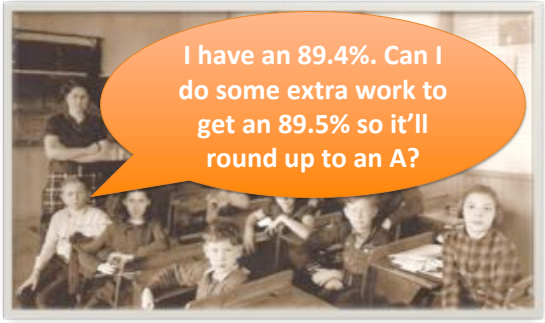
Improve Your Tests, Lessons, and Student Learning with Rigorous Rubrics

Tim Hudson, PhD
Senior Director of Curriculum Design
DreamBox Learning
@DocHudsonMath

#MathRubric
NCTM 2015

Problems to Solve



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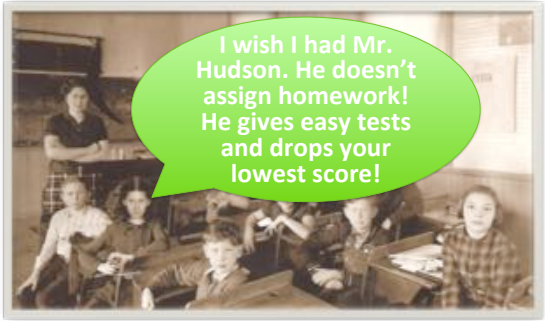

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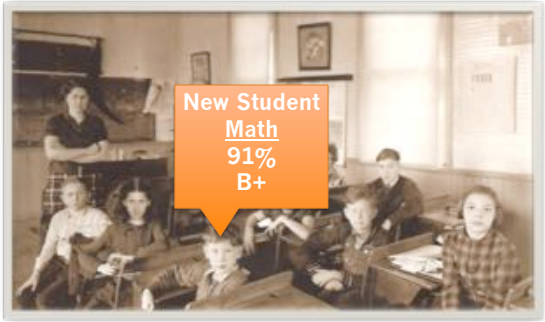

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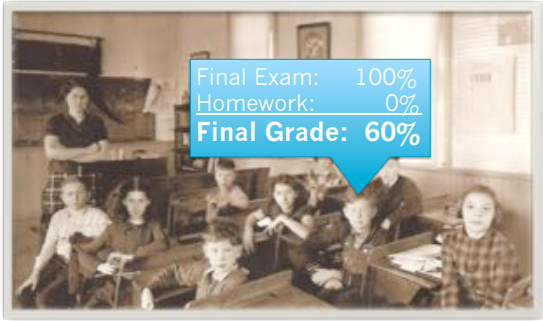

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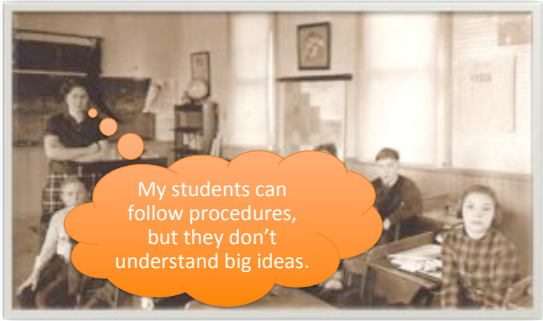
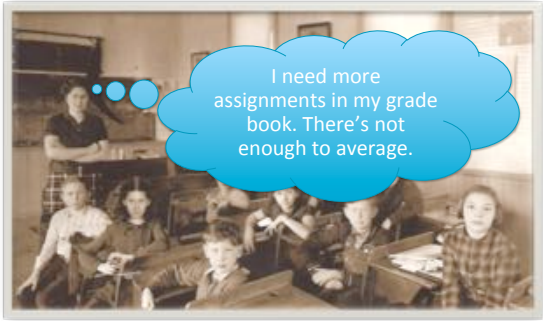


Problems to Solve



NY Times, 10/5/2014

The **final exam** for Math 96 ["developmental math"] would make up **35 percent** of the total grade, and as the day of the test approached, Mr. de Jesus knew that with the **demerits** he would face **for his poor attendance and his unfinished homework**, there was little chance he would pass. On the morning of the exam, he didn't show up, and **he failed the class for the third time**. As it happened, more than **40 percent of the students** in the class **also failed**.

Community College Students Face a Very Long Road to Graduation
by Ginia Bellafonte

Common Failure by Design

- Over-weighted final exam.
- Likely use of arithmetic mean.
- Penalties unrelated to content achievement
  - Attendance is not a proxy for understanding
  - A zero means no evidence of learning was collected
- 1 student failing 3 times
- 40% of students failing in a single term

We have the
WRONG GOALS
for students in Math

What are the RIGHT Goals?

- What is mathematics?
- What are a mathematician's habits of mind and dispositions?
- What is a school math program "in business" to accomplish?

We give
POOR FEEDBACK
to students in Math

What is QUALITY Feedback?

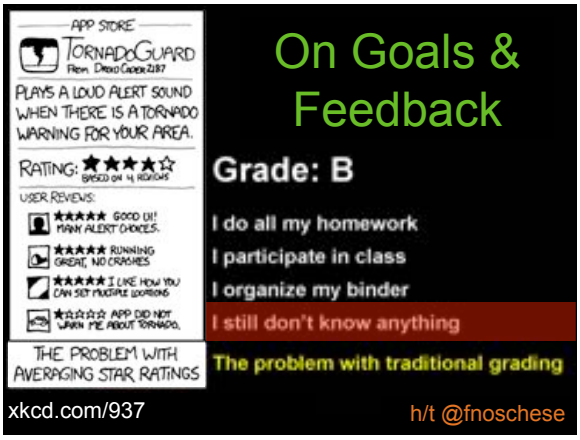
What percentage did your doctor give you at your most recent routine check-up?

What is QUALITY Feedback?

Weight Instagram & Twitter Equally?	Monthly or 8-week Progress Reports?
Tier 2 and 3 Interventions?	Points off if they like Nickelback?

Grading Friends

Wrong Goals
\+ Poor Feedback
Low Achievement



Session as Advertised

Students often care more about points and less about understanding mathematics because **percent-based grading systems distract from key outcomes**. Learn how **teachers collaborated** to turn standards into Novice-Expert rubrics that improved tests, lessons and student performance. Hear how **rubrics transform curriculum, grading & rigor at any grade level.**

Algebra 1 Program

Parkway School District St. Louis, MO	• K-12 with over 17,000 students • 4 Traditional HS, 1 Alternative HS • 60 HS Math Teachers
District Algebra 1 Curriculum Team	• Common Assessments & Grading Practices • Asst Supt, Principals, Dept Chairs in Support • Summer Workshops, Release Days
Confluence	• Mission "ALL" Students • Eliminated B Track • Teacher Evaluation Rubrics

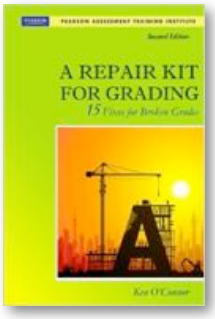
% Proficient & Advanced Algebra 1 End-of-Course Exam (MO)

	2009	2010	2011	2012
Central HS	50%	62%	66%	**81%**
North HS	43%	52%	52%	**68%**
South HS	47%	52%	67%	**78%**
West HS	72%	72%	77%	**86%**
District	51%	58%	66%	**78%**
Total Students	1001	960	947	813

A Repair Kit for Grading:

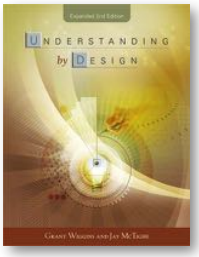
15 Fixes for Broken Grades

by Ken O'Connor



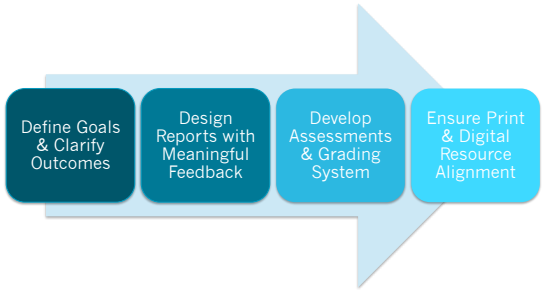
Plan Backwards

1. Identify desired results
2. Determine acceptable evidence
3. Plan learning experiences and instruction

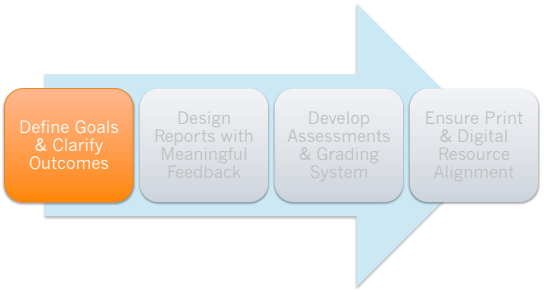


Understanding by Design, Wiggins & McTighe, ©2005

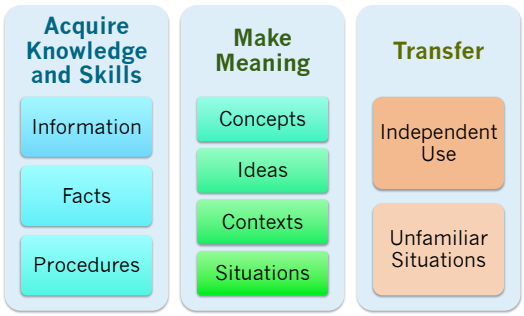
Math Program Design



Math Program Design



Learning Outcomes A-M-T



Pop Quiz

For a bicycle race, Donald's time was:

3 hours, 4 minutes, and 11 seconds.

Keina's time was:

2 hours, 58 minutes, and 39 seconds.

How long was Keina finished before Donald crossed the finish line?

one strategy

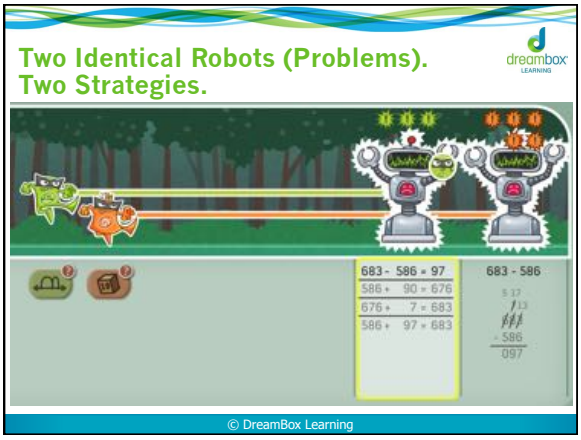
Hours	Minutes	Seconds
2	63	71
3 1	4 1	1 X
2	58	39
0	5	32

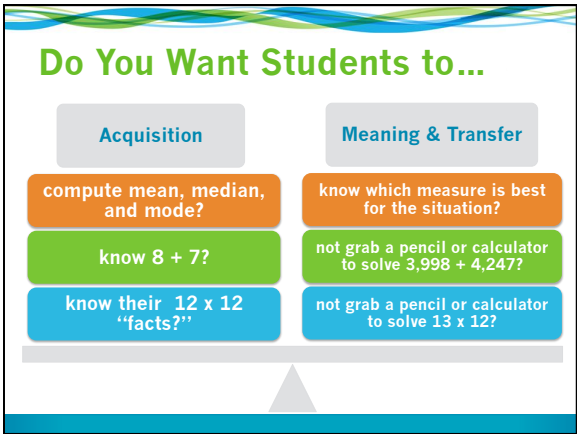
304 – 298 = ?

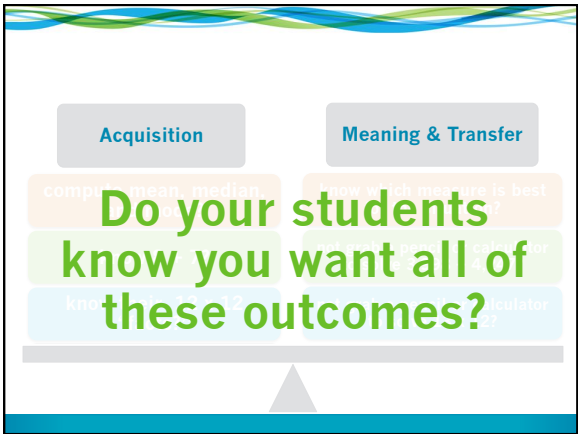
Invented Strategy?

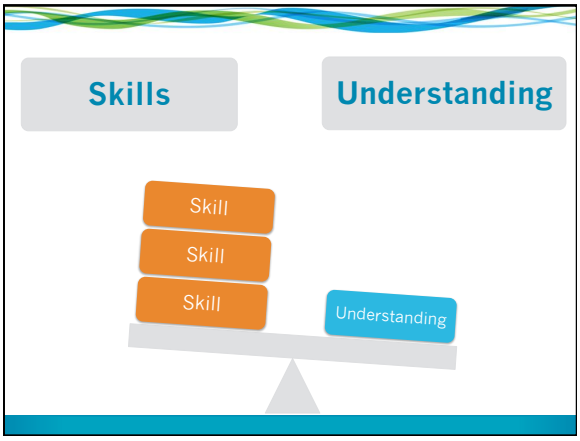
$$\begin{array}{r} 304 \\ -\ 298 \\ \hline 006 \end{array}$$

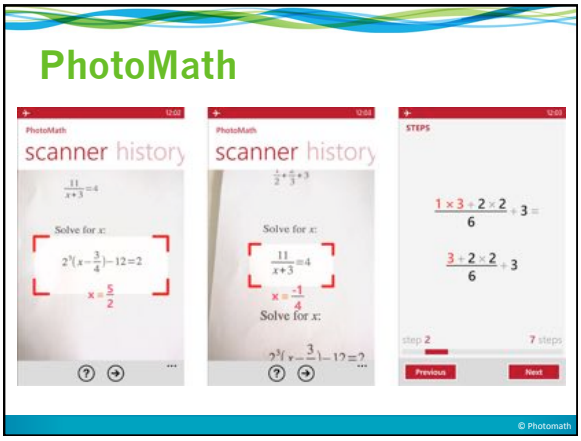

Two Monsters (Problems). One Strategy.
dreambox LEARNING
233- 113 = 120
816 - 554
© DreamBox Learning


Two Identical Robots (Problems). Two Strategies.
dreambox LEARNING
683 - 586 = 97
683 - 586
© DreamBox Learning

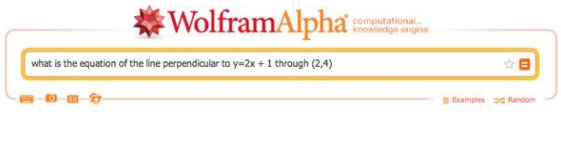

Do You Want Students to…
Acquisition
Meaning & Transfer
compute mean, median, and mode?
know which measure is best for the situation?
know 8 + 7?
not grab a pencil or calculator to solve 3,998 + 4,247?
know their 12 x 12 "facts?"
not grab a pencil or calculator to solve 13 x 12?


Acquisition
Meaning & Transfer
Do your students know you want all of these outcomes?


Skills
Understanding
Skill
Skill
Skill
Understanding

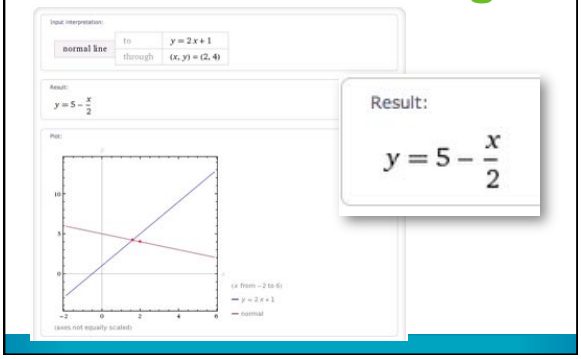

PhotoMath
scanner history
scanner history
STEPS
© Photomath

Algebra 1



what is the equation of the line perpendicular to y=2x + 1 through (2,4)

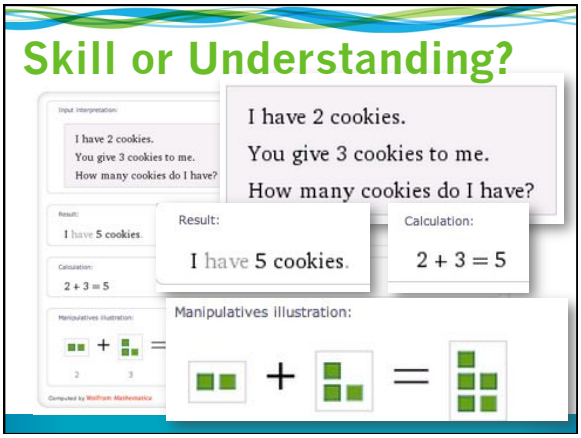
Skill or Understanding?



Kindergarten

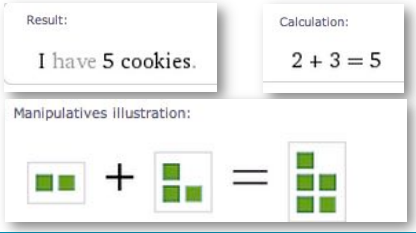
i have 2 cookies. you give me 3 cookies. How many cookies do I have?

Skill or Understanding?



What Grade does Wolfram|Alpha get?

i have 2 cookies. you give me 3 cookies. How many cookies do I have?



Better Goals for Students

David Bressoud, Mathematical Association of America (www.maa.org/columns):

"If computers can solve [math] problems so efficiently, why do we drill our students in answering them?"

http://www.maa.org/external_archive/columns/launchings/launchings_08_09.html

Better Goals for Students

David Bressoud, (cont'd)

"There are **important mathematical ideas** behind these methods, and showing one knows how to solve these problems is **one way** of exhibiting working knowledge of these ideas."

http://www.maa.org/external_archive/columns/launchings/launchings_08_09.html

Better Goals for Students

David Bressoud, (cont'd)

"The existence of Wolfram|Alpha does push instructors to **be more honest** about their use of standard problems **executed by memorizing algorithmic procedures**.

http://www.maa.org/external_archive/columns/launchings/launchings_08_09.html

Better Goals for Students

David Bressoud, (cont'd)

"If a student feels that she or he has **learned nothing** that cannot be pulled directly from Wolfram|Alpha, then the course really has been **a waste of time**."

http://www.maa.org/external_archive/columns/launchings/launchings_08_09.html

Waste of Time?

From a 5th grade teacher in NY:

"I had a lot of good people teaching me math when I was a student – earnest and funny and caring. But the math they taught me wasn't good math. Every class was the same for eight years:

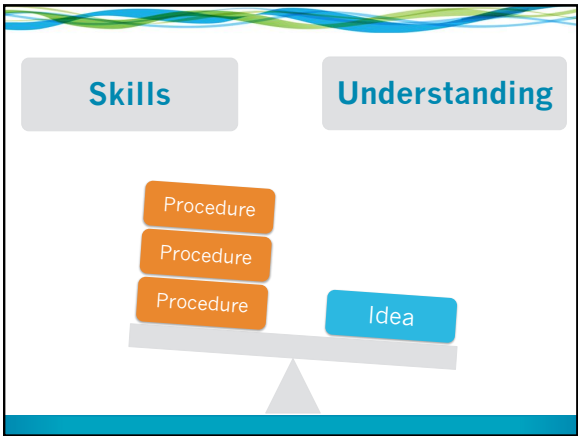
'Get out your homework, go over the homework, here's the new set of exercises, here's how to do them. Now get started. I'll be around.'"

Teaching What Matters Most by Strong, Silver, and Perini, © 2001, p. 55

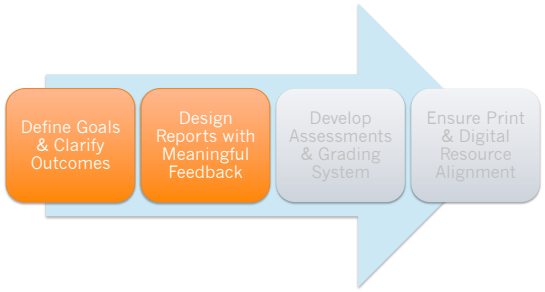
What were the Goals?

"They were so concerned with making sure we knew how to do every single procedure we never learned how to **think mathematically**. I did well in math but I never understood what I was doing. **I remember hundreds of procedures but not one single mathematical idea**."

p. 55, Teaching What Matters Most, Strong, Silver, & Perini, ©2001

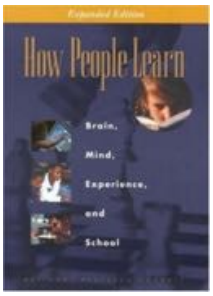


Math Program Design



How People Learn

1. Learning: From Speculation to Science
2. **How Experts Differ from Novices**
3. Learning and Transfer
4. How Children Learn
5. Mind and Brain



Measuring Anything

1. If it matters at all, it is detectable or observable
2. If it is detectable, it can be detected as an amount (or **a range of possible amounts**)
3. If it can be detected as a range of possible amounts, it is measurable

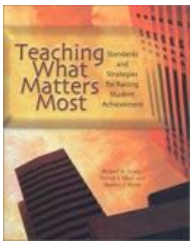
How to Measure Anything, D.W. Hubbard

Range of Understanding

If you want it as an outcome for your students, you can build a Novice-Expert rubric for it

Rubric for Thought

	Expert	Practitioner	Apprentice	Novice
Inquiry				
Knowledge Acquisition				
Problem Solving				
Communication				
Reflection				



Teaching What Matters Most by Strong, Silver, and Perini, © 2001, p. 58

Process: Inquiry

Expert	Proficient	Developing	Novice
Can formulate questions and seek answers independently; generates, tests, and refines hypotheses according to well-formulated criteria; uses evidence powerfully and persuasively; foresees and responds to counterarguments.	Looks for and uses questions to guide investigation; uses criteria to generate hypotheses; uses evidence effectively, but may fail to fully address counterarguments	Can use pre-drafted questions to direct investigation but needs help formulating her own; may have trouble telling quality hypotheses apart from guesses; substantiates some claims; pays little attention to counterarguments	Fails to look for questions to guide investigation; generates hypotheses haphazardly; fails to use evidence to substantiate claims

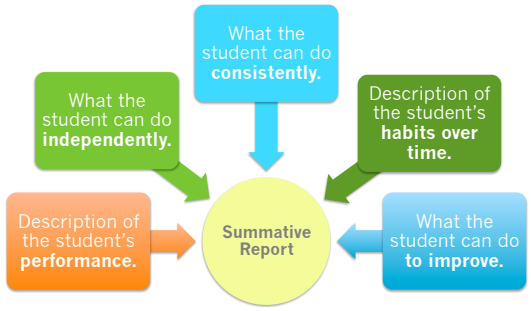
Teaching What Matters Most by Strong, Silver, and Perini, © 2001, p. 58

Process: Problem Solving

Expert	Practitioner	Developing	Novice
Is constantly looking for and posing relevant questions; experiments with a variety of solutions and perspectives	Restates problems; understands there is more than one way to attack a problem; surveys own understanding to determine progress toward solution	Accepts problems on their own terms (e.g., rarely restates them to make them more meaningful); often generates only one or two obvious solutions	Avoids difficult problems; looks for convenient solutions; rarely questions ideas

Teaching What Matters Most by Strong, Silver, and Perini, © 2001, p. 58

Rubrics Should Communicate…



Concept & Skill: Central Tendency

Expert	Proficient	Developing	Novice
Apply new and unfamiliar statistical measures to make predictions and draw conclusions.	**Justify the most appropriate statistical measures** of center to make predictions and draw conclusions.	**Apply** mean, median, mode, and range to solve problems and make predictions. **(MO Alg 1 D2A)**	**Compute** mean, median, mode, and range given a data set.

Knowledge: Function Properties

Expert	Proficient	Developing	Novice
Given tables, graphs, or equations of **unfamiliar non-linear functions**, determine and define properties of those functions.	Given a table, graph, or equation, **classify a function as linear, quadratic, or exponential** and justify your answer.	Given a table, graph, or equation, **classify** a function as linear or non-linear and justify your answer. **(MO Alg 1 A1D)**	Given a table or graph, classify a relationship as a **function or non-function** and justify your answer.

Skill: Factoring Polynomials

Expert	Proficient	Developing	Novice
Factor polynomials with **more than three terms, more than one variable, or a degree higher than two**.	**Completely factor** any given quadratic expression. **MO Alg 1 A2B**	Factor trinomials with a **leading coefficient of one**.	Factor out a **Greatest Common Factor** (GCF) from any polynomial.

Imagine receiving this level of detail when a new student transfers into your class.

		Proficient	Developing	Novice
		1.1 Meaningfully and mathematically represent a contextual situation in multiple ways. Represent a problem in context with a data table, graph, and equation (linear, quadratic, and exponential).	Translate an equation into a graph.	Translate data in a table into a graph. Translate an equation or a graph into a data table.
	Compare all real numbers and place them on a number line.	1.2 Represent, compare, and order rational and irrational numbers, including approximate, locations on a number line. **N1A***	Place numbers on a number line and write inequalities if they are all in the same format (i.e., decimals, fractions), if they have the same denominator or the same number of decimal places.	Place numbers on a number line and write inequalities if the numbers are all in the same format (either whole numbers, decimals to two places, or simple fractions).
2. Identify Relationships (Classifying Mathematical Models)	Given tables, graphs, or equations of unfamiliar non-linear functions, determine and define properties of those functions.	2.1 Given a table, graph, or equation, classify a function as linear, quadratic, or exponential and justify your answer.	Given a table, graph, or equation, classify a function as linear or non-linear and justify your answer. **A1D**	Given a table or graph, classify a relationship as a function or non-function and justify your answer.
	Determine several models (including unfamiliar, non-linear functions) that might represent a given situation. Of those options, justify the model that best represents the situation.	2.2 Determine the type(s) of functions (linear, quadratic, or exponential) that might model a given situation. Of those options, justify the type of function that best models the situation. **A3A**	Explain the similarities and differences of tables, graphs, or equations of linear, quadratic, and exponential relationships. **A1C**	Explain the similarities and differences in the tables or graphs of linear and non-linear functions.
3. Analyze Relationships (Making Predictions with Mathematical Models)	Justify the relevant domain and range of any relationship from context.	3.1 Justify the relevant domain and range of a linear, quadratic, or exponential relationship from context.	Determine the domain and range of a relationship from an equation or graph.	Determine the domain and range of relationships given a table.
	Generate an equation that might model a given situation that appears to be linear and use it to make predictions about future data.	3.2 Consider multiple equations that might model a situation. Select and justify the best model for predicting the relationship.	Make and justify predictions about a relationship when given a table.	Make and justify predictions about a relationship when given a graph, including scatter plots. **D3A**
	Apply new and unfamiliar statistical measures to make predictions and draw conclusions.	3.3 Justify the most appropriate statistical measures of center to make predictions and draw conclusions.	Apply mean, median, mode, and range to solve problems and make predictions. **D2A**	Find the mean, median, mode, and range of a set of numbers.

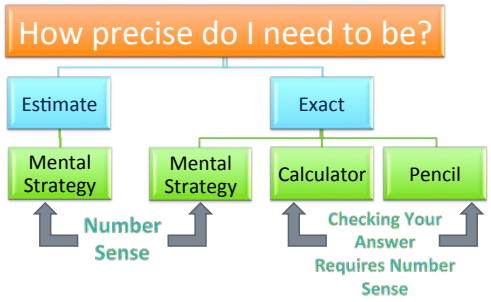
Key Points

- Avoid negatives: "~~The student CAN'T…~~"
- Share with students & parents up front
- Expected to be Novice at the start?
  - Yes for content (i.e., parabolas, algorithms)
  - No for process (i.e., inquiry, problem solving)
- These are not meant to create "ability groups." Engage rich tasks together.

CCSSM 3.NBT.2

Fluently add and subtract within 1000 using strategies and algorithms based on place value, properties of operations, and/or the relationship between addition and subtraction.

Computation "Experts"



Student Self-Assessment Rubric

Expert	Proficient	Developing	Novice
I make reasonable estimates when adding and subtracting beyond 1,000. I can figure out and prove how unfamiliar and new algorithms operate.	I add, subtract, and estimate within 1,000, both with and without a pencil. I can explain when different strategies and algorithms may or may not be appropriate or efficient.	**3.NBT.2** I can add and subtract within 1,000 using properties of operations, algorithms, place value, and the relationship between addition and subtraction. I prefer to use: _____ for every problem.	I can add and subtract numbers within _____ accurately on paper. In my head, I can add and subtract numbers within _____ accurately. My favorite strategies are: _____

Interviews & Observations

Pencil & Paper assessments are not well-suited to collect evidence of some important math outcomes such as estimation, fluency, and mental math.

Key Point

- If it's an outcome we want – or promise – we **MUST** assess it and report progress to students and parents
- If it's not assessed and reported, we'll never know if students have demonstrated it. (So why even bother to pretend we do it?)

The Mission of the Parkway School District is to ensure

all students are capable, curious, and confident learners

who **understand and respond** to the **challenges** of an **ever-changing world**.

Realities

- We've always measured what's easy to measure and then been disappointed when students aren't able to do things that are more difficult to measure, such as demonstrate curiosity, transfer and critical thinking
- There is no field where measurement is about 100% accuracy
- Given Mission, to say, "I don't know which students are curious" is a dereliction of duty

Curious Learners

Expert	Practitioner/ Developing	Novice
I continually ask insightful questions both inside and outside of class that extend the conversation and learning into new areas.	I ask some questions before and during class, but often only when prompted to, and only in relation to the current conversation and lesson.	I do not ask questions either before or after being presented with information in class. I ask unrelated questions or just ask for facts.
When I am presented with new information, I always ask questions to determine its value and credibility.	I often trust what I hear or read, but if something sounds really weird, I ask questions to learn more.	I immediately accept what is presented. I want an easy answer or method, so I can mindlessly use it forever.
I don't care if I'm wrong, fail, or make a mistake. These experiences only improve my understanding.	When I'm presented with a challenge, I usually keep at it until I solve it. I'm not complacent with just simple answers.	If I'm not successful, I stop trying. I only ever think about problems someone else tells me about.

Evidence of Curiosity: Assess Student Questions

East High School has been recording the number of 12th graders who drop out of school before earning a diploma. The principal of East High School has asked you to help her reduce the number of students who drop out of school. She gives you this data table:

Dropping Out at East High School in 12th Grade from 2001-2011

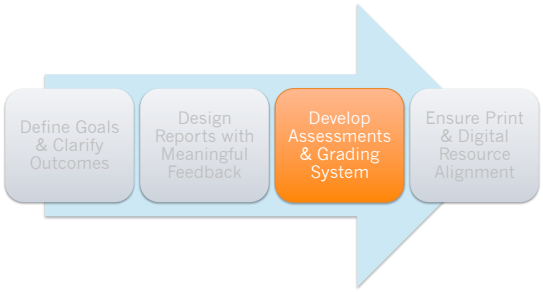
School Year	2001-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11
Number of Seniors who Dropped Out	21	24	25	48	24	27	25	28	32	30

1. Write two questions you would ask the principal at East High School about these dropout data.

What if we gave a Curiosity Report?

Course	6-week	12-week	Semester
Algebra 1	Novice	Novice	Novice
Modern American History	Novice	Expert	Novice
Biology	Expert	Proficient	Novice
Orchestra	Proficient	Proficient	Proficient
Physical Education	Novice	Novice	Proficient
Honors English 1	Proficient	Proficient	Expert
Introduction to Business	Expert	Expert	Expert

Math Program Design



Assessment Design

- Rubrics = design schematics for tests.
  - If we couldn't write an assessment item aligned with the rubric, we re-worked the rubric until it described measurable student performance.
- Four test sections: a few problems aligned with each rubric category.
- Students couldn't only complete the Proficient and Expert items on a test.

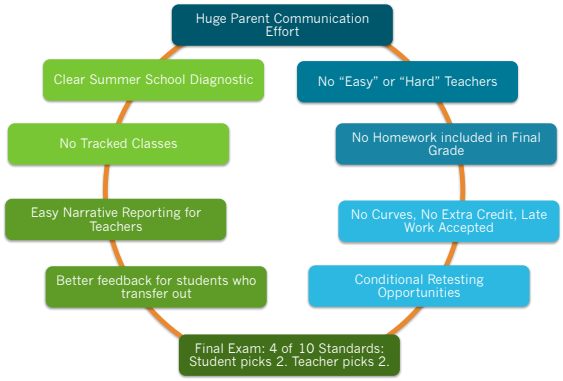
A, B, C … That's All

The semester grade will not be calculated using percentages, but rather by using the chart below. Please note that students not earning a C or higher will be required to re-take the first semester of Algebra 1.

Ratings	Number of Ratings (out of 11) used to Determine the Semester Grade			
	A	B	C	Retake 1st Semester
Expert	At least 5	--	--	--
Proficient	--	--	--	--
Developing	0	2 or fewer	4 or fewer	More than 4
Novice	0	0	0	Any

To help understand this assessment system, here are a few examples:

- 3 Expert ratings, 4 Proficient, and 4 Developing - Semester Grade is a C
- 2 Expert rating, 7 Proficient, and 2 Developing - Semester Grade is a B
- 7 Expert ratings, 2 Proficient, and 2 Developing - Semester Grade is a B
- 8 Expert ratings and 3 Proficient ratings - Semester Grade is an A
- 6 Proficient ratings and 5 Developing ratings - Retake 1st Semester
- 7 Proficient ratings, 3 Developing, and 1 Novice - Retake 1st Semester



Better Help Sessions

Juniors in Honors Pre-Calculus:

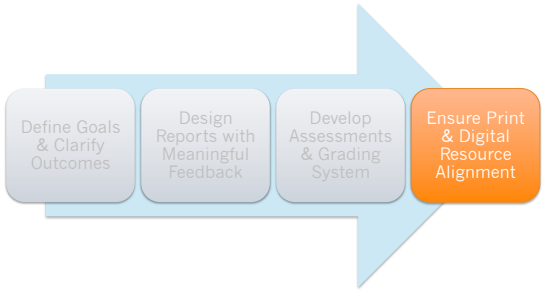
- "I have an 89.4%. Can I do some extra work to get an 89.5% so it'll round up to an A. My GPA could use a 4.0 instead of a 3.0."
- "I need help on Section 3.2."

Freshmen in Algebra 1:

- "I know I can compute mean, median, and mode, but I really don't know which one is best. Can you help me understand how to pick?"

When you change the assessment system, you change the conversation with students.

Math Program Design



Draft CC SMP 7 Rubric

Look for and make use of structure.

Expert	Proficient	Developing	Novice
I look for patterns and structures outside of class and make connections that are not immediately obvious. I use and analyze the value of these structures.	I look closely to discern useful patterns and structures in class. I step back to get an overview and shift perspective to gain more insight. I make use of structures I find to solve problems.	I look haphazardly for patterns when asked, but I'm not sure how to look or to know when I've found something useful. I am able to use simple structures.	I look for simple, obvious patterns. I am able to use simple structures with someone's help.

Who Did the Looking?

From a 5th grade teacher in NY:

"I had a lot of good people teaching me math when I was a student – earnest and funny and caring. But the math they taught me wasn't good math. Every class was the same for eight years:

'Get out your homework, go over the homework, here's the new set of exercises, here's how to do them. Now get started. I'll be around.'"

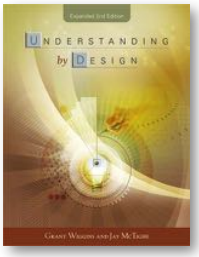
Teaching What Matters Most by Strong, Silver, and Perini, © 2001, p. 55

If it's believed that learners are merely passive receivers of information and procedures, then what would logically follow in the classroom?

Transmission View of Learning
Students are "Looking"

Plan Backwards

1. Identify desired results
2. Determine acceptable evidence
3. Plan **learning experiences** and **instruction**



Understanding by Design, Wiggins & McTighe, ©2005

Transmission & Instruction

"Let me explain step-by-step how a mathematician looks for patterns."

"I've shown you the mathematical structure. Now I'll show you how to use it."

Learning Experience

"As you independently solve this problem, you'll be thinking like a mathematician."

"On your own, you'll need to look for the structure. And find it. Then use it."

Learning is not accomplished by putting thoughts into a mind, but rather by empowering a mind to generate thoughts.

3rd Grade Alternate Approach

On a 15-item test

	Novice	Developing	Proficient	Expert	Total
Number of Items *Completely* Correct					
Number of Total Items	5	5	3	2	15

First Trimester # Correct Items 30 Total Test Items 4 Expert 6 Proficient 10 Developing 10 Novice		Combined Number of Proficient AND Expert Items Completely Correct (out of 10)					
		10	9	7-8	5-6	3-4	< 3
Combined Number of Novice AND Developing Items Completely Correct (out of 20)	18-20	A	A	B	B	C	N
	16-17	A	B	B	C	C	N
	14-15	B	B	C	C	N	N
	12-13	B	C	C	N	N	N
	10-11	C	C	N	N	N	N
	< 10	N	N	N	N	N	N

First Trimester # Correct Items 30 Total Test Items 4 Expert 6 Proficient 10 Developing 10 Novice		Combined Number of Proficient AND Expert Items Completely Correct (out of 10)					
		10	9	7-8	5-6	3-4	< 3
Combined Number of Novice AND Developing Items Completely Correct (out of 20)	18-20	28-30	29	25-28	23-26	21-24	N
	16-17	26-27	25-26	23-25	21-23	19-21	N
	14-15	24-25	23-24	21-23	19-21	N	N
	12-13	22-23	21-22	19-21	N	N	N
	10-11	20-21	19-20	N	N	N	N
	< 10	N	N	N	N	N	N

First Trimester % Correct Items 30 Total Test Items 4 Expert 6 Proficient 10 Developing 10 Novice		Combined Number of Proficient AND Expert Items Completely Correct (out of 10)					
		10	9	7-8	5-6	3-4	< 3
Combined Number of Novice AND Developing Items Completely Correct (out of 20)	18-20	93-100%	90-97%	83-93%	77-87%	70-80%	< 77%
	16-17	87-90%	83-87%	77-83%	70-77%	63-70%	< 67%
	14-15	80-83%	77-80%	70-77%	63-70%	< 63%	< 60%
	12-13	73-77%	70-73%	63-70%	< 63%	< 57%	N
	10-11	67-70%	63-67%	57-63%	< 57%	N	N
	< 10	< 67%	< 63%	< 60%	N	N	N