SUPPORTING THE HIGH QUALITY TEACHING OF MATHEMATICS:

BALANCING THE EQUATION

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THE CHALLENGE

1. Every student (and every parent) in this country should be able to expect that the student will have consistent opportunities to develop mathematical skillfulness in school.
2. This depends on high quality teaching skill.
3. Getting that kind of teaching skill is not something that can be developed individually, one teacher or school at a time. Professionalism means having shared practice, standards of skill, and norms for high quality work.

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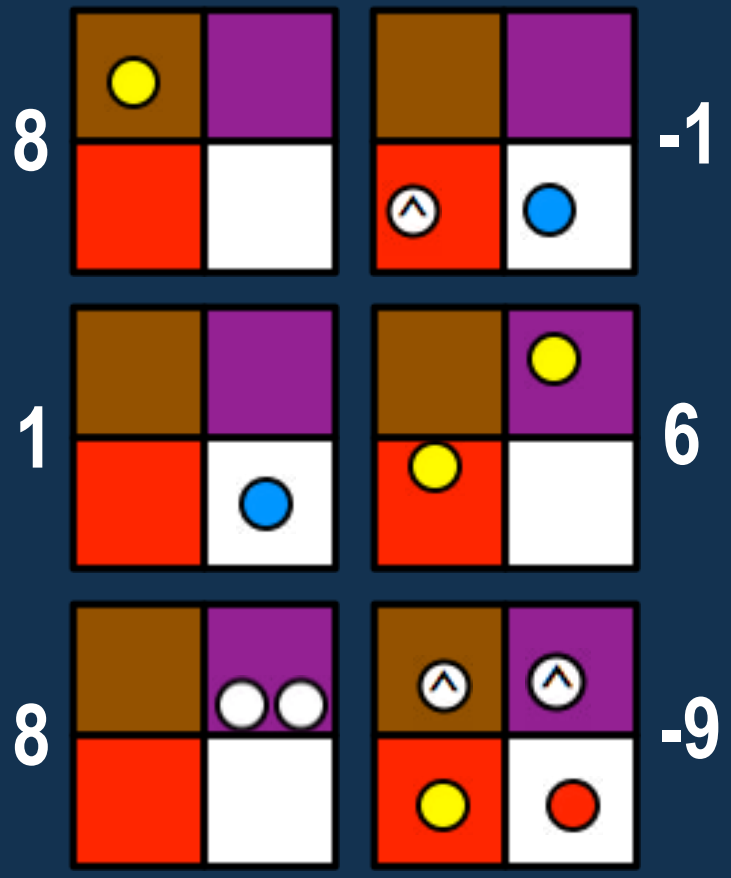
What does it mean to be "mathematically skillful"?

THE MINICOMPUTER



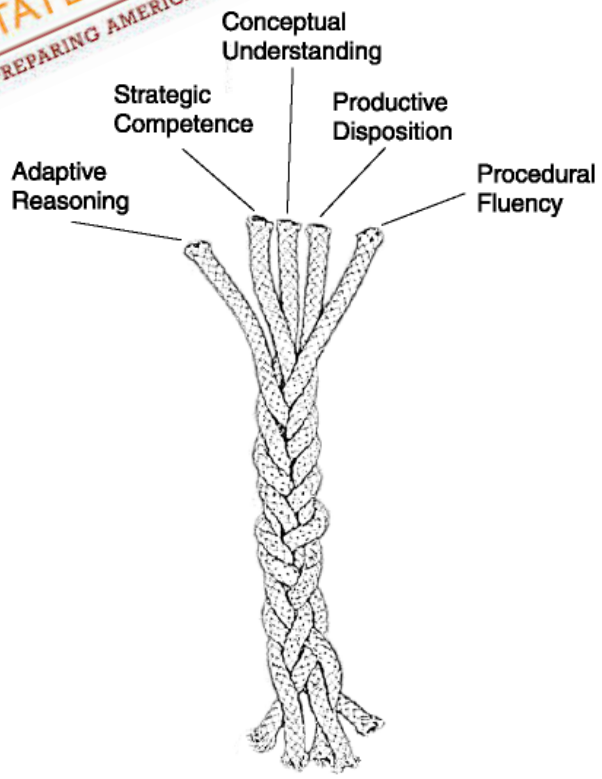
(Papy Minicomputer)

WHAT IS THIS PROBLEM ASKING, AND WHAT IS INVOLVED IN TRYING TO SOLVE IT?

Using exactly one positive and one negative checker, find all the numbers that can be represented on this minicomputer board.

Prove your answer and explain why.

STRANDS OF MATHEMATICAL PROFICIENCY



Intertwined Strands of Proficiency

- ***Conceptual understanding*** - comprehension of mathematical concepts, operations, and relations
- ***Procedural fluency*** - skill in carrying out procedures flexibly, accurately, efficiently, and appropriately
- ***Strategic competence*** - ability to formulate, represent, and solve mathematical problems
- ***Adaptive reasoning*** - capacity for logical thought, reflection, explanation, and justification
- ***Productive disposition*** - habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy

Kilpatrick, J., J. Swafford, and B. Findell. (2001). *Adding It Up: How Children Learn Mathematics*. Washington, DC: National Academy Press.

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THE COMMON CORE:
WHAT IS ENTAILED IN BEING MATHEMATICALLY SKILLFUL?

CONCEPTS AND PROCEDURES	MATHEMATICAL PRACTICES
▪ Understanding of operations (+, x) ▪ Fluency with whole number computational skills (+, x) ▪ Multi-digit computation ▪ Understanding of mathematical structure	▪ Making sense of and interpreting problems ▪ Representing mathematical ideas in strategic ways ▪ Persevering with complex mathematical problems ▪ Constructing mathematical arguments ▪ Looking for and using regularity in mathematical reasoning ▪ Looking for and making use of mathematical structure

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TEACHING AS A COMPLEX BALANCING ACT

Teaching all students to become mathematically skillful entails balancing three traditional dualities:

1. Focus on mathematical concepts and procedures AND mathematical practices
2. Teach in ways that are both teacher-directed AND student-centered
3. Work to fill students' gaps AND to accelerate their capabilities with complex mathematical work

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HIGH-LEVERAGE INSTRUCTIONAL PRACTICES

High-leverage practices (HLPs) are instructional tasks and activities that powerfully promote learning and are fundamental to skillful teaching.

Based on work done at the University of Michigan School of Education in the redesign of our teacher education program, and at TeachingWorks, an organization housed at U-M whose mission it is to improve the quality of teaching and learning by transforming teachers' education.

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FIVE HIGH-LEVERAGE TEACHING PRACTICES TO DEVELOP STUDENTS' SKILLFULNESS

1. Establish norms and routines for mathematical work
2. Elicit students' mathematical thinking
3. Respond to common patterns of students' mathematical thinking
4. Modify mathematics tasks
5. Lead group discussions about mathematics

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① Establish norms and routines for mathematical work

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NORMS AND ROUTINES FOR PRODUCTIVE MATHEMATICAL WORK

1. Teaching students to listen to and respond to others with interest and respect
2. Holding students accountable for reasoning
3. Using multiple calling on strategies, according to purpose
4. Explicitly supporting students to present at the board: audibly, clearly
5. Modeling and supporting the recording of one's own and others' mathematical ideas and reasoning
6. Encouraging writing, representing, drawing mathematical ideas
7. Analyzing errors as part of productive mathematical work

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② Elicit students' mathematical thinking

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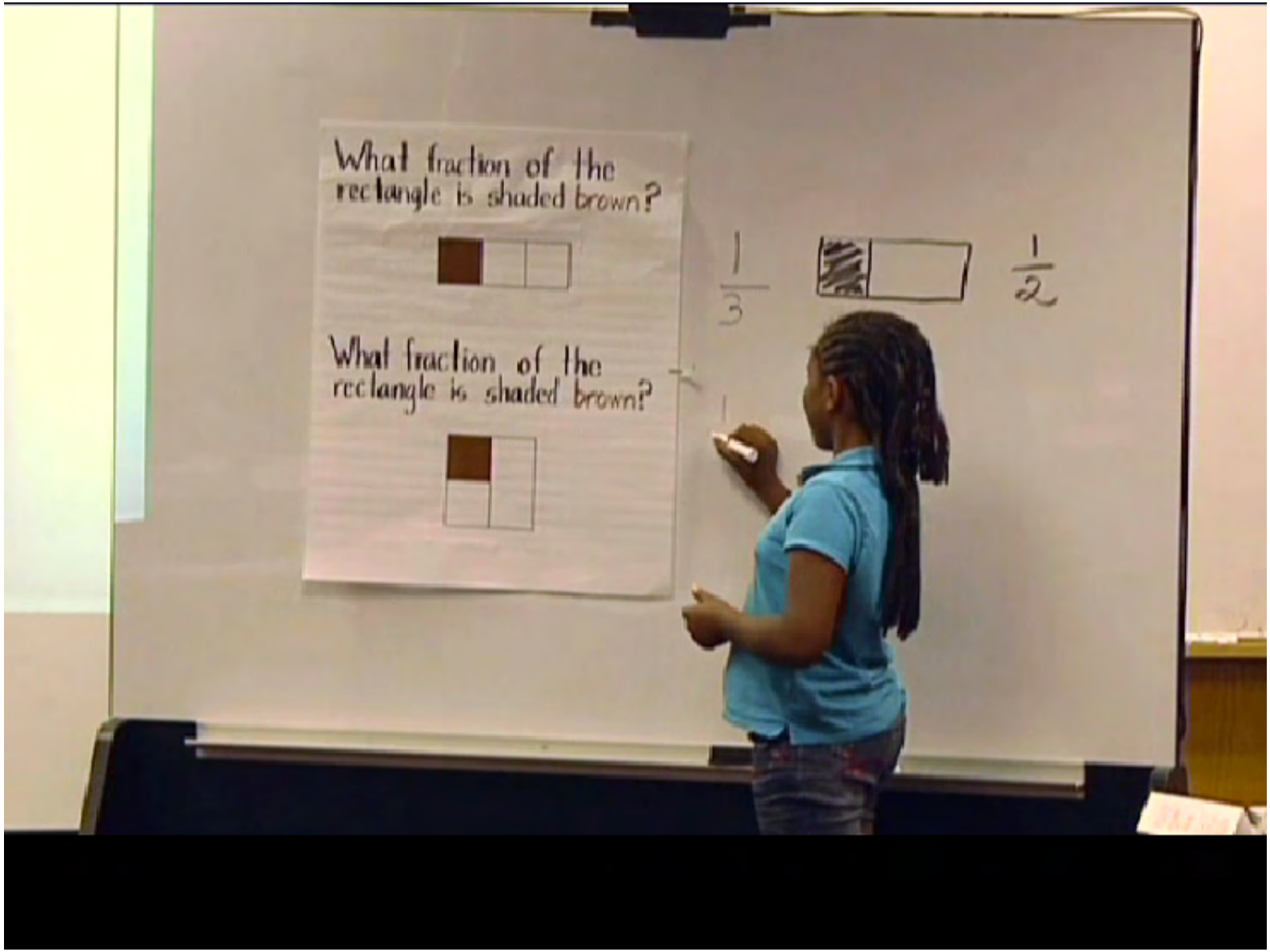

③ Respond to common patterns of students' mathematical thinking

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④ Modify mathematics tasks

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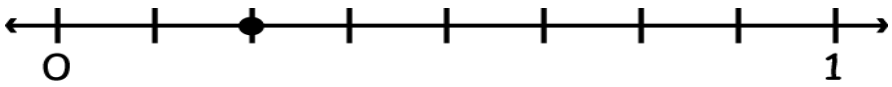
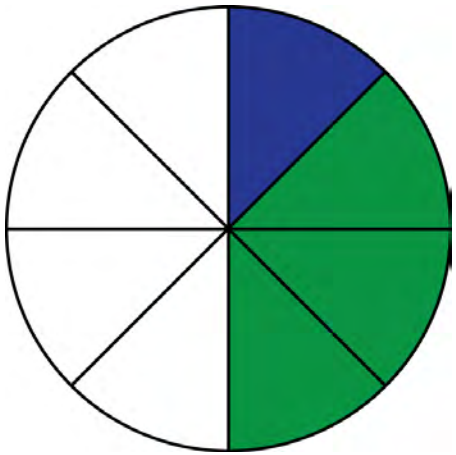
NOTICE "SAFE" TASKS

What makes these tasks "safe"?





1. Much of the thinking is done for the children (e.g., equal partitioning; shading; labeling)
2. Protect from error — supports getting "correct" answer

THUS, THESE TASKS ARE ACTUALLY POTENTIALLY UNSAFE.

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ANOTHER "SAFE TASK"

Write number sentences for 10:

___ + ___ =	___ + ___ =
___ + ___ =	___ + ___ =
___ + ___ =	___ + ___ =
___ + ___ =	___ + ___ =
___ + ___ =	___ + ___ =
___ + ___ =	

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ALTERNATIVE MORE CHALLENGING TASK

Write equations for 10.

How many different equations are there for 10?

What are the features of this task compared with the "safe" version?

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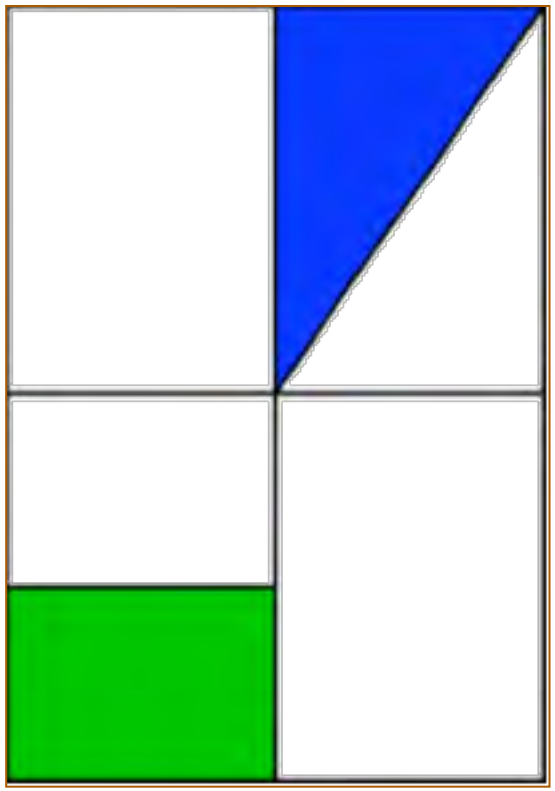
BUILD TASKS THAT SUPPORT STUDENTS DOING MATHEMATICAL WORK



What fraction of the big rectangle is shaded blue?

What fraction of the big rectangle is shaded green?

What fraction of the big rectangle is shaded altogether?

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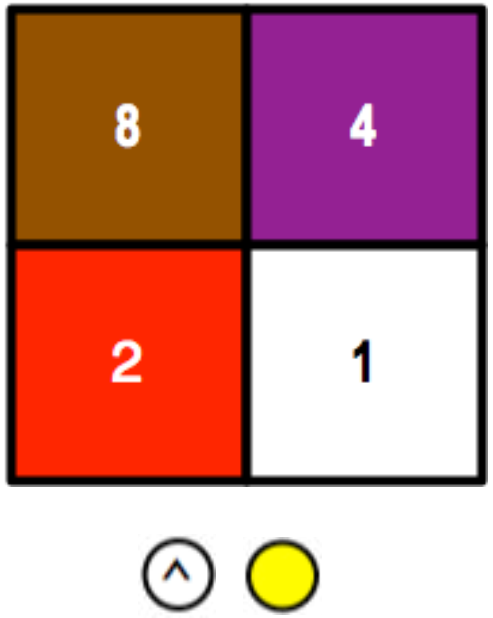
TASKS THAT HELP TO FILL GAPS AND INVOLVE COMPLEX MATHEMATICAL WORK



Using exactly one positive and one negative checker, find all the numbers that can be represented on this minicomputer board.

Prove your answer and explain why.

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ATTEND CLOSELY TO WORDING

POSSIBLE PROBLEM:

I have pennies, nickels, and dimes in my pocket. If I pull out two coins, what amounts of money might I have?

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CONSIDER WITH CARE ALTERNATIVE WORDING

1. I have pennies, nickels, and dimes in my pocket. If I pull out two coins, what amount of money might I have?
2. I have pennies, nickels, and dimes in my pocket. If I pull out two coins, how many combinations are possible?
3. I have pennies, nickels, and dimes in my pocket. If I pull out two coins, how many different amounts of money are possible? Prove that you have found all the amounts that are possible.

What are the differences among these three formulations?

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TEACHING STUDENTS TO BE SUCCESSFUL WITH COMPLEX TASKS

- Help students to believe they can do hard work
- Scaffold complex work appropriately
- Make wise judgments about what to leave open and what to make explicit
- Comment on mathematics, and mathematical productions, not features of students
- Support error as a fruitful site for mathematical work, and teach students to use error productively

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⑤ Lead group discussions about mathematics

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THREE TYPES OF MATH DISCUSSIONS

1. Practicing
2. Learning concepts or procedures together
3. Discussing solutions to a problem

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PARTS OF A DISCUSSION

1. Setting up the problem**
2. Monitoring student work
3. Launching the discussion
4. Orchestrating**
5. Concluding

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SETTING UP THE PROBLEM

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VIEWING FOCUS

1. What are the purposes of the discussion?
2. What is the teacher doing to lead the discussion?
3. What roles are students playing?

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ORCHESTRATING THE DISCUSSION

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CONCLUSIONS

1. Teaching all students to be mathematically skillful requires teaching that is skillful.
2. Skillful teaching involves balancing traditional dualisms about content vs. process, teacher-direction vs. student-centeredness, and remediation vs. enrichment.
3. Supporting teachers to develop skill with high-leverage teaching practices is key to the development of students' mathematical skillfulness.

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