

Looking Beyond Skills: Supporting Learners Who Struggle

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Session Overview

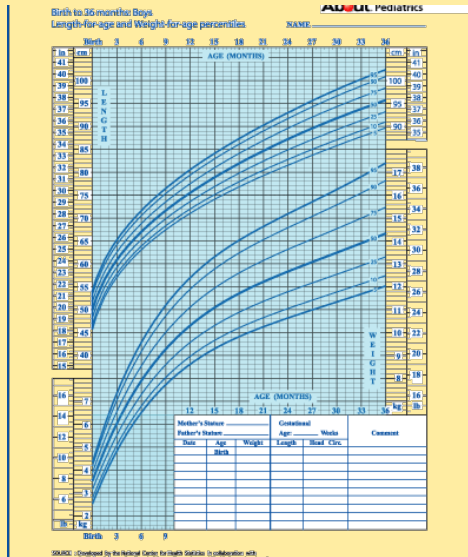
- Overview of progress monitoring
- Summary of Algebra Screening and Progress Monitoring project
- Description of measures
- Interpretation of student scores related to expressions and equations
- Instructional strategies related to student performance



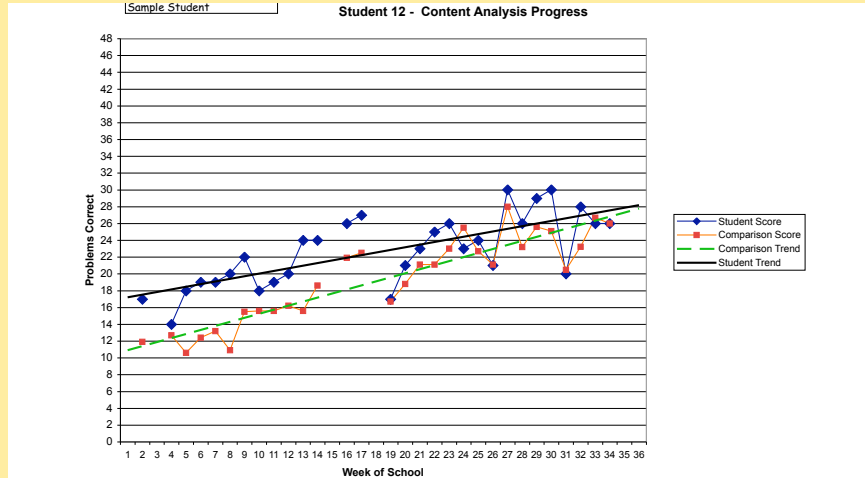
Progress Monitoring



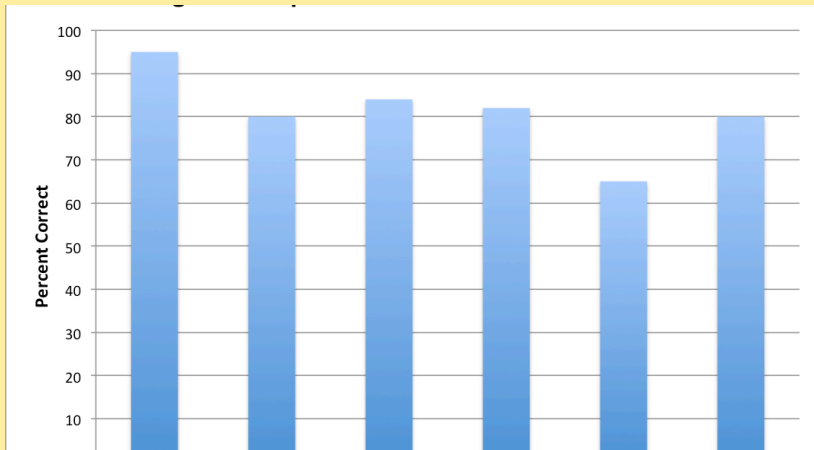
Indicators of Development



Sample Progress Monitoring Graph



Common Assessment Practices in Mathematics



A Note on Mastery Monitoring

- Ms. Markley has created brief 10-item quizzes about the main concepts in her unit. She gives these every few days during the unit to see if students are acquiring the important concepts. She says she is using this method to monitor her students' progress.
- DO YOU AGREE?



Key Characteristics of Progress Monitoring Measures

- More commonly used in reading (DIBELS, ORF)
- Brief (about 5-7 minutes)
- Efficient (easy to give, easy to score)
- Standardized administration and scoring
- Multiple forms of constant difficulty and comparable content
- Provide indicators about student growth toward long-term course outcomes
- Technical adequacy



Algebra Screening and Progress Monitoring

- Collaboration between Iowa State University and University of Missouri; 4 years of funding from US Department of Education, Institute of Education Science
- School partners in 3 states
 - 25-28 teachers/year
 - 1800-2200 high school Algebra I students/year
- Refine existing procedural progress monitoring measures
- Develop and refine conceptual progress monitoring measures



What are Big Ideas in Algebra for you?

- What skills would be important to assess?
- What concepts would be important to assess?



Types of Understandings

- Procedural: Student can perform a computation or algorithm by following a series of prescribed steps.
- Conceptual: Student understands the basis of why a computation or algorithm works and can apply it later, without reteaching. Student can identify, describe, and explain a big idea related to a topic or a class of problems. Generalizations are evident.
- Problem solving: Student can solve a problem when there is no specific solution pathway or algorithm.



Procedural Measures for Algebra Progress Monitoring



Procedural Measures

- Algebra Basic Skills
- Algebra Foundations
- Algebra Content Analysis



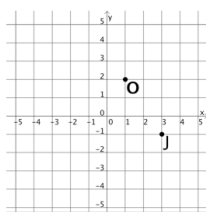
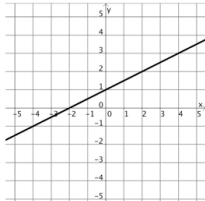
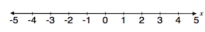
Algebra Basic Skills

Algebra Basic Skills 1		Page 1	
Solve: $9 + a = 15$	$a =$	Solve: $10 - 6 = g$	$g =$
Evaluate: $12 + (-8) + 3$		Simplify: $9 - 4d + 2 + 7d$	
Simplify: $2x + 4 + 3x + 5$		Simplify: $5(3 - n) - n$	
Solve: $4 = 12 - k$	$k =$	Solve: $(q)(5) = 30$	$q =$
Simplify: $4(3 + u) - 7$		Simplify: $2 + w(w - 5)$	



Algebra Foundations

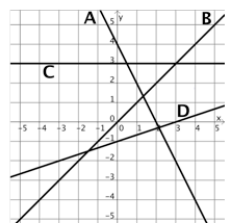
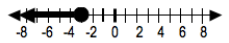
Algebra Foundations 1 Page 1

<p>List the ordered pair for each point:</p> <p>J(,) O(,)</p> 	<p>Complete the table:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>u</th> <th>$3u$</th> </tr> </thead> <tbody> <tr> <td>6</td> <td>18</td> </tr> <tr> <td>7</td> <td>21</td> </tr> <tr> <td>8</td> <td></td> </tr> <tr> <td>9</td> <td>27</td> </tr> </tbody> </table>	u	$3u$	6	18	7	21	8		9	27	<p>Complete the table:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>n</th> <th>$4n + 7$</th> </tr> </thead> <tbody> <tr> <td>-1</td> <td>3</td> </tr> <tr> <td>-2</td> <td></td> </tr> <tr> <td>-3</td> <td>-5</td> </tr> <tr> <td>-4</td> <td>-9</td> </tr> </tbody> </table>	n	$4n + 7$	-1	3	-2		-3	-5	-4	-9	<p>Complete the table:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>b</th> <th></th> </tr> </thead> <tbody> <tr> <td>-3</td> <td>-6</td> </tr> <tr> <td>0</td> <td>-3</td> </tr> <tr> <td>3</td> <td>0</td> </tr> <tr> <td>6</td> <td>3</td> </tr> </tbody> </table>	b		-3	-6	0	-3	3	0	6	3	 <p>Calculate the slope _____</p> <p>What is the y-intercept? _____</p>
u	$3u$																																	
6	18																																	
7	21																																	
8																																		
9	27																																	
n	$4n + 7$																																	
-1	3																																	
-2																																		
-3	-5																																	
-4	-9																																	
b																																		
-3	-6																																	
0	-3																																	
3	0																																	
6	3																																	
<p>If $y > 9$, two possible values for y are _____ and _____.</p>	<p>Evaluate: $9 \cdot 4 - 6$</p>	<p>Simplify: $7a + (2a + a)$</p>	<p>Solve: $8 = n + 3$ $n =$ _____</p>																															
<p>Evaluate $4b + 2$ when $b = 1$ _____ $b = 3$ _____</p>	<p>Write an expression for this phrase: <i>The difference of a number and 6</i></p>	<p>Evaluate: $(-2) \cdot (-4)$</p>	<p>Graph the inequality $m > -4$</p> 																															

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Algebra Content Analysis

Algebra Content Analysis 1

<p>Solve: $19 = 3x + 4$ $x =$ _____</p> <p>A) 5 B) $7\frac{2}{3}$ C) 15 D) 45</p>	<p>Evaluate $a^2 - c + 2$ when $a = 4$ and $c = 6$</p> <p>A) 1 B) 5 C) 13 D) 34</p>	<p>Which line on the graph represents the equation $y + 2x = 4$?</p>  <p>A) Line A B) Line B C) Line C D) Line D</p>
<p>Evaluate the expression: 6^{-2}</p>	<p>Solve the system of linear equations: $x - y = 4$ $x + 2y = 19$</p>	<p>This graph shows the solution for which inequality?</p> 

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Conceptual Measures for Algebra Progress Monitoring



Conceptual Measures

- Targets big ideas
- Focuses on deeper understanding
- Applies skills
- Three measures
 - Concept of Variable
 - Proportional Reasoning
 - Translations, Functions, and Graphing



Concept of Variable

Concept of Variable A

Page 1

Jon said, " $m - 1$ is always greater than $1 - m$." Do you agree with Jon?

- A. Yes, Jon is correct because m is a positive number.
- B. Yes, Jon is correct because you cannot substitute a negative number for m .
- C. No, Jon is not correct because $1 - m$ is greater than $m - 1$ when m is negative integer.
- D. No, Jon is not correct because these expressions are equivalent.

Answer _____

If $x = d + 2$ and $d + 2 + x = y$, then which of the following statements is true?

- A. $y = 2d + 4 + x$
- B. $4d + 2 = y$
- C. $y = 2x$
- D. $6d = y$

Answer _____



Proportional Reasoning

Proportional Reasoning A

Page 1

For every foot of fence built (t), a carpenter needs a consistent number of nails (n). What does the equation tell you?

$$n = 12t + 24$$

- A. You need 36 nails and boards.
- B. The number of nails increases by 12 for every foot of fence.
- C. The number of nails increases 12 times for every foot of fence.
- D. The number of nails increases by 24 for every foot of fence.

Answer _____

Do these ratios represent the same relationship? 3:4 and $\frac{18}{24}$

- A. No, because one is written like a fraction.
- B. No, because they are different numbers.
- C. Yes, because they are both in the ratio of 3 to 4.
- D. Yes, because they are written like a ratio.

Answer _____

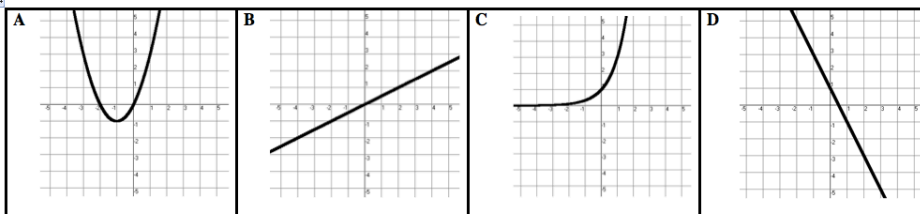


Translations, Functions, and Graphing

Translations, Functions and Graphing Form B

Page 11

For items 1 to 9, match the letter for each equation to a corresponding graph or data table.



1.	<table border="1"><thead><tr><th>x</th><th>y</th></tr></thead><tbody><tr><td>2</td><td>-3</td></tr><tr><td>1</td><td>-1</td></tr><tr><td>0</td><td>1</td></tr><tr><td>-1</td><td>3</td></tr><tr><td>-2</td><td>5</td></tr></tbody></table>	x	y	2	-3	1	-1	0	1	-1	3	-2	5	2.	<table border="1"><thead><tr><th>x</th><th>y</th></tr></thead><tbody><tr><td>4</td><td>2</td></tr><tr><td>2</td><td>1</td></tr><tr><td>0</td><td>0</td></tr><tr><td>-2</td><td>-1</td></tr><tr><td>-4</td><td>-2</td></tr></tbody></table>	x	y	4	2	2	1	0	0	-2	-1	-4	-2	3.	<table border="1"><thead><tr><th>x</th><th>y</th></tr></thead><tbody><tr><td>2</td><td>9</td></tr><tr><td>1</td><td>3</td></tr><tr><td>0</td><td>1</td></tr><tr><td>-1</td><td>$\frac{1}{3}$</td></tr><tr><td>-2</td><td>$\frac{1}{9}$</td></tr></tbody></table>	x	y	2	9	1	3	0	1	-1	$\frac{1}{3}$	-2	$\frac{1}{9}$	4.	<table border="1"><thead><tr><th>x</th><th>y</th></tr></thead><tbody><tr><td>2</td><td>8</td></tr><tr><td>1</td><td>3</td></tr><tr><td>0</td><td>0</td></tr><tr><td>-1</td><td>-1</td></tr><tr><td>-2</td><td>0</td></tr></tbody></table>	x	y	2	8	1	3	0	0	-1	-1	-2	0
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5.	$y = -2x + 1$ _____	6.	$y = x^2 + 2x$ _____	7.	$y = 3^x$ _____	8.	$y = (x + 1)^2 - 1$ _____	9.	$y = \frac{1}{2}x$ _____																																														

10. Circle the number(s) of the equation that show(s) a non-constant rate of change. 5 6 7 8
Explain your answer.

12. Becky graphed the equation in problem 8. Joe graphed the equation $y = x^2 - 1$. How does Joe's graph compare to Becky's graph?

- A) Joe's graph is translated down 1 units from Becky's graph.
B) Joe's graph is translated right 1 units from Becky's graph.

Exploring Student Responses

Solving Equations

- Skill: can solve an equation using multiple methods
- Conceptual: can create an equation with a particular solution



Skill (ABS): Solving Equations

$$16 - p = 7$$

How would students solve in 2nd semester, high school algebra I?



Skill (ABS): Solving Equations:

Solve: $16 - p = 7$ $\frac{-16}{-1} = \frac{-16 + 7}{-1}$	$p = \frac{-16 + 7}{-1}$
Solve: $16 - p = 7$ $\frac{-16}{-1} = \frac{-16 + 7}{-1}$	$p = -9$ ✓

In Year 1 of our project, 1,201 students completed an ABS measure in which this was the first item.

67% gave the correct answer.

18% gave the wrong answer.

15% skipped the item.



Skill (ACA): Solving Equations

$$4f + 6 = 26$$

- A. 5
- B. 8
- C. 20
- D. 32

How do you predict students solved?



Skill (ACA): Solving Equations

<p>Solve: $4f + 6 = 26$ $f =$</p> <p>$4f + 6 = 26$ $\quad \underline{-6}$ $4f = 20$ $\quad \underline{-4}$ $f = 5$</p> <p>a) 5 b) 8 c) 20 d) 32</p>	<p>Solve: $4f + 6 = 26$ $f =$</p> <p>$20 + 6 = 26$</p> <p><u>20</u></p> <p><u>20</u></p> <p><u>20</u></p> <p><u>20</u></p> <p><u>20</u></p> <p><u>20</u></p> <p>a) 5 b) 8 c) 20 d) 32</p> <p>0 ✓</p>	<p>Solve: $4f + 6 = 26$ $f =$</p> <p>$\begin{array}{r} 20 \\ -10 \\ \hline 10 \end{array}$</p> <p>a) 5 b) 8 c) 20 d) 32</p> <p>0</p>
<p>ASPM Algebra Screening & Progress Monitoring</p> <p>1127 students; First item on the measure</p>		<p>a. 79% b. 5% c. 4% d. 2%</p>

Conceptual (CoV): Solving Equations

Dan challenged Amy to write an equation that has a solution of 3. Which equation could Amy have written?

- A. $x + 2 = 3$
 B. $-2x = 6$
 C. $4 - x = 10 - 3x$
 D. $3 + x = -(x + 3)$

Conceptual (CoV): Solving Equations

Dan challenged Amy to write an equation that has a solution of 3. Which equation could Amy have written?

- A. $x + 2 = 3$
- B. $-2x = 6$
- C. $4 - x = 10 - 3x$
- D. $3 + x = -(x + 3)$

CoV A 2012-2013		
a	231	61.6
b	53	14.13333333
c	53	14.13333333
d	38	10.13333333
total	375	

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What do the data suggest?

- What areas of weakness?
- What areas of strength?

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Equal Sign—Two Levels of Understanding

Operational: Students see the equal sign as signaling something they must “do” with the numbers such as “give me the answer.”

Relational: Students see the equal sign as indicating two quantities are equivalent, they represent the same amount. More advanced relational thinking will lead to students generalizing rather than actually computing the individual amounts. They see the equal sign as relating to “greater than,” “less than,” and “not equal to.”

Knuth, E. et. al (2008). The importance of equal sign understanding in the middle grades. *Mathematics Teaching in the Middle School*, 13, 514–519.



Why is understanding the equal sign important?

Table 1 Percent of students at each grade level who provided each type of equal sign definition as their best definition ($n = 375$)

Best Definition	Grade 6	Grade 7	Grade 8
Relational	29	36	46
Operational	58	52	45
Other	7	9	8
No response/ don't know	6	3	1

Knuth, E. et. al (2008). The importance of equal sign understanding in the middle grades. *Mathematics Teaching in the Middle School*, 13, 514–519.



Skill (ACA): Evaluating expressions

Evaluate $2x + 3 - y^3$ when $x = 5$ and $y = -2$.

- A. 21
- B. 19
- C. 7
- D. 5

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Skill ACA: Evaluating Expressions

Evaluate $2x + 3 - y^3$ when
 $x = 5$ and $y = -2$

$$2(5) + 3 - 2y^3$$

$$10 + 3 - 2y^3$$

$$10 + 3 - 8y$$

$$-3 - 3$$

$$7 - 8y$$

- a) 21
- b) 19
- c) 7
- d) 5

✓ 0

Evaluate $2x + 3 - y^3$ when
 $x = 5$ and $y = -2$

$$2 \cdot 5 = 10 + 3 = 13 - 8 = 5$$

- a) 21
- b) 19
- c) 7
- d) 5

0 ✓

Evaluate $2x + 3 - y^3$ when
 $x = 5$ and $y = -2$

$$2(5) + 3 - (-2)^3$$

$$10 + 3 - 12$$

$$13 - 12$$

- a) 21
- b) 19
- c) 7
- d) 5

5

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1137 students;
11th item on the
measure

- a. 4%
- b. 48% 35% skipped
the item
- c. 9%
- d. 4%

Conceptual (PRA): Evaluating expressions

In the expression $2j - 8$, the value of j increases by $\frac{1}{2}$. What is the effect on the value of the expression?

- A. The value of $2j - 8$ increases by $\frac{1}{2}$
- B. The value of $2j - 8$ increases by 1
- C. The value of $2j - 8$ decreases by $\frac{1}{2}$
- D. The value of $2j - 8$ decreases by 8



Conceptual (PRA): Evaluating expressions

In the expression $2j - 8$, the value of j increases by $\frac{1}{2}$. What is the effect on the value of the expression?

PR A PR3 2012-2013		
a	81	50
b	21	12.96296296
c	47	29.01234568
d	13	8.024691358
total	162	

- A. The value of $2j - 8$ increases by $\frac{1}{2}$
- B. The value of $2j - 8$ increases by 1
- C. The value of $2j - 8$ decreases by $\frac{1}{2}$
- D. The value of $2j - 8$ decreases by 8



Conceptual (PRA): Evaluating expressions

In the expression $4b + 1$, the value of b increases by 5. What is the effect on the value of the expression?

- The value of the expression increases by 1
- The value of the expression increases by 5
- The value of the expression increases by 10
- The value of the expression increases by 20



Conceptual (PRA): Evaluating expressions

In the expression $4b + 1$, the value of b increases by 5. What is the effect on the value of the expression?

PR A PR10 2012-2013		
a	22	12.64367816
b	67	38.50574713
c	21	12.06896552
d	64	36.7816092
total	174	

- The value of the expression increases by 1
- The value of the expression increases by 5
- The value of the expression increases by 10
- The value of the expression increases by 20



What do the data suggest?

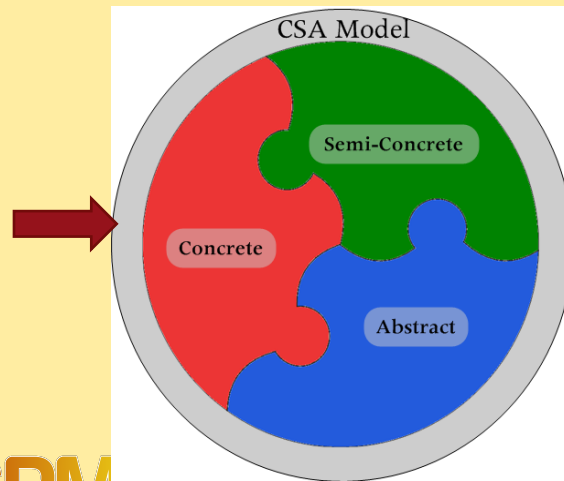
- What areas of weakness?
- What areas of strength?



Instructional Strategies



CSA: Concrete—Semi-Concrete— Abstract



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John de Villiers, 2006, & Bay-Williams, J. (2013). Elementary and Middle School Mathematics: Teaching developmentally. New York: Pearson.


CSA: Concrete—Semi-Concrete— Abstract

- Does not suggest a linear sequencing of representations
- Use representations concurrently
- Links representations, leading to the ability to working eventually with abstract symbols

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Create Mental Residues

- Establishes foundational understanding
- Models the physical action is the important
- Does not fade away or disappear
- Supports their thinking about the operation

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Dougherty, B. J. (2008). Measure up: A quantitative view of early algebra. In Kaput, J. J., Carraher, D. W., & Blanton, M. L. (Eds.), *Algebra in the early grades*, (pp. 389–412). Mahwah, NJ: Erlbaum.

Characteristics of tasks that promote learning

- Introduce every topic with problem solving
- Every lesson includes five forms of communication
 - Reading
 - Speaking
 - Critical listening
 - Writing
 - Multiple representations
- Topics are connected
- Students have 8–15 days to move a concept to a skill
- Challenging problems for all students

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Developing understanding

- Logical reasoning and by inspection

$$5 + x = 12$$

What number added to 5 equals 12?

What basic fact do you know that could tell you the missing addend?



Developing understanding

Working backwards and
fact families

$$32 = 17 + y$$

$$5 + x = 12$$

$$5 + x = 12$$

$$x + 5 = 12$$

$$12 - 5 = x$$

$$12 - x = 5$$



Developing understanding

- Making a table

$$3x + 2 = 4x - 3$$

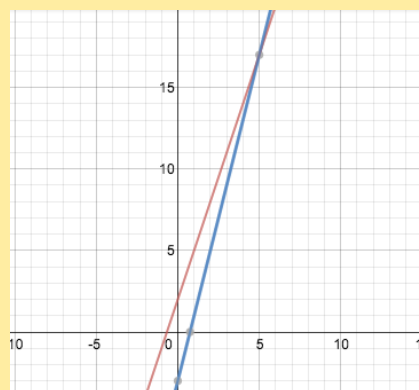
x	$3x + 2$	$4x - 3$
2	8	5
4	14	13
5	17	17

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Developing understanding

Graphing

$$3x + 2 = 4x - 3$$



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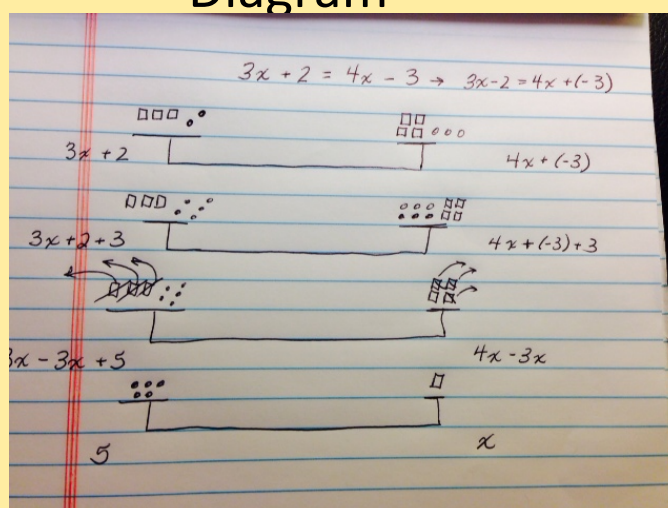
Developing understanding

Diagram

$$3x + 2 = 4x - 3$$

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Diagram



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Equivalent Equations

$$3x + 2 = 4x - 3$$

$$3x + 2 + 3 = 4x - 3 + 3$$

$$3x - 3x + 5 = 4x - 3x$$

$$5 = x$$



Equivalent Equations

$$3x + 2 = 4x - 3$$

$$3x + 5 = 4x \quad A_3$$

$$5 = x \quad S_{3x}$$



Changing our questioning techniques



Changing skill tasks to support deeper thinking

Solve for x :

a. $2x + 4 = 3x - 8$



Change the Task

- Reversibility question
 - Find an equation whose solution is 12.
 - Find another equation, with variables on both sides of the equal sign, whose solution is 12.

Change the Task

- Generalization questions
 - Find a linear equation whose solution is a whole number.
 - Is it possible to predict if the solution of an equation is a whole number? Why or why not?

Change the Task

- Flexibility question

Solve:

$$2x - 8 = 3x + 4$$

Solve it another way.



57

Change the Task

- Flexibility question

Solve:

$$2x - 8 = 12$$

$$2(x + 2) - 8 = 12$$

$$2(2x + 2) - 8 = 12$$



58

You try!

2-4 Solving Two-Step and Multi-Step Inequalities Algebra 1

Lesson & Examples Guided Practice Practice & Problem Solving

PRACTICE AND PROBLEM SOLVING

Independent Practice Skills Practice Application Practice

Solve each inequality and graph the solutions.

16. $4r - 9 > 7$ 17. $3 \leq 5 - 2x$ 18. $\frac{w+3}{2} > 6$ 19. $11w + 99 < 77$
 20. $9 \geq \frac{1}{2}v + 3$ 21. $-4x - 8 > 16$ 22. $8 - \frac{2}{3}z \leq 2$ 23. $f + 2\frac{1}{2} < -2$
 #39 24. $\frac{3n-8}{5} \geq 2$ 25. $-5 > -5 - 3w$ 26. $10 > \frac{5-3p}{2}$ 27. $2v + 1 > 2\frac{1}{3}$
 #43 28. $4(x+3) > -24$ 29. $4 > x - 3(x+2)$ 30. $-16 \geq 33 - 3h$
 #45 31. $-2 > 7x - 2(x-4)$ 32. $9 - (9)^2 > 10x - x$ 33. $2a - (-3)^2 \geq 13$
 #49 34. $6 - \frac{x}{3} + 1 > \frac{2}{3}$ 35. $12(x-3) + 2x > 6$ 36. $15 \geq 19 + 2(q-18)$
 #51 37. **Communications** One cell phone company offers a plan that costs \$29.99 and includes unlimited night and weekend minutes. Another company offers a plan that costs \$19.99 and charges \$0.35 per minute during nights and weekends. For what numbers of night and weekend minutes does the second company's plan cost more than the first company's plan?
 #53
 #59

Solve each inequality and graph the solutions.

38. $-12 > -4x - 8$ 39. $5x + 4 \leq 14$ 40. $\frac{2}{3}x - 5 > 7$
 41. $x - 3x > 2 - 10$ 42. $5 - x - 2 > 3$ 43. $3 < 2x - 5(x+3)$
 44. $\frac{1}{6} - \frac{2}{3}m \geq \frac{1}{4}$ 45. $4 - (r-2) > 3 - 5$ 46. $0.3 - 0.5n + 1 \geq 0.4$
 47. $6^2 > 4(x+2)$ 48. $-4 - 2n + 4n > 7 - 2^2$ 49. $\frac{1}{4}(p-10) \geq 6 - 4$
 50. Use the inequality $-4r - 8 \leq 12$ to fill in the missing numbers.

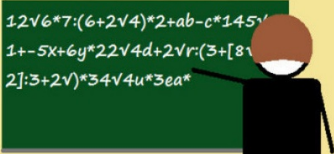
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Example based teaching

- Here's how you.
- Now you solve these.
- I do
- We do
- You do

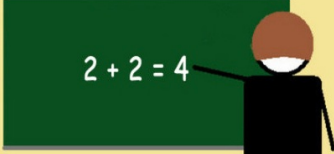
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What's on the blackboard



$12\sqrt{6} * 7 * (6 + 2\sqrt{4}) * 2 + ab - c * 145$
 $1 + -5x + 6y * 22\sqrt{4}d + 2\sqrt{r} * (3 + [8$
 $2] : 3 + 2\sqrt{v} * 34\sqrt{4}u * 3ea *$

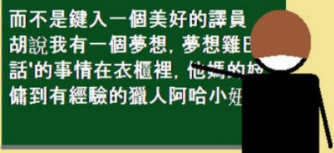
What the teacher is seeing



$2 + 2 = 4$


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What the students are seeing



而不是鍵入一個美好的譯員
 胡說我有一個夢想，夢想雞白
 話'的事情在衣櫃裡，他媽的
 備到有經驗的獵人阿哈小好

What the students remember



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Teaching and Learning

- Telling isn't teaching.
- Told isn't taught.
- Listening isn't learning.



Discussion Questions? Comments?

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(to learn more about access to the procedural measures, contact Anne or visit

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