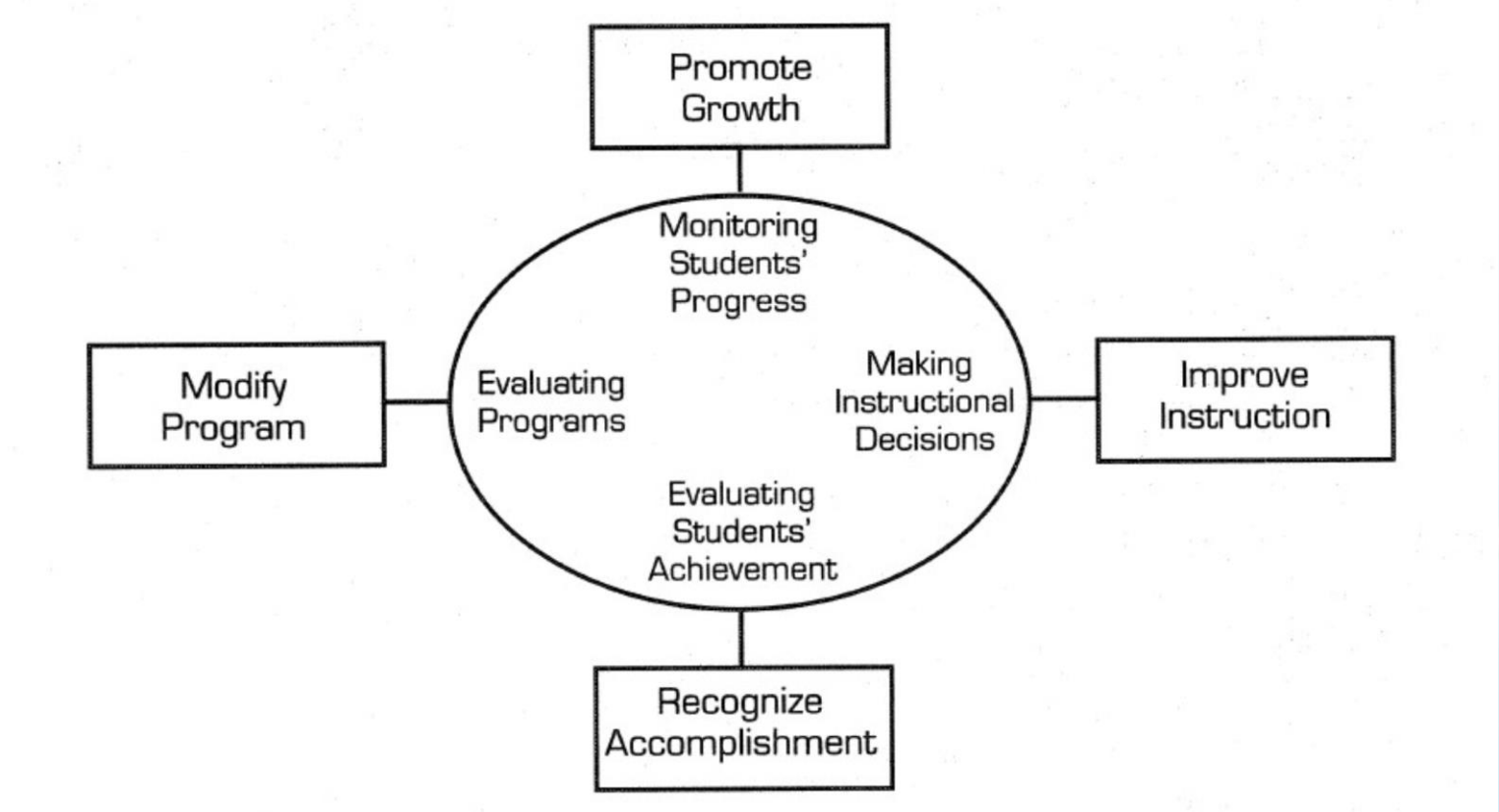


Assessment Standards for School Mathematics

Four Purposes of Assessment and Their Results



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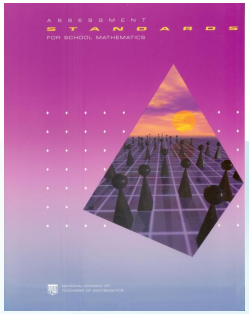

Assessment Standards for School Mathematics

The Mathematics Standard
Assessment should reflect the mathematics that all students need to know and be able to do.

The Learning Standard
Assessment should enhance mathematics learning.

The Equity Standard
Assessment should promote equity.

The Openness Standard
Assessment should be an open process.

The Inferences Standard
Assessment should promote valid inferences about mathematics learning.

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Assessment should be a coherent process.

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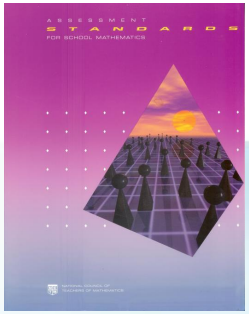

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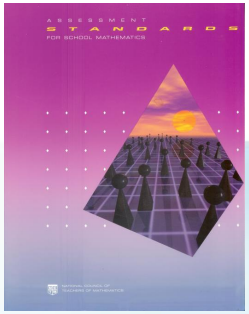

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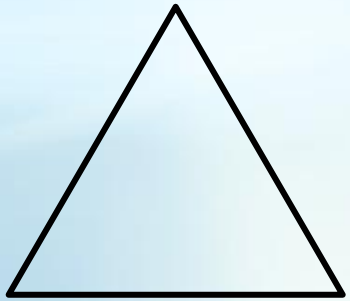
Assessment that Promotes Valid Inferences

Learning target:

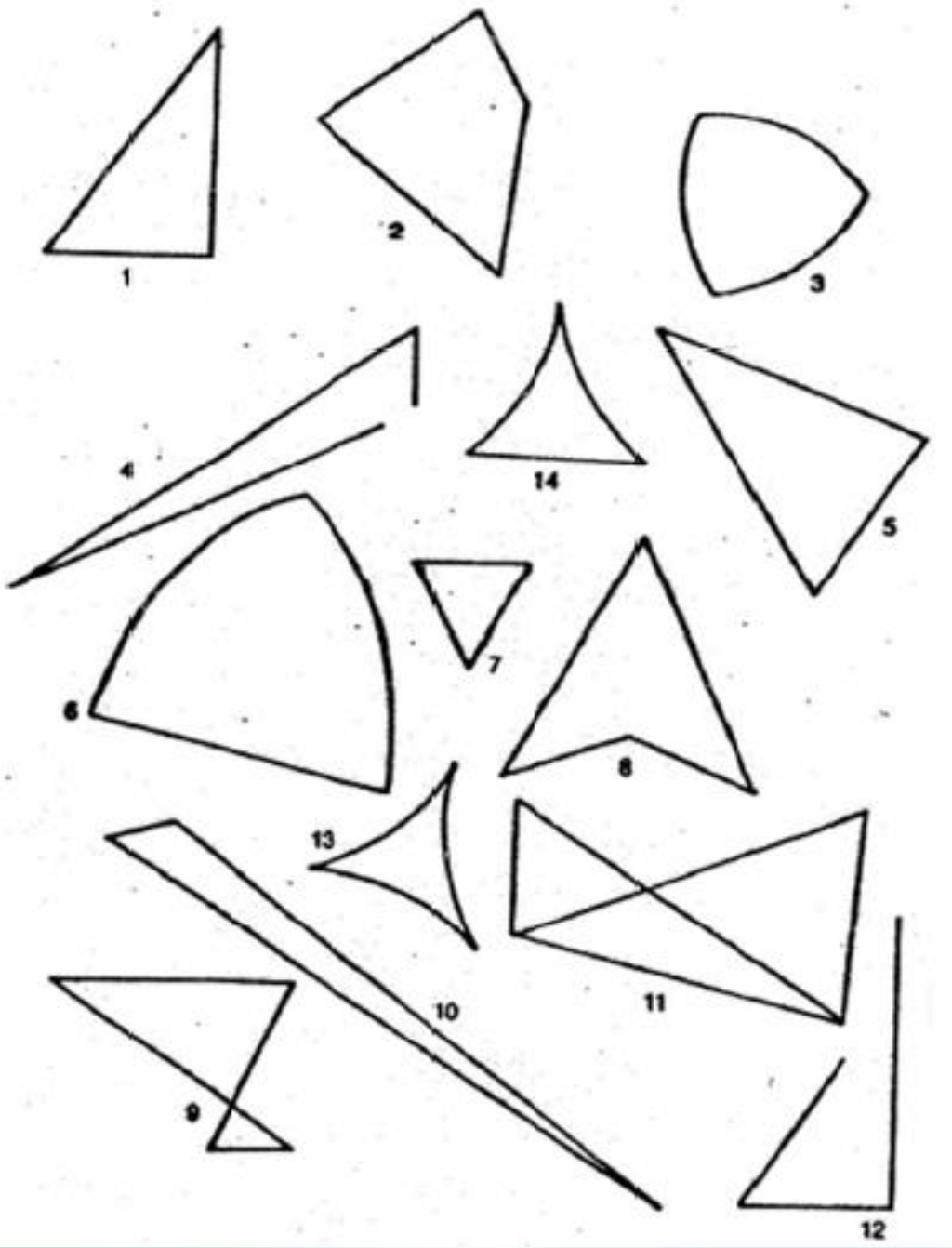
Understanding the definition of a triangle.

Performance task:

Draw a triangle.



Circle All the Triangles



Micromessages About Mathematics

- What do we model in our examples, homework and assessments?
- Do we vary our tasks/examples/use of notation to help prevent formation of common misconceptions?
- What opportunities do we give students to explicitly address common misconceptions?

2nd Semester Algebra 1 Students

Bart said, "$t + 3$ is less than $5 + t$."

Always true	Sometimes true	Never true
37.9%	47.3%	14.8%

Explain your answer.

- It depends on what *t* is. If *t* is a fraction (or negative) it could be anything.
- Only if *t* is like positive.
- If *t* is smaller than a certain # than it will be true if its not it won't be.
- You can move around addition problems.

Barbara Dougherty, July 2016

2nd Semester Algebra 1 Students

Bart said, "$t + 3$ is less than $5 + t$."

Student focus group feedback:
"You really need to talk to someone who knows math. The variable always comes first."

1. $3x + 5 = 17$
2. $5 + 3x = 17$
3. $y = mx + b$
4. $y = 3x + 5$

Linear regression: $y = a + bx$

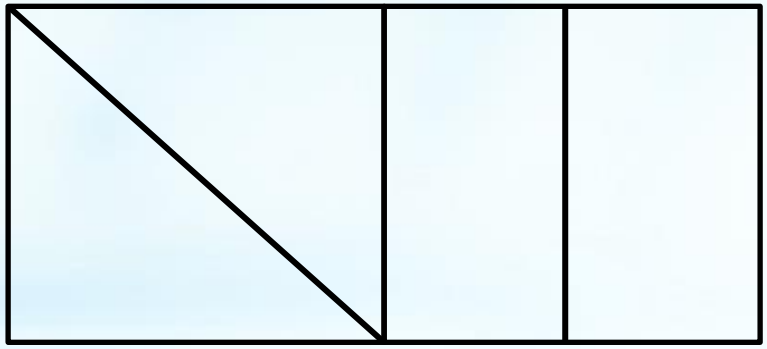
Barbara Dougherty, July 2016

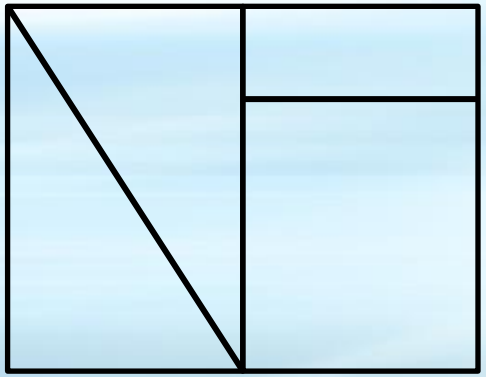
Be Cognizant of Your Messages

- Explicit messages
- Implicit micromessages
  - About mathematics concepts, procedures and symbols.
  - About each of your student's beliefs about his/herself as a learner and doer of mathematics.

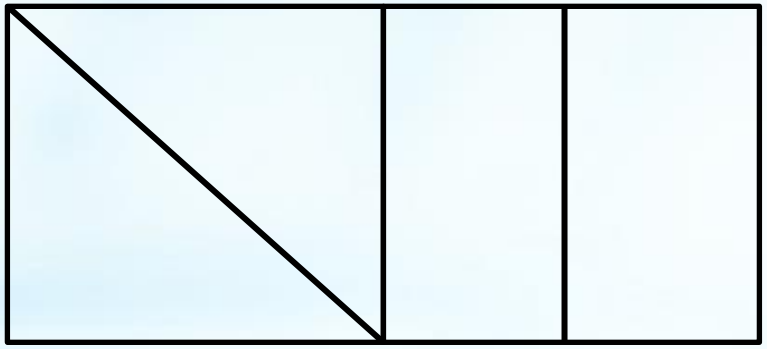
Partner with peers to uncover unintentional biases and messages!

Grade 2: Equal Partitions





Grade 2: Equal Partitions



Grade 6: Percents

Four of five dentists interviewed recommended Yukkey Gum. What percentage of the dentists interviewed did **not** recommend it?

Answer: 20%

Of means multiply, so I multiplied four times five and got 20 percent.

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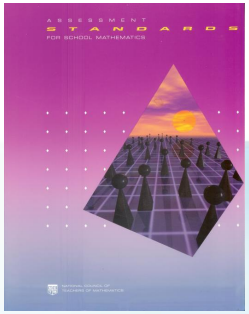

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Grade 6

6.G. Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems.

What tasks would you use to asses students' proficiency with this standard?

What Tasks Would You Use?

6.G. Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems.

- Compute area of different figures?
- Explain the relationship between the areas of different figures?
- Find a missing side of a rectangle or base/height of a triangle, given the area and another side?

What Tasks Would You Use?

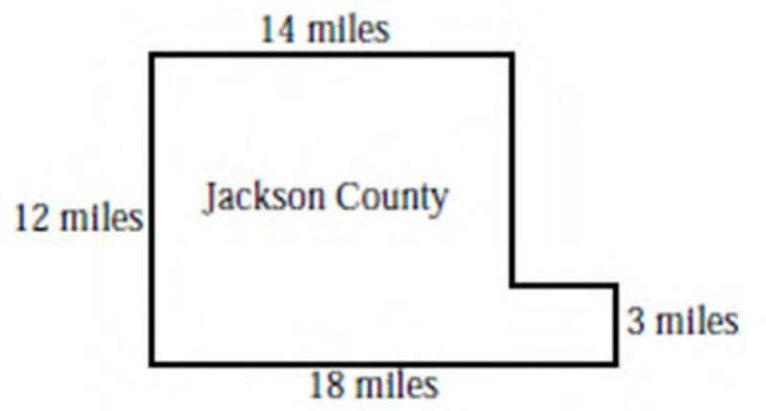
6.G. Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems.

- What applications?
- "A rectangular carpet is 12 feet long and 9 feet wide. What is the area of the carpet in square feet?"

County Concerns

1. The Jackson County Executive Board is considering a proposal to conduct aerial spraying of insecticides to control the mosquito population. An agricultural organization supports the plan because mosquitoes cause crop damage. An environmental group opposes the plan because of possible food contamination and other medical risks.

Here are some facts about the case:



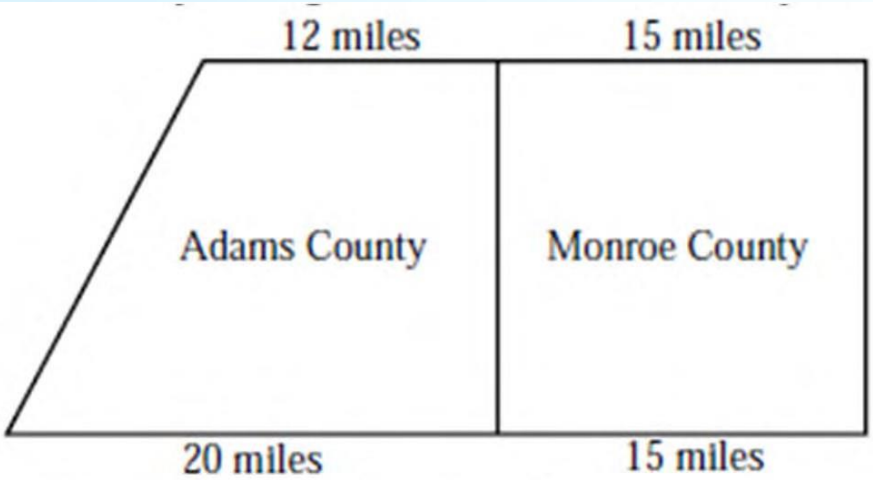
- A map of Jackson County is shown here.
- All county boundaries are on north–south line or an east–west line.
- The estimated annual cost of aerial spraying is $29 per acre.
- There are 640 acres in 1 square mile.
- Plan supporters cite a study stating that for every $1 spent on insecticides, farmers would gain $4 through increased agricultural production.

a. What is the area of Jackson County in square miles? In acres?
b. What would be the annual cost to spray the whole county?
c. According to plan supporters, how much money would the farmers gain from the spraying program?

County Concerns

2. The sheriff of Adams County and the sheriff of Monroe County are having an argument. They each believe that their own county is larger than the other county.

   Who is right? Write an explanation that would settle the argument.



All boundaries run directly north–south or east–west, except for the western boundary of Adams County.

Getting from Arithmetic to Algebra: Balanced Assessments for the Transition, Teachers College Press, 2012

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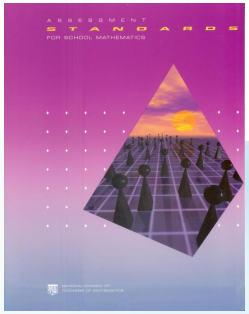

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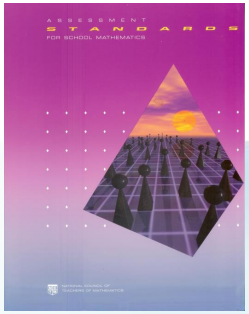

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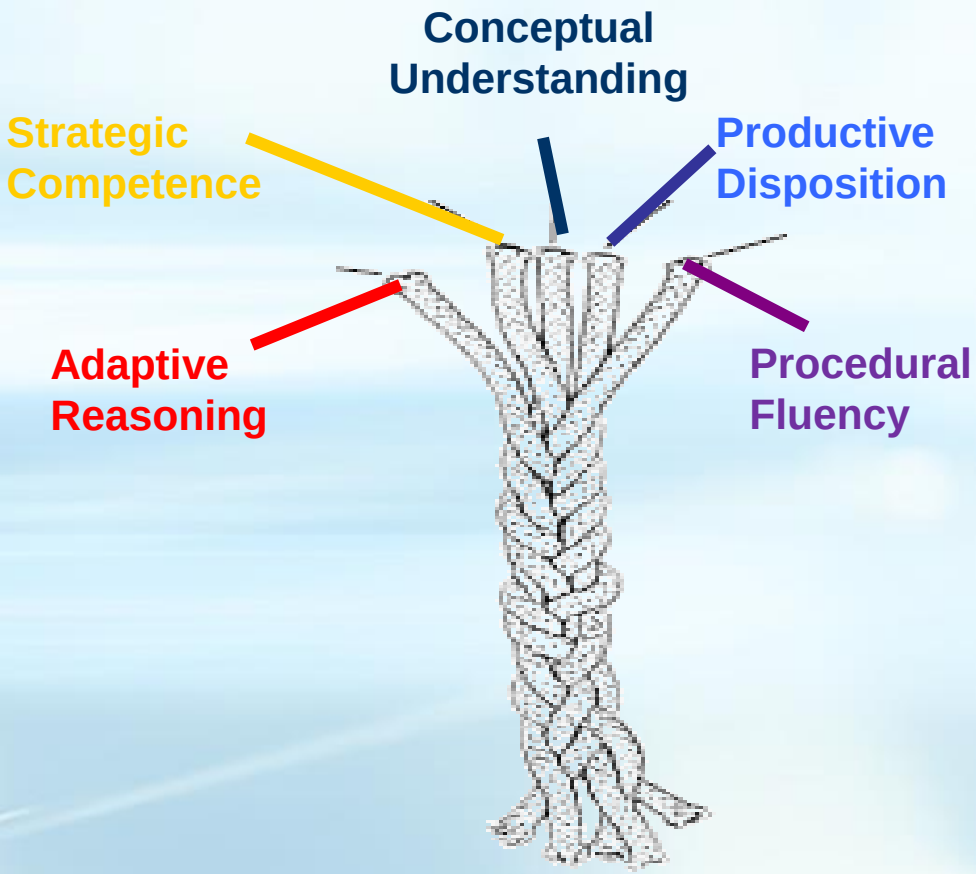
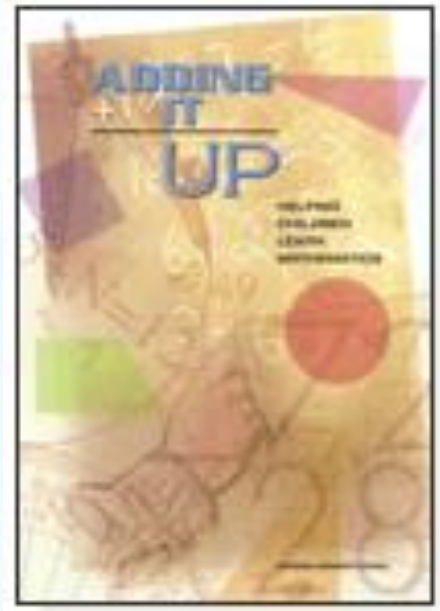
To what extent do your current assessments provide evidence about all the strands of proficiency?

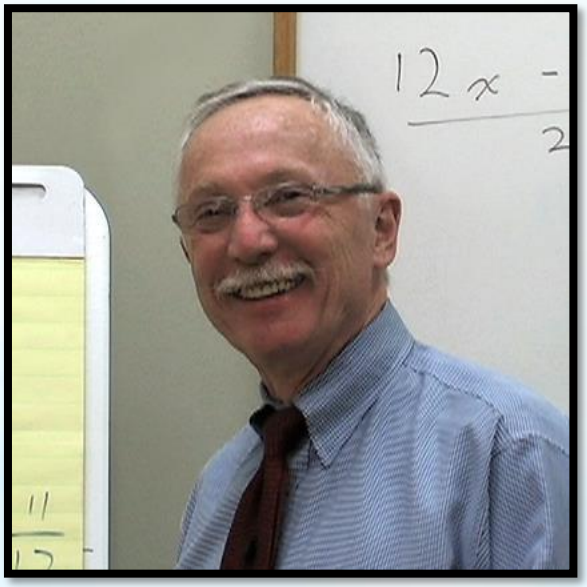




NRC (2001). *Adding It Up*. Washington, D.C.: National Academies Press.

Evaluating *Understanding*

"***Understand***" is intended to mean that students can explain the concept with mathematical reasoning including concrete illustrations, mathematical representations, and example applications.



Phil Daro, Author CCSS

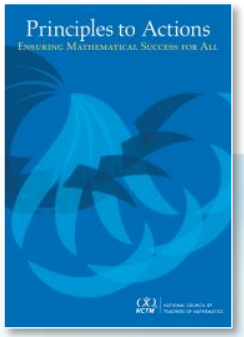
Making Sense of *Understanding*

Students who ***understand*** a concept can:

A. Use it to make sense of and explain quantitative situations (Model with Mathematics)
B. Incorporate it into their own arguments and use it to evaluate the arguments of others (Construct viable arguments and critique the reasoning of others)
C. Bring it to bear on the solutions to problems (Make sense of problems and persevere in solving them)
D. Make connections between it and related concepts

- Phil Daro

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS
CELEBRATING 100 YEARS

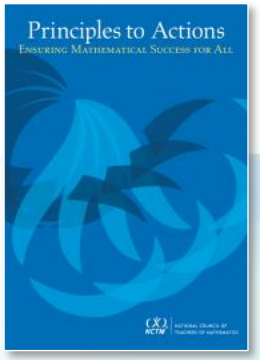


Principles to Actions: Ensuring Mathematical Success for All

Guiding Principles for School Mathematics

1. **Teaching and Learning**
2. **Access and Equity**
3. **Curriculum**
4. **Tools and Technology**
5. **Assessment**
6. **Professionalism**

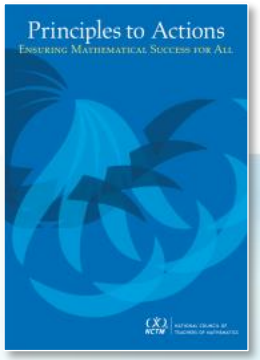
→ Essential Elements of Effective Math Programs



Assessment

An excellent mathematics program ensures that assessment is an integral part of instruction, ***provides evidence of proficiency with important mathematics content and practices****, includes a variety of strategies and data sources, and informs feedback to students, instructional decisions and program improvement.*

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS
CELEBRATING 100 YEARS



Professionalism

In an excellent mathematics program, educators hold themselves and their colleagues accountable for the mathematical success of every student and for their personal and **collective professional growth** toward effective teaching and learning of mathematics.

Collaborative Team Work

- An examination and prioritization of the mathematics content and mathematics practices students are to learn.
- **The development and use of common assessments to determine if students have learned the agreed-on content and related mathematical practices.**
- **The use of data to drive continuous reflection and instructional decisions.**
- The setting of both long-term and short-term instructional goals.
- **Development of action plans to implement when students demonstrate they have or have not yet attained the standards.**
- Discussion, selection, and implementation of common research-informed instructional strategies and plans.

Principles to Actions, pp. 103-104

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS
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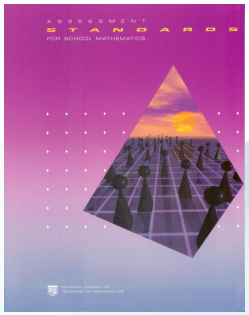
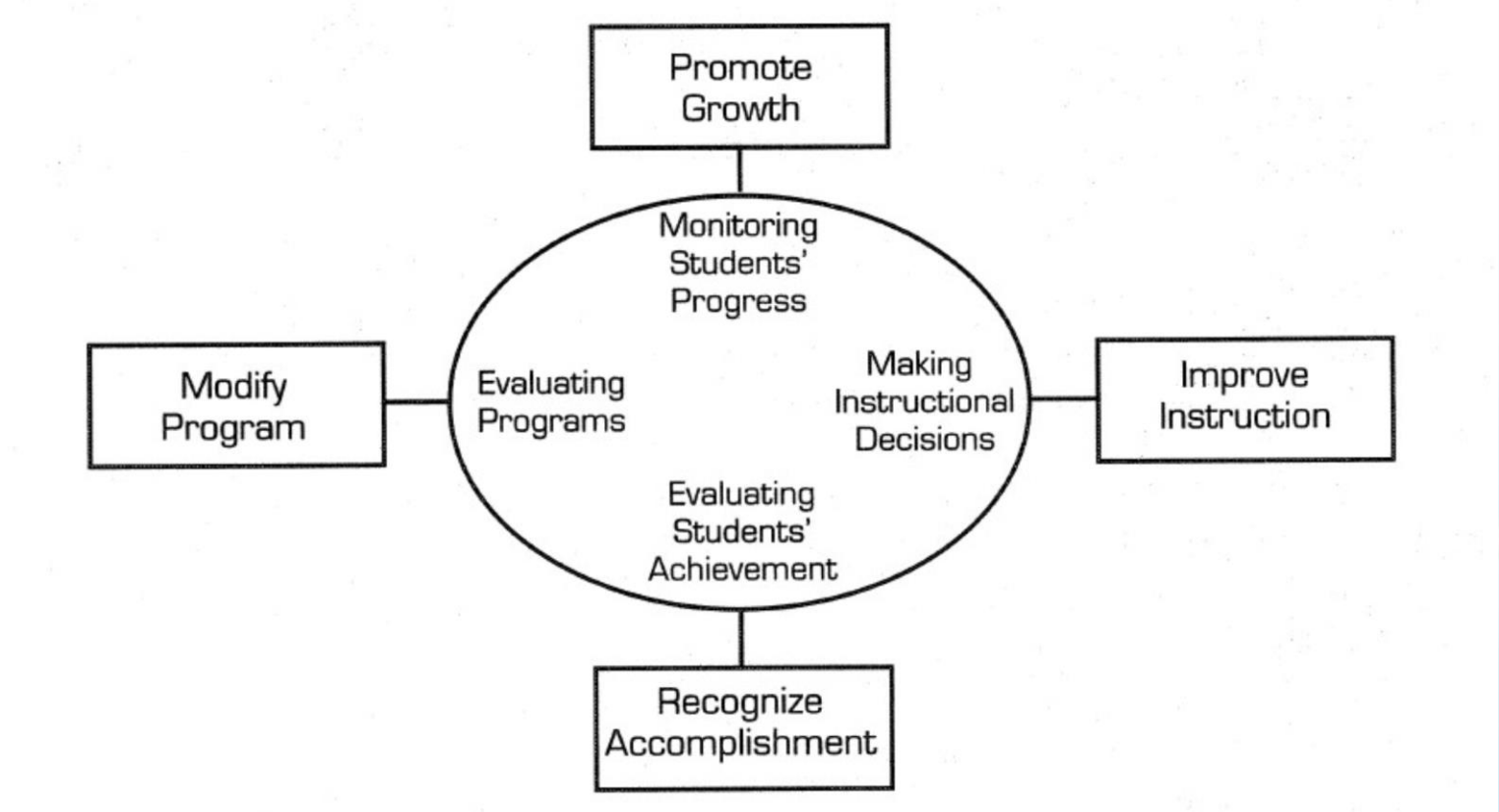


Assessment Standards for School Mathematics

Four Purposes of Assessment and Their Results



Formative Assessment

[Hattie (2009)] found formative assessment and the related strategies of self-assessment and feedback to be ranked in the top 10 of the 138 interventions examined . . . Further . . . not only are the gains associated with formative assessment use larger than most instructional innovation strategies . . . this process has also been found to be particularly helpful for students who have previously struggled (Wiliam, 1989), and appears to produce learning that is sustained over extended periods of time (Wiliam, 2005).

Sliver & Mills, NCTM, 2018

CCSSO State Collaborative on Assessment and Student Standards

2006

Formative assessment is a process used by teachers and students during instruction that provides feedback to adjust ongoing teaching and learning to improve students' achievement of intended instructional outcomes.

2017

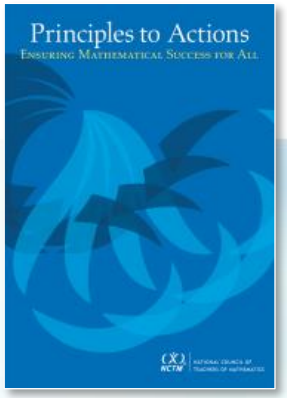
Formative assessment is a planned, ongoing process used by all students and teachers to improve student understanding of intended disciplinary outcomes, supporting students becoming more self-directed learners.

Effective use of the formative assessment process requires students and teachers to integrate the following practices:

- Clarifying learning targets with a broader progression of learning;
- Eliciting and analyzing evidence of student understanding;
- Engaging in self-assessment, self-reflection, and peer assessment;
- Providing actionable feedback; and
- Using evidence and feed back to move learning forward by adjusting either learning strategies or next instructional steps.

Silver & Mills, NCTM, 2018

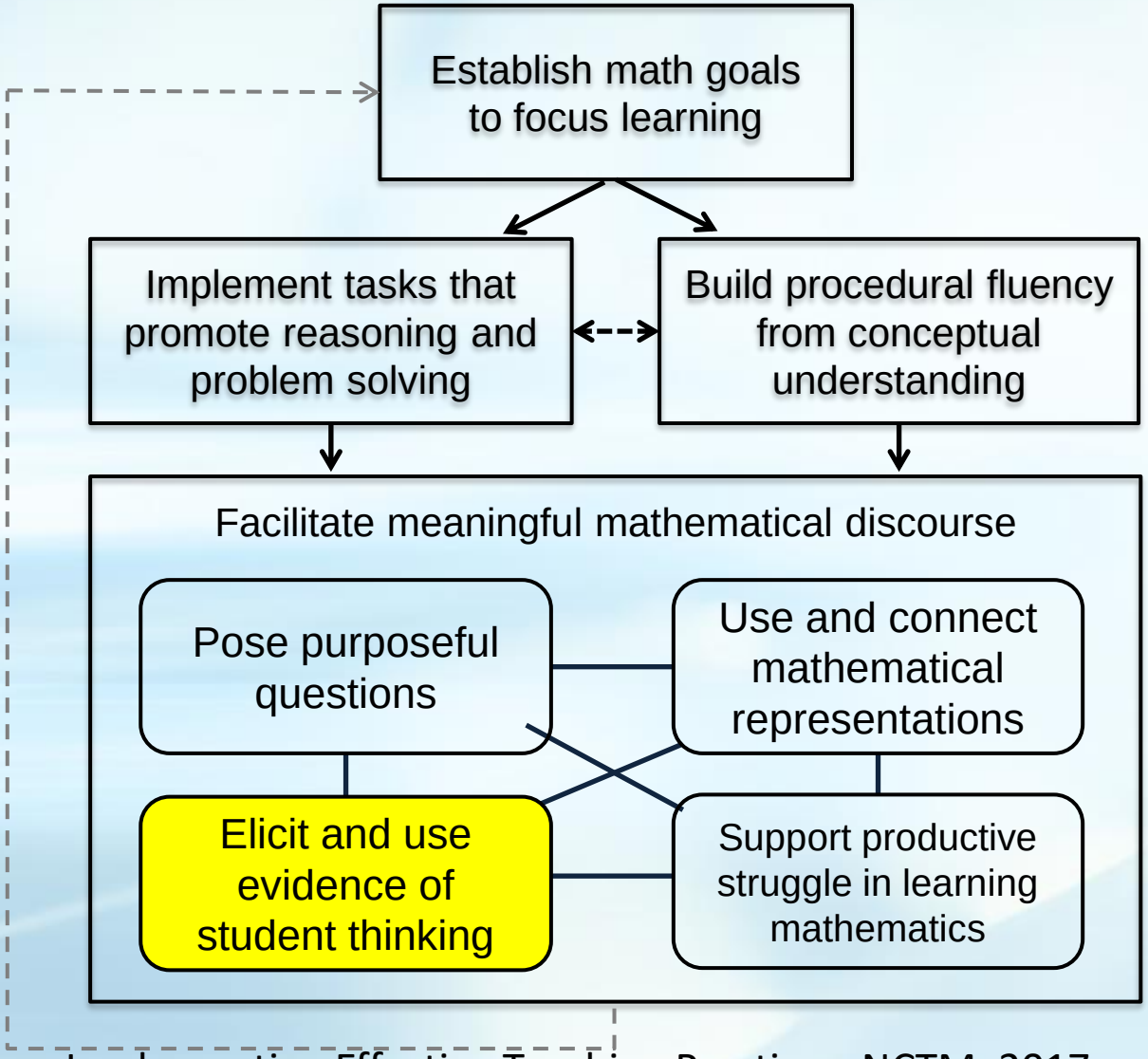
NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS
CELEBRATING 100 YEARS



Effective Mathematics Teaching Practices

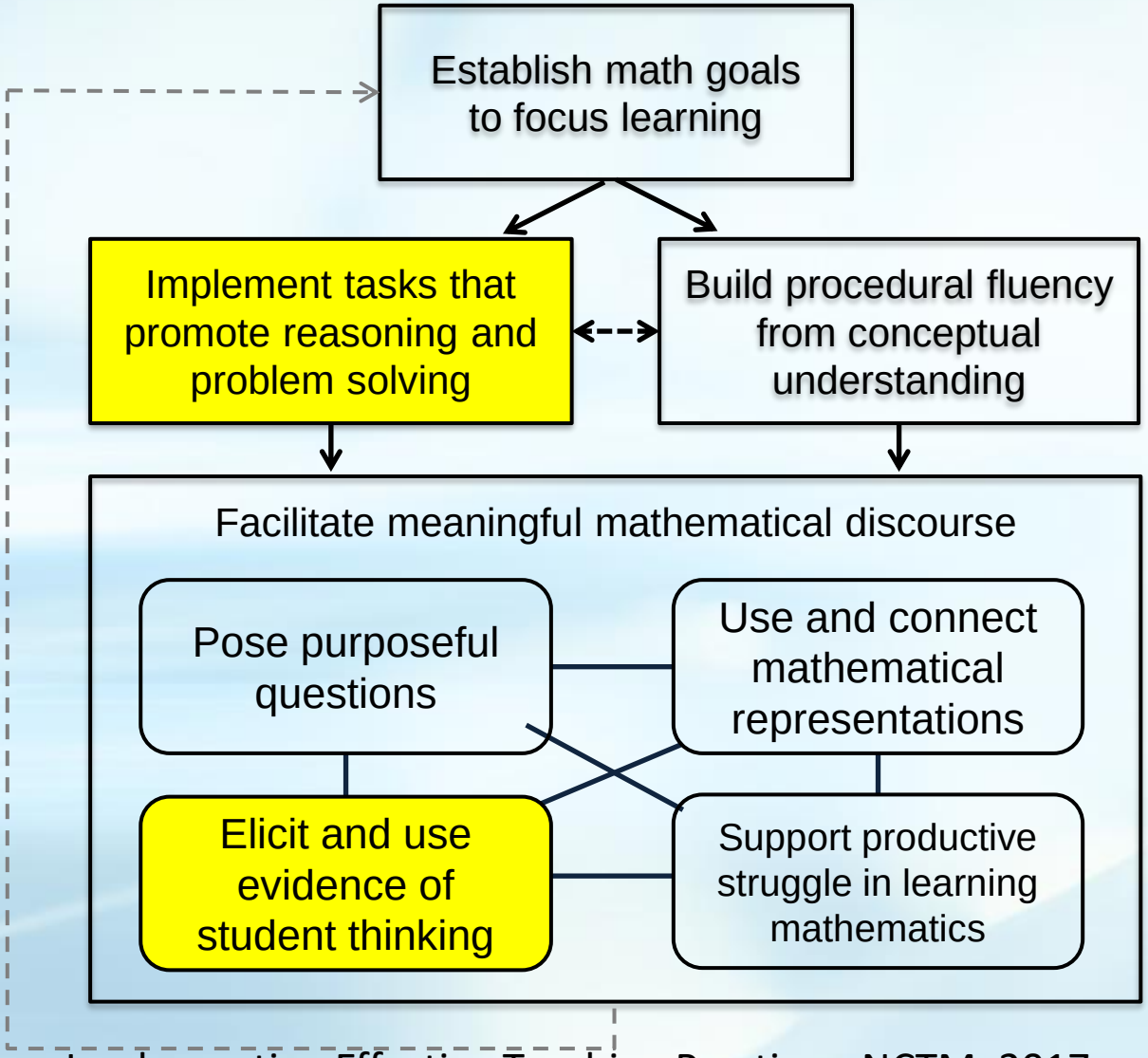
1. Establish mathematics **goals** to focus learning.
2. Implement **tasks** that promote reasoning and problem solving.
3. Use and connect mathematical **representations.**
4. Facilitate meaningful mathematical **discourse**.
5. Pose purposeful **questions**.
6. Build **procedural fluency** from conceptual understanding.
7. Support **productive struggle** in learning mathematics.
8. **Elicit and use evidence** of student thinking.

Effective Mathematics Teaching Practices



Taking Action: Implementing Effective Teaching Practices, NCTM, 2017

Effective Mathematics Teaching Practices



Taking Action: Implementing Effective Teaching Practices, NCTM, 2017

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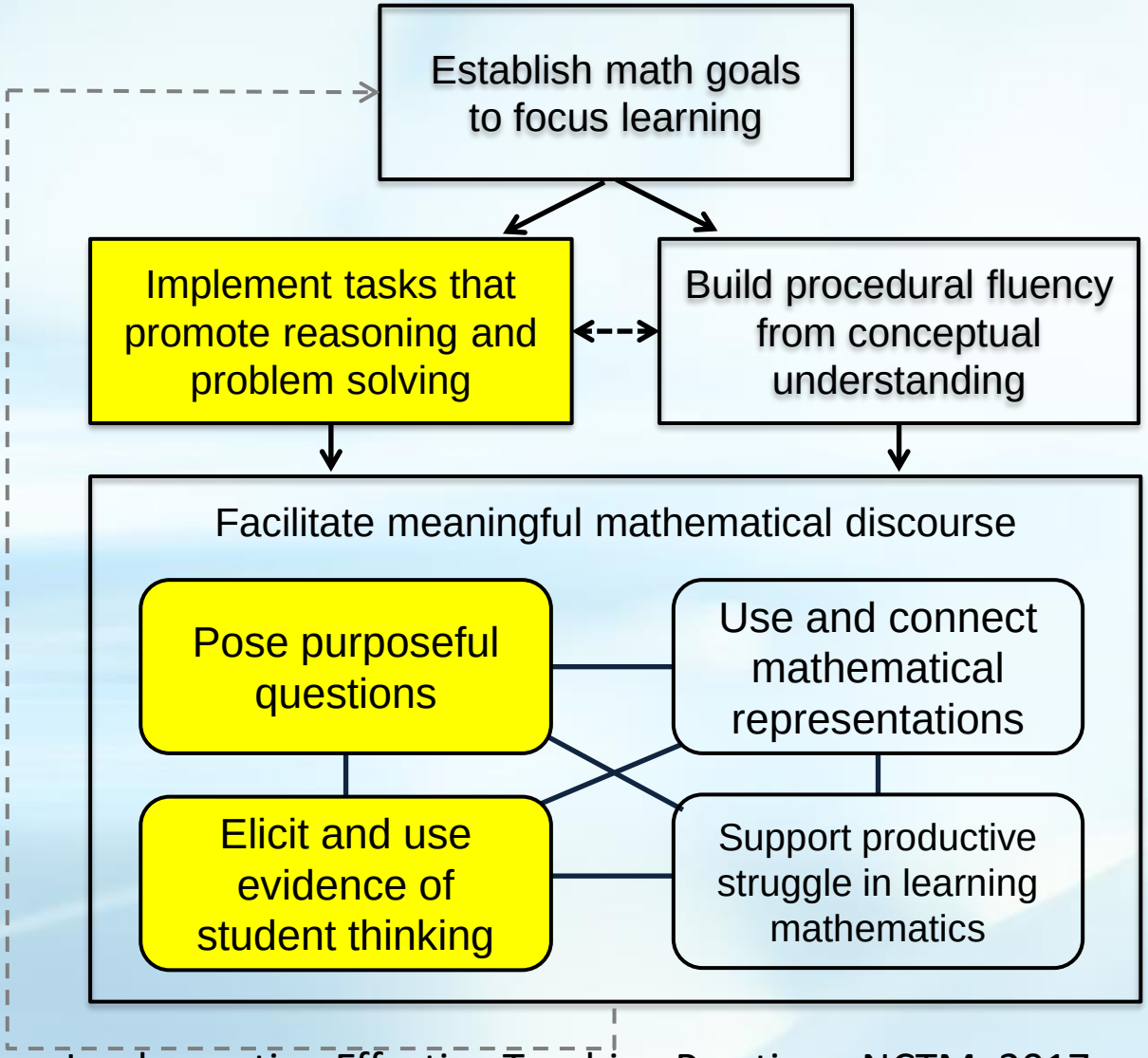
Effective Mathematics Teaching Practices



Taking Action: Implementing Effective Teaching Practices, NCTM, 2017

NATIONAL TEACHERS CELEBRATING

Four Situations

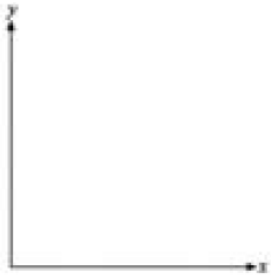
1. Sketch a graph to model each of the following situations.
   Think about the shape of the graph and whether it should be a continuous line or not.

A: Candle

Each hour a candle burns down the same amount.

x = the number of hours that have elapsed.

y = the height of the candle in inches.

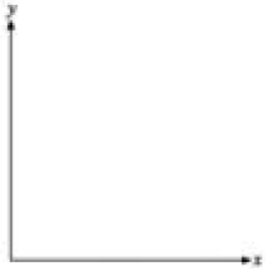


B: Letter

When sending a letter, you pay quite a lot for letters weighing up to an ounce. You then pay a smaller, fixed amount for each additional ounce (or part of an ounce.)

x = the weight of the letter in ounces.

y = the cost of sending the letter in cents.

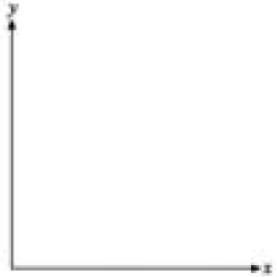


C: Bus

A group of people rent a bus for a day. The total cost of the bus is shared equally among the passengers.

x = the number of passengers.

y = the cost for each passenger in dollars.

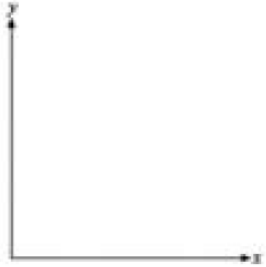


D: Car value

My car loses about half of its value each year.

x = the time that has elapsed in years.

y = the value of my car in dollars.



Boston, et al.
NCTM, 2017

Solve the Four Situations Task

1. Why is this task appropriate for eliciting evidence of student thinking?
2. What mathematical understanding might the task reveal?
3. What misconceptions might the task reveal?

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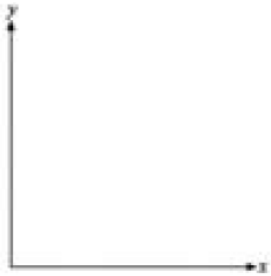

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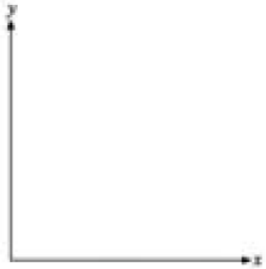

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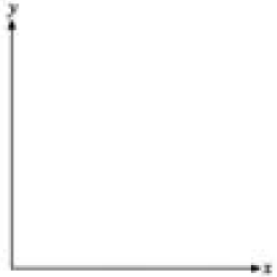

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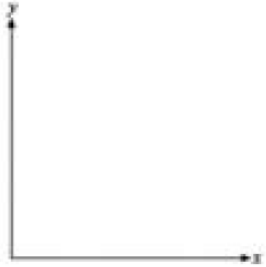

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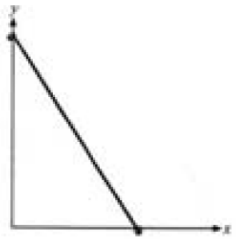

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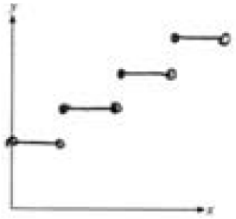

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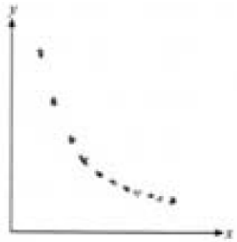

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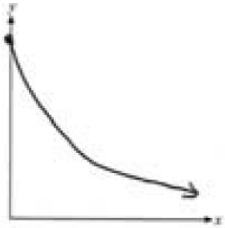

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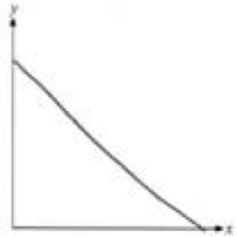

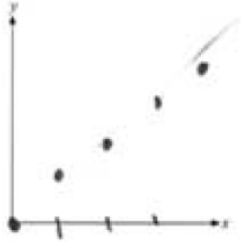

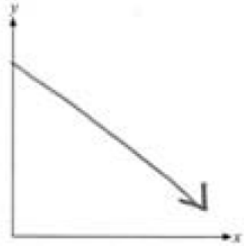

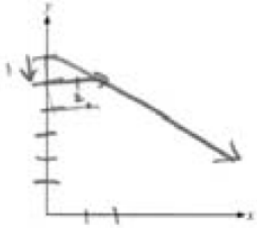

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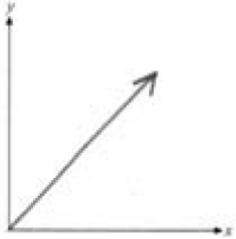

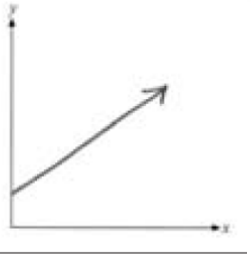

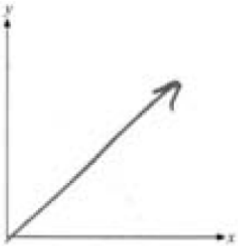

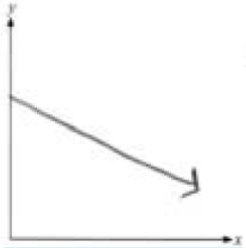

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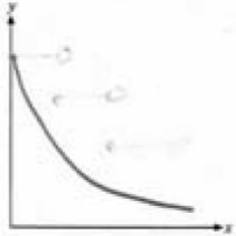
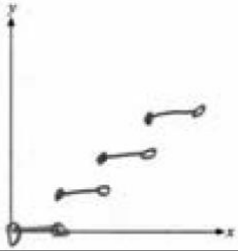
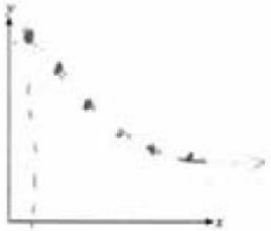
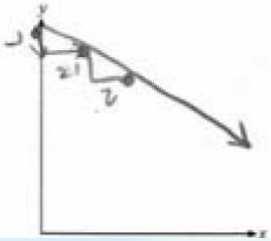


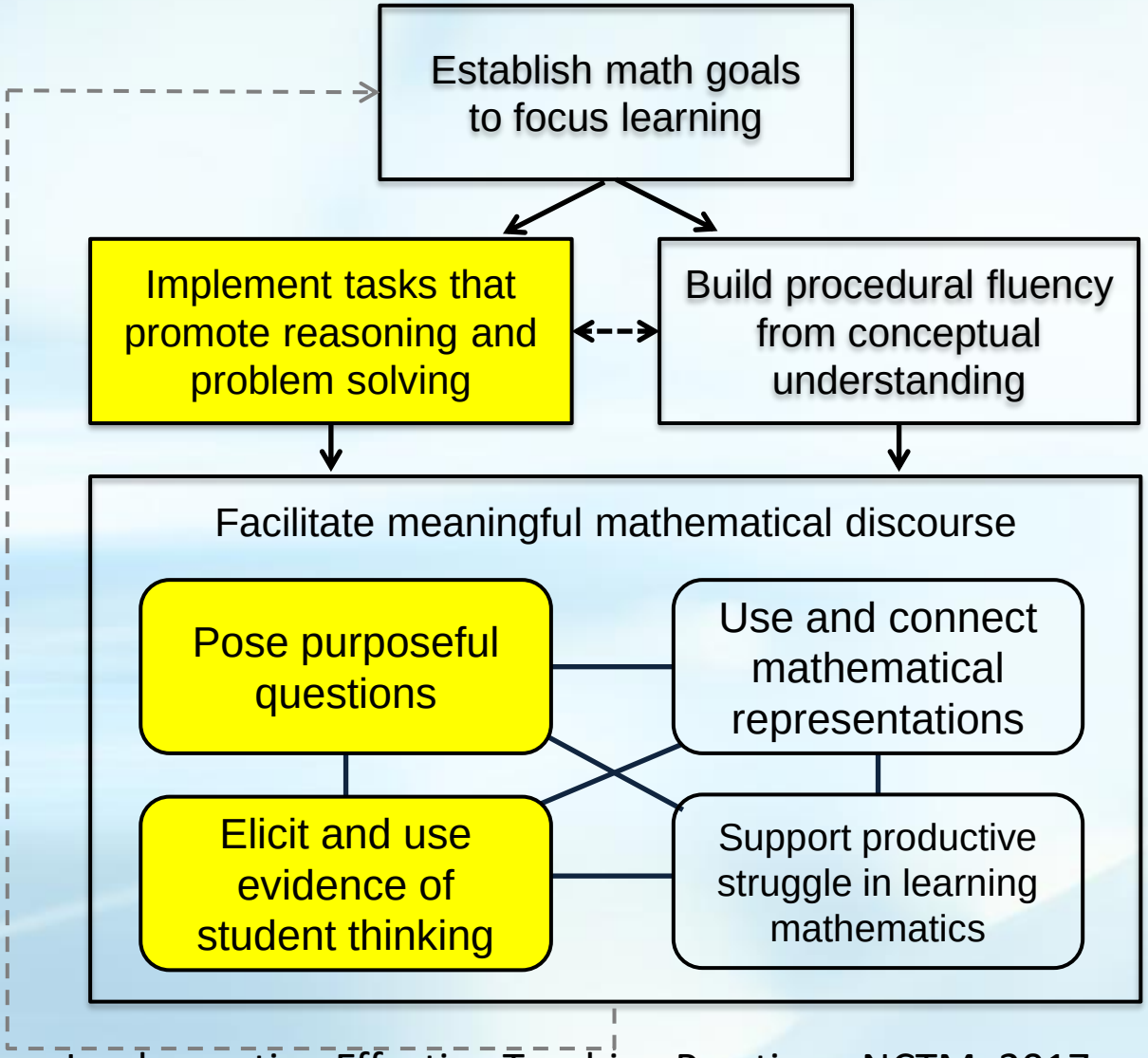






NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS
CELEBRATING 100 YEARS

Effective Mathematics Teaching Practices



Taking Action: Implementing Effective Teaching Practices, NCTM, 2017

Formative Assessment Strategies

- Effective questioning during small group and whole-class discussions
- Making students' responses visible:
  - Mini or large whiteboard responses for individual and/or small-group discourse
  - All-student response systems such as SMART boards
- Traffic lights or red and green disks for students' responses and/or to indicate understanding
- Exit slips and warm-ups, with discussion of selected misconceptions (e.g., "My Favorite *No*").
- Partner discussion, e.g., homework review.

Adapted from Wiliam (2011)

Use On-Going Distributive Practice for Formative Assessment

Staying Sharp 12

Practicing algebra skills

1. The following points are on the graph of a particular line: $(-2,6)$, $(0,5)$, $(2,4)$, $(6,2)$, $(8,1)$, $(10,0)$, $(12,-1)$. What is the y-intercept of the line?

   Answer with supporting work:

2. Complete four rows of an x-y table for the following function: $y = 2x + 7$

x	y

Previewing upcoming learning

3. Bobby and Billy sit on one side of a seesaw. When their older brother, Adam, who weighs 110 pounds, sits on the other side, the seesaw tilts down on Adam's side. What can you conclude about Bobby and Billy's combined weight? What can you conclude about their individual weights?

   Answer with explanation

4. Adam sits on one side of a seesaw; his twin brothers sit on the other side; the seesaw is perfectly balanced. Then, the twins sit on one side and Mr. Howard and his dog sit on the other side; the scale again is perfectly balanced. What will happen if Adam sits on one side of the seesaw and Mr. Howard and his dog sit on the other?

   Answer with explanation:

Reviewing prealgebra skills

5. Polygon DEFGH is a regular pentagon. If the sum of all of the interior angles is $540°$, what is the measure of $\angle E$?

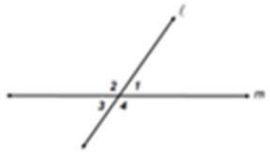
   Answer with supporting work:

6. In the diagram shown below, line ℓ intersects line m. If the measure of $\angle 1$ is $70°$, find:

   $m\angle 2 =$ ____

   $m\angle 3 =$ ____

   $m\angle 4 =$ ____

From *Intensified Algebra*, Agile Mind

ESSA

Requires that state assessments

- Be aligned to the challenging State academic content standards;
- Address the depth and breadth of those standards; all of a state's standards be assessed.

Does not require that tests include performance assessments.

Allows states to use "nationally recognized high school assessments" (SAT, ACT) as part of their assessment system.

- Design to distinguish students; not measure proficiency
- Lack of performance assessment; not assessing mathematical processes/practices

What about "Test-Prep"?

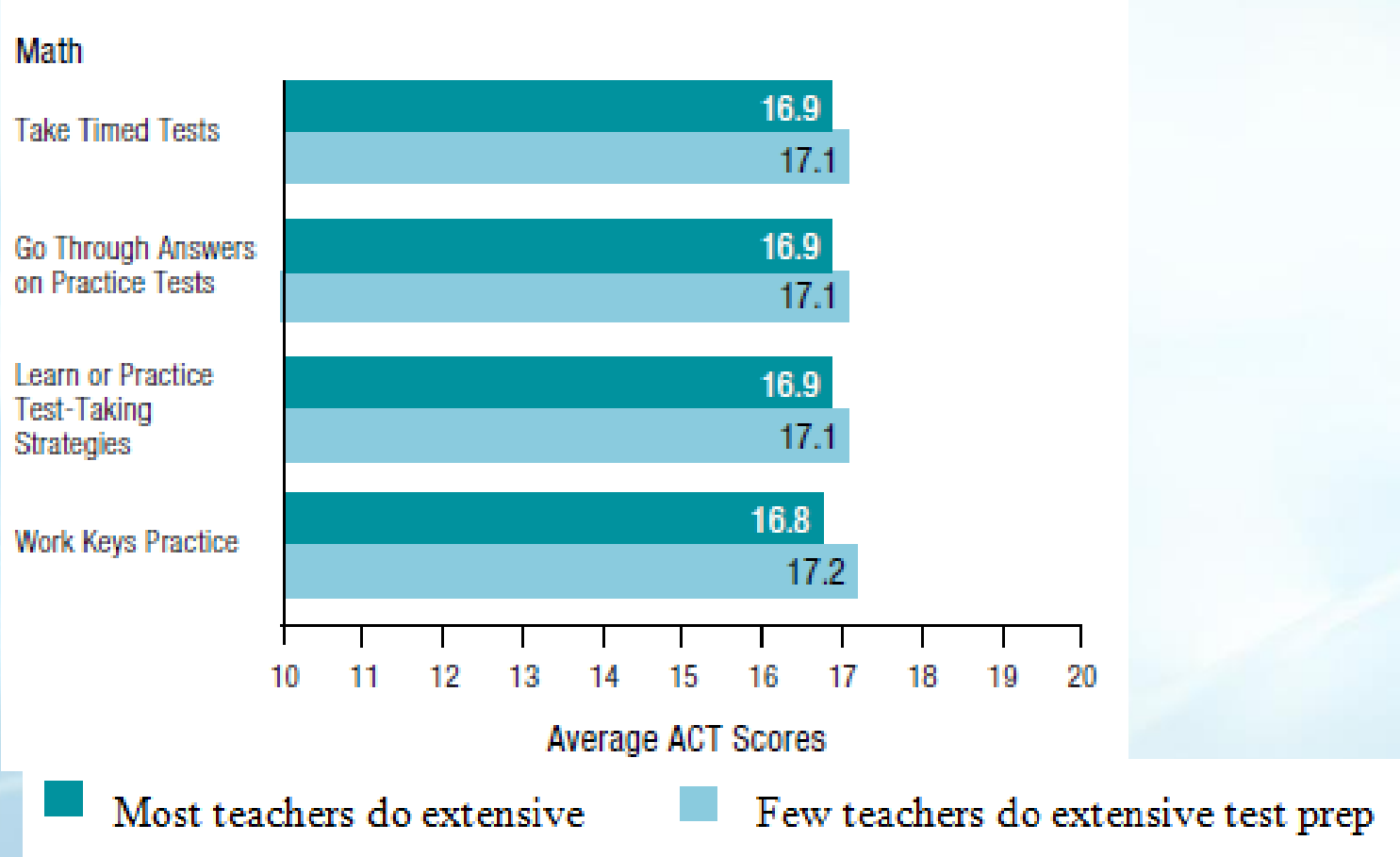
Too often, teachers are putting regular instruction "on hold" to spend class time practicing test questions. While on the surface this may appear to make sense, research indicates just the opposite—

test scores are lower in schools where teachers spend large amounts of time on test prep.

(Allensworth, Correa, & Ponisciak, 2008)

Intensive Test Prep Produces the Same or Lower Scores as Little or No Test Prep

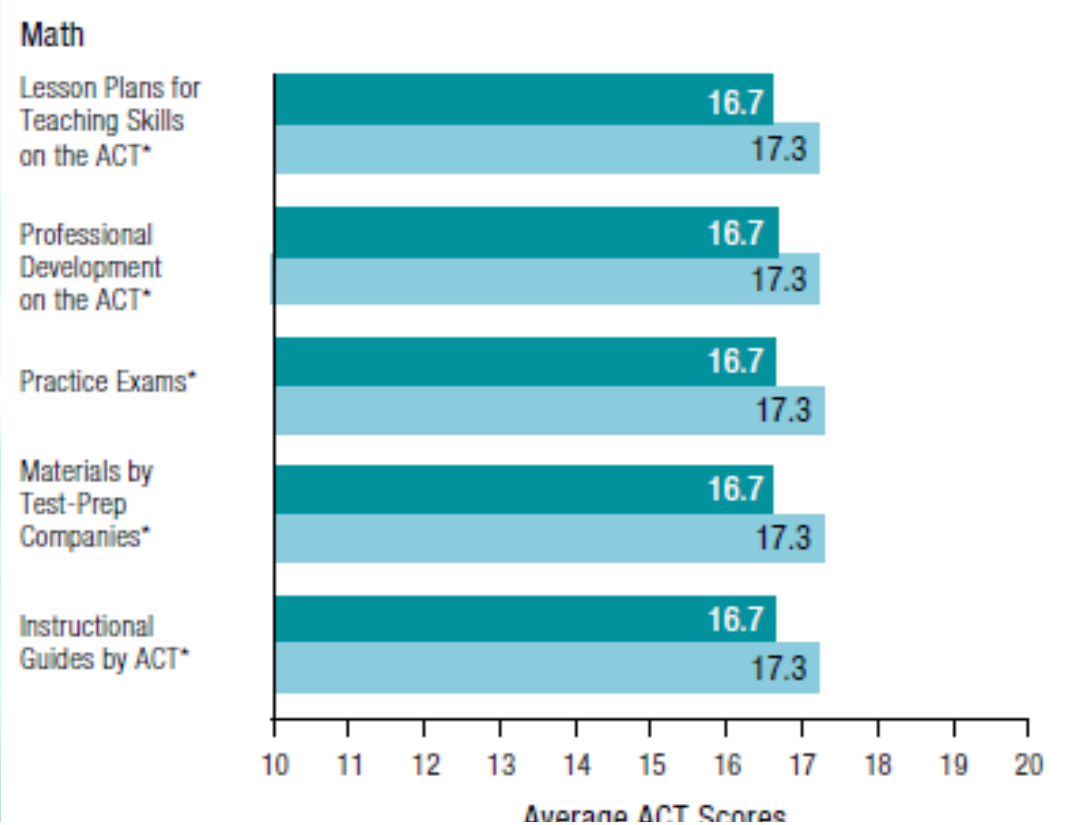
All Test-Prep



(Allensworth, Correa, & Ponisciak, 2008)

Intensive Test Prep Produces the Same or Lower Scores as Little or No Test Prep

ACT Test-Prep Materials



Most teachers do extensive

Few teachers do extensive test prep

(Allensworth, Correa, & Ponisciak, 2008)

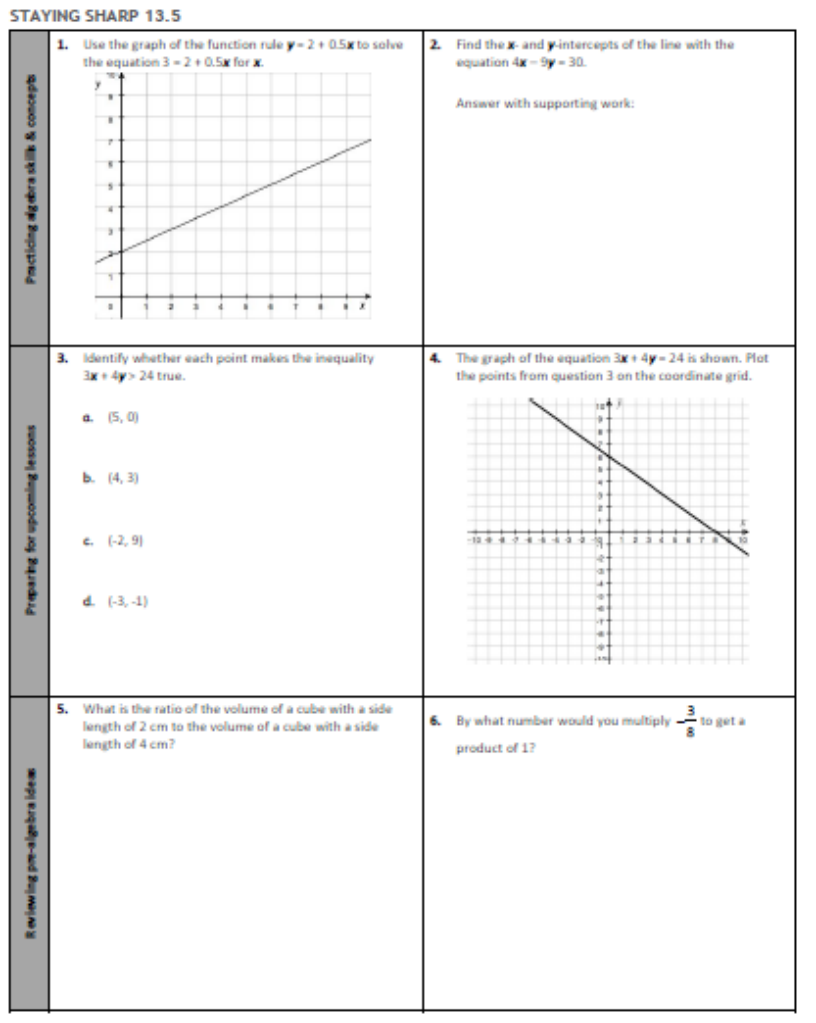
Effective Assessment Practice
Ongoing Review and Practice

Providing students with periodic opportunities to practice using concepts and skills, along with feedback about their performance, helps students solidify their knowledge and promotes retention, reflection, generalization, and transfer of knowledge and skill.

IES Practice Guide, 2007

Distributed Practice

- Openers
- Homework
- Incorporate into instructional and/or assessment tasks



STAYING SHARP 13.5

Practicing algebra skills & concepts

1. Use the graph of the function rule $y = 2 + 0.5x$ to solve the equation $3 = 2 + 0.5x$ for x.

2. Find the x- and y-intercepts of the line with the equation $4x - 9y = 30$.

   Answer with supporting work:

Preparing for upcoming lessons

3. Identify whether each point makes the inequality $3x + 4y > 24$ true.

   a. (5, 0)

   b. (4, 3)

   c. (-2, 9)

   d. (-3, -1)

4. The graph of the equation $3x + 4y = 24$ is shown. Plot the points from question 3 on the coordinate grid.

Reviewing pre-algebra ideas

5. What is the ratio of the volume of a cube with a side length of 2 cm to the volume of a cube with a side length of 4 cm?

6. By what number would you multiply $\frac{3}{8}$ to get a product of 1?

Good Instruction is the Best Test-Prep

- Students acquire conceptual knowledge as well as skills to enable them to organize their knowledge, transfer knowledge to new situations, and acquire new knowledge.
- Students engage with challenging tasks that involve active meaning-making.
- Students know what is expected

Hiebert & Grouws, 2007

What Have We Learned?

- How to design and score high quality assessment items that assess all aspects of mathematical proficiency.
  - Large banks of high quality performance items

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Mathematics Assessment Project
http://map.mathshell.org/

Mathematics Assessment Project

ASSESSING 21ST CENTURY MATH

Welcome to the Mathematics Assessment Project

Home | About | News | Lessons | Tasks | Tests | PD Modules | TRU Framework | Standards

The Mathematics Assessment Project is part of the Math Design Collaborative initiated by the Bill & Melinda Gates Foundation. The project set out to design and develop well-engineered tools for formative and summative assessment that expose students' mathematical knowledge and reasoning, helping teachers guide them towards improvement and monitor progress. The tools are relevant to any curriculum that seeks to deepen students' understanding of mathematical concepts and develop their ability to apply that knowledge to non-routine problems.

More about the Math Assessment Project

Lessons

Formative Assessment Lessons: *Classroom Challenges*

100 lessons for formative assessment, some focused on developing math concepts, others on solving non-routine problems. A Brief Guide for teachers and administrators (PDF) is recommended reading before using these lessons for the first time.

Tasks

Summative Assessment Tasks

A set of 94 exemplar summative assessment tasks to illustrate the range of performance goals required by CCSSM. The tasks come with scoring rubrics and examples of scored student work.

Tests

Prototype Tests

Complete summative test forms and rubrics designed to help teachers and students monitor their progress using a range of task types similar to the 'Tasks' section.

PD Modules

Professional Development Modules

5 Prototype modules that encourage groups of teachers to explore the practical and pedagogical concepts behind the

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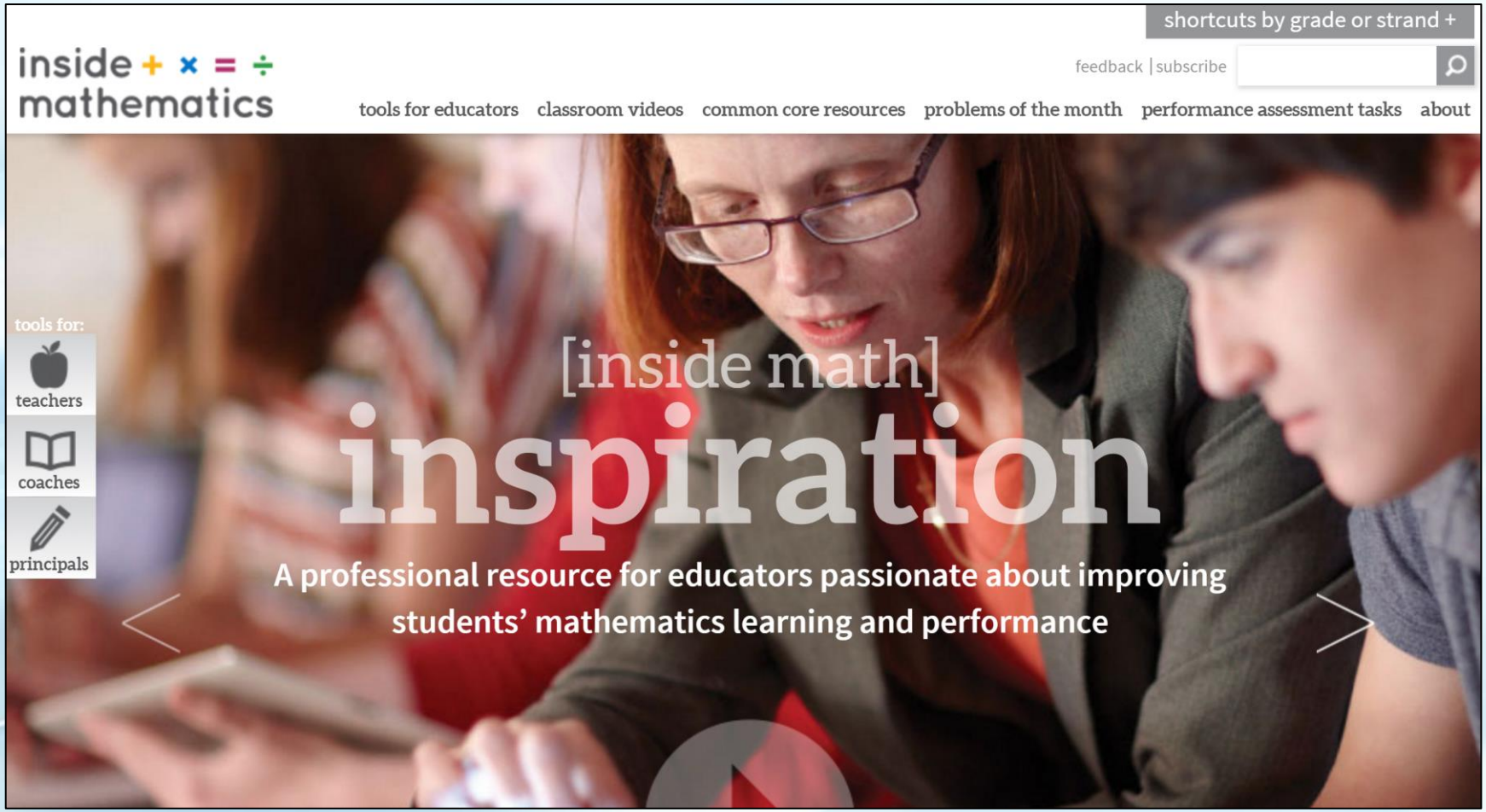
Inside Mathematics

http://www.insidemathematics.org/



Additional Assessment Resources include:

- Released NAEP items
- Released PISA & TIMSS items
- Released state assessment items
- Balanced Assessment Project
- Silicon Valley Mathematics Initiative
- Smarter Balanced Assessment Consortium
- NCTM and NCSM publications

What Have We Learned?

- How to design and score high quality assessment items that assess all aspects of mathematical proficiency.
  - Large banks of high quality performance items
- We need increased emphasis on assessing conceptual understanding and mathematical processes (SMPs) in addition to procedural skills.
- On-going review and practice is more effective than suspending new learning before a high stakes test to practice test content (“test-prep”).
- The strong positive effects of high quality formative assessment on student achievement.
- The value of teacher collaboration in the assessment process.
- We need to continue to emphasize using assessment policies and practices to promote, not undermine, high levels of mathematics learning by each and every student.

Educational assessments should be coupled with a schooling purpose that emphasizes more human capacity building rather than sorting and selecting. The thrust here is that it is a societal good to foster extensive, high-level knowledge, skills and abilities in intellectual, technical, and civic participation domains, for successive cohorts of the American population. And in turn, assessments should function principally to help actualize such human capital production.

A.Wade Boykin (2014)

Cited in Strutchens & Silver, 2018

Thank You!

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