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Beyond Fluency: Deepening Knowledge About What Students Know

Grades K – 5

Marla Olson
maolson@cojusd.org

Christine Roberts
croberts@ers.tcoe.org
@tcoechristine

Beyond Fluency: Deepening Knowledge About What Students Know

When talking about our session and the conference on social media, please use the CMC twitter handle @CAMathCouncil and hashtag #cmcmath.

Table Introductions

- Introduce yourself to your table. Include your role, grade-level(s), district, and an interesting fact.
- Share what you are hoping to learn during this session.

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Outcomes

- Understand our COJUSD district approach to developing and assessing fluency.
- Gain a deeper understanding of how our district plan is supporting students in increasing their fluency with numbers and operations so that they can better meet the rigor of the CCSSM.
- Discuss shifts in teacher knowledge of student thinking gained through their work with the phases of fluency and formative assessments.

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Cutler – Orosi Joint Unified School District

Cutler-Orosi	
Population 2010	18,269
Hispanic/Latino	88%
White	5.7%
Asian	5.2%
Other	1.1%
Primary Industry	Agriculture
Unemployment Rate	30.1%
Per Capita Income	$11,929
Free/Reduced Meals	100%

4,178 students
49.7% English Learners

3 Elementary Schools (Cutler, Golden Valley, Palm)
El Monte Middle School (6th – 8th)
Orosi High School
Lovell (Alternative)

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Our Approach to Fluency: An Overview

As we began our work with fluency, we needed to:

- Understand how fluency could be a vehicle to support deeper student understanding.
- Redefine what math fact fluency is and what it should look like.
- Describe ways to develop fluency with students.
- Assess fluency across the district formatively and find a way to report this information quarterly.
- Reflect on what we were learning and make adjustments.

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Why focus on mathematical fluency?

Why focus on fluency?

https://flic.kr/p/4GW2c2

To support all students in accessing rich mathematics content.

Fluency in Mathematics

"According to CCSSM, fluency is "skill in carrying out procedures flexibly, accurately, efficiently and appropriately" (CCSSO 2010, p. 6). Thus, far from just being a measure of speed, fluency with multiplication facts involves flexibly and accurately using an appropriate strategy to find the answer efficiently."

- *Three Steps to Mastering Multiplication Facts* by Gina Kling and Jennifer Bay-Williams

"Three Steps to Mastering Multiplication Facts", Gina Kling and Jennifer Bay-Williams, Teaching Children Mathematics, May 2015, Vol.21, issue 9, http://www.nctm.org/Publications/Teaching-Children-Mathematics/2015/Vol21/Issue9/Three-Steps-to-Mastering-Multiplication-Facts/

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Fluency Standards in Grades K - 6

Grade	Fluency Standard
K	K.OA.5 Fluently add and subtract within 5.
1	1.OA.6 Add and subtract within 20, demonstrating fluency for addition and subtraction within 10. Use strategies such as counting on; making ten (e.g., 8 + 6 = 8 + 2 + 4 = 10 + 4 = 14); decomposing a number leading to a ten (e.g., 13 – 4 = 13 – 3 – 1 = 10 – 1 = 9); using the relationship between addition and subtraction (e.g., knowing that 8 + 4 = 12, one knows 12 – 8 = 4); and creating equivalent but easier or known sums (e.g., adding 6 + 7 by creating the known equivalent 6 + 6 + 1 = 12 + 1 = 13).
2	2.OA.2 Fluently add and subtract within 20 using mental strategies.[2] By end of Grade 2, know from memory all sums of two one-digit numbers. (Footnote: 2. See standard 1.OA.6 for a list of mental strategies.) 2.NBT.5 Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction.
3	3.OA.7 Fluently multiply and divide within 100, using strategies such as the relationship between multiplication and division (e.g., knowing that 8 × 5 = 40, one knows 40 ÷ 5 = 8) or properties of operations. By the end of Grade 3, know from memory all products of two one-digit numbers. 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.
4	4.NBT.4 Fluently add and subtract multi-digit whole numbers using the standard algorithm.
5	5.NBT.5 Fluently multiply multi-digit whole numbers using the standard algorithm.
6	6.NS.2 Fluently divide multi-digit numbers using the standard algorithm. 6.NS.3 Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation.

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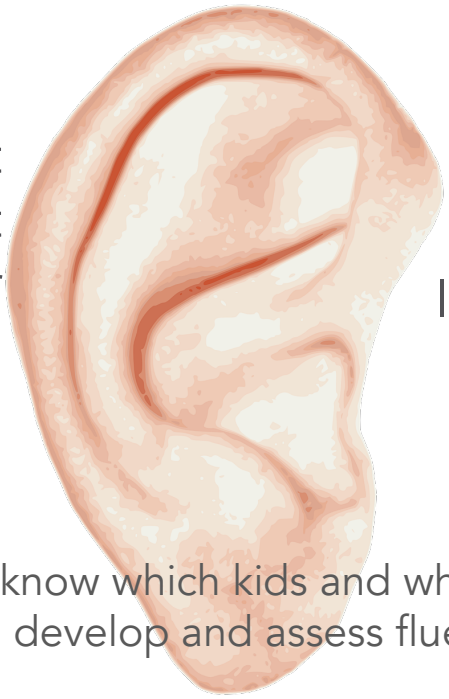
Too often we hear that the kids don't know their basic facts . . .



Instead ask:
Which kids?
And
Which facts?

In order to know which kids and which facts, we need to develop and assess fluency.

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Redefining Mathematical Fluency

What is fluency?
How do we shift beliefs about what it is and is not?

Fast and accurate

Flexible, appropriate use of strategies, efficient, and accurate thinkers

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What is fluency in mathematics?

"According to CCSSM, fluency is "skill in carrying out procedures flexibly, accurately, efficiently and appropriately" (CCSSO 2010, p. 6). Thus, far from just being a measure of speed, fluency with multiplication facts involves flexibly and accurately using an appropriate strategy to find the answer efficiently."

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What is fluency in mathematics?

NCTM Position Paper, p. 2-3

Fluency is not a simple idea. Being fluent means that students are able to choose flexibly among methods and strategies to solve contextual and mathematical problems, they understand and are able to explain their approaches, and they are able to produce accurate answers efficiently. Fluency builds from initial exploration and discussion of number concepts to using informal reasoning strategies based on meanings and properties of the operations to the eventual use of general methods as tools in solving problems.

- Principles to Actions: Ensuring Mathematical Success for All, NCTM, p. 42

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Mastering Basic Facts

Phase 1: Counting
(Counts or counts on with objects or mentally)

Phase 2: Deriving
(Reasoning strategies based on known facts)

Phase 3; Mastery
(Efficient production of answers)

Adapted from Baroody, 2006

"Enriching Addition and Subtraction Fact Mastery Through Games" by Gina Kling and Jennifer Bay-Williams, Teaching Children Mathematics Volume 21, No. 4, November 2014

Research Findings

Study of students learning math facts in two ways – through *strategies* or *memorization*.

"Importantly the study...found that those who learned through strategies achieved 'superior performance' over those who memorized, they solved problems at the same speed, and showed better transfer to new problems." (Delazer et al, 2005)

From "Fluency Without Fear: Research Evidence on the Best Ways to Learn Math Facts" by Jo Boaler, 2015, page 4

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Research Findings

"…research evidence points in one direction: The best way to develop fluency with numbers is to develop number sense and to work with numbers in different ways, not to blindly memorize without number sense."

– Boaler, Page 3

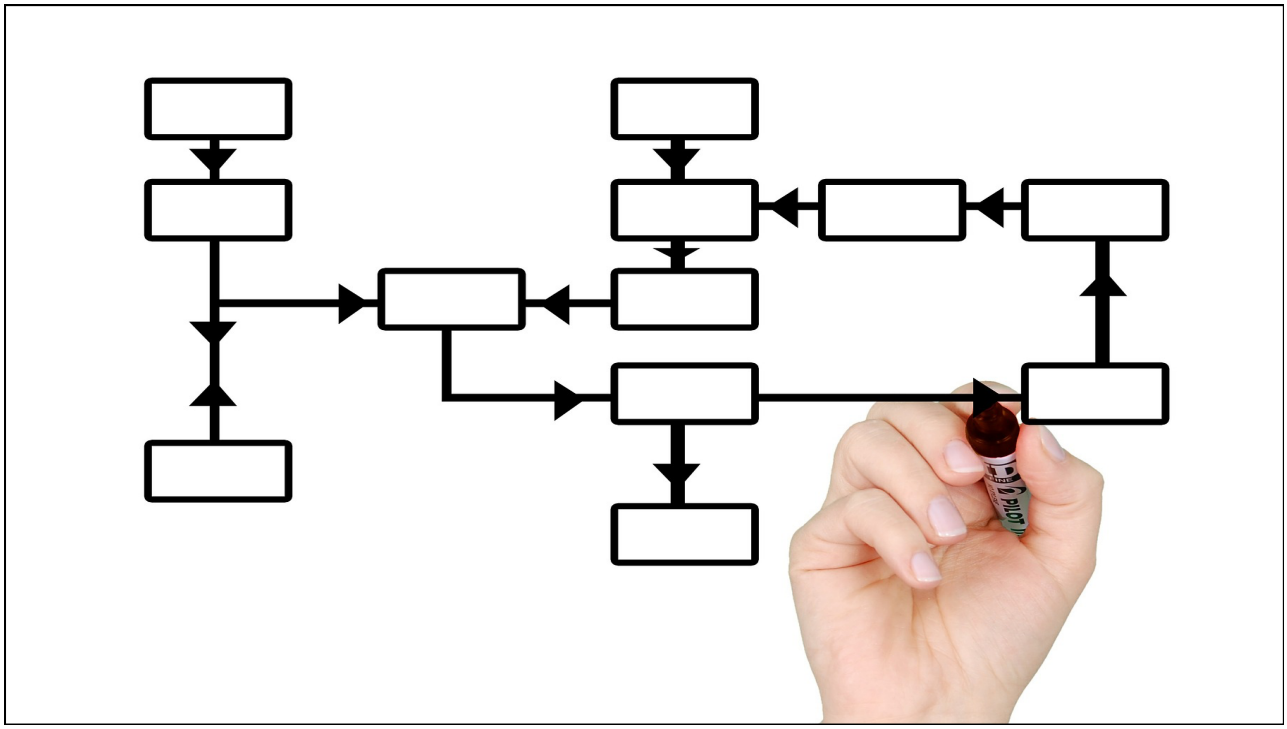
From "Fluency Without Fear: Research Evidence on the Best Ways to Learn Math Facts" by Jo Boaler, 2015, page 3

Research Findings

Data from 13 million 15-year olds on the International PISA mathematics test.

"...the *lowest* achieving students are those who focus on memorization and who believe that memorizing is important when studying mathematics. The *highest* achievers in the world are those who focus on big ideas in mathematics and connections between ideas.

From "Fluency Without Fear: Research Evidence on the Best Ways to Learn Math Facts" by Jo Boaler, 2015, page 5



Supporting Fluency School & District Wide

- Develop fluency 5 – 15 minutes daily using:
  - Number Talks
  - Routines
  - Games
- Assess fluency 1-2 times per month using formative assessments.
- Use these assessments to guide your on-going fluency instruction and support.
- Report student fluency phases quarterly.

Discuss

- What new insights have you gained about what mathematical fluency is?
- What questions do you have?

Developing Fluency

In what ways do you develop student fluency?

Developing Fluency

When and How?

- Daily for 5 - 15 minutes.
- At the end of the lesson or during another time in the day (fluency work cannot overshadow the lesson for the day).

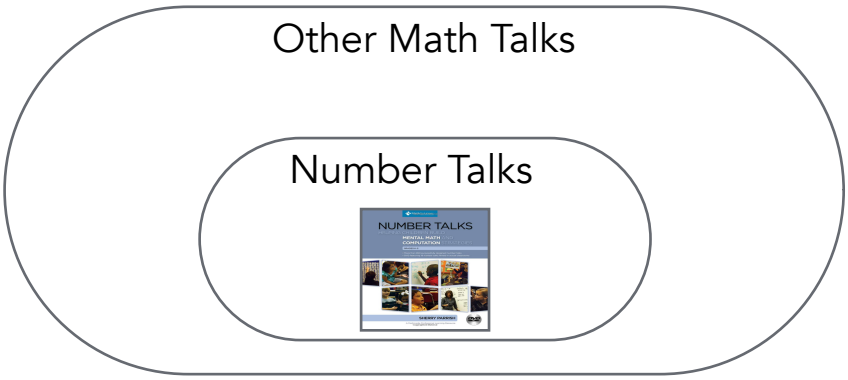
Number Talks	Games	Meaningful Practice
Quick Images/Visuals Rekenreks Computational problems Number strings (series of related computational problems)	Targeted Practice (focus on a particular group of facts) General Practice (all facts for a particular operation) Computer games/Apps	Story Problems Contextual problems Ten Frames/Arrays Visual representations

Number Talks

Use Number Talks to:

- Explore specific strategies.
- Make connections between strategies.
- Compare strategies to deepen understanding and increase efficiency.
- Provide opportunities for students to hear about and utilize new strategies.

Math Talks & Routines



Counting Routines

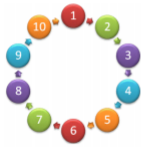
- Choral Counting – Students count a number sequence aloud together.
- Count Around the Clock – Choose a counting sequence. One at a time, students count around the circle.
- Start and Stop Counting – Similar to Choral Counting with a "Start" and "Stop" number. Students may be able to identify the difference between the numbers.

https://flic.kr/p/4zFnC8

Adapted from Number Sense Routines: Building Numnerical Literacy Every Day in Grades K-3, Jessica F. Shumway, pages 24-25

I HAVE...?, WHO HAS . . .?

I have 80. Who has 20+20?	I have 40. Who has 10+20?



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Context

- How many peeps?
- How does 3 x 16 appear in this picture?
- How does 4 x 12 appear in this picture?
- How does 4 x (3 x 4) appear in this picture?

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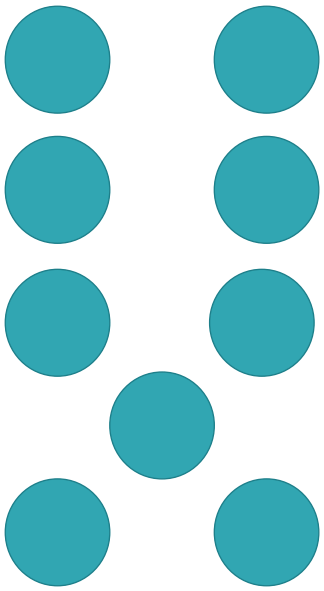
Quick Images/Visual Number Talks



Elham Kazemi and Allison Hintz, Intentional Talk

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T - F Equations

Decide if the equations are true or false. Explain your answer.

a. $2 + 5 = 6$
b. $3 + 4 = 2 + 5$
c. $8 = 4 + 4$
d. $3 + 4 + 2 = 4 + 5$
e. $5 + 3 = 8 + 1$
f. $1 + 2 = 12$
g. $12 = 10 + 2$
h. $3 + 2 = 2 + 3$
i. $32 = 23$

Illustrative Mathematics, https://www.illustrativemathematics.org/content-standards/1/OA/D/7/tasks/466

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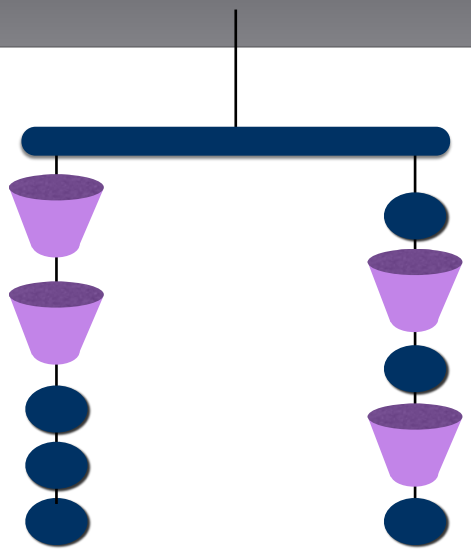
Balance Puzzles

This mobile *always* balances.

Why?



Transitions to Algebra, https://solveme.edc.org/Mobiles.html

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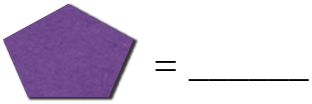
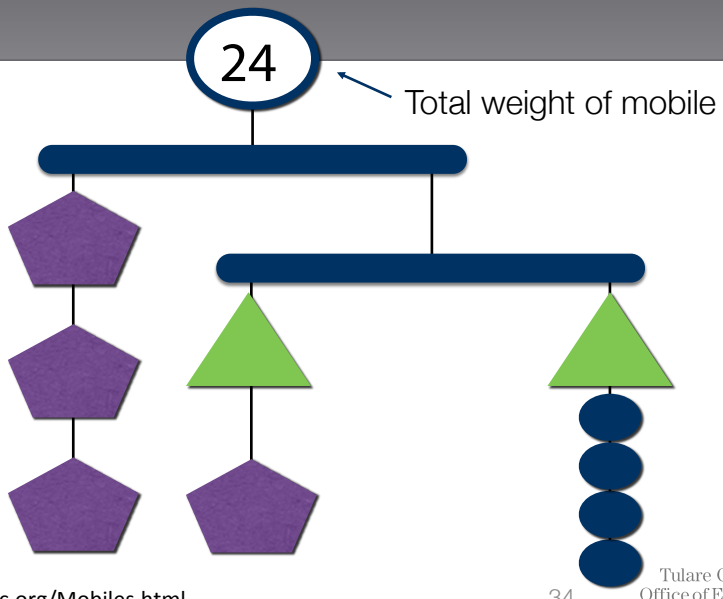
Mobile Puzzles



= _____

= _____

= _____



Transitions to Algebra, https://solveme.edc.org/Mobiles.html

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Which one doesn't belong?

4	8	9	12

Inspired by http://wodb.ca/

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Find the Factors

FIND THE FACTORS 1-10 587

X										
			40							
								20		
	8			32		40			72	
			50							
								6		
			20							
								18		
		36			18		42			48
			70							
								2		

Level TWO © 2015 Iva Sallay findthefactors.com

Non-commercial use copying permitted

http://findthefactors.com/category/puzzles/level-2-puzzle/

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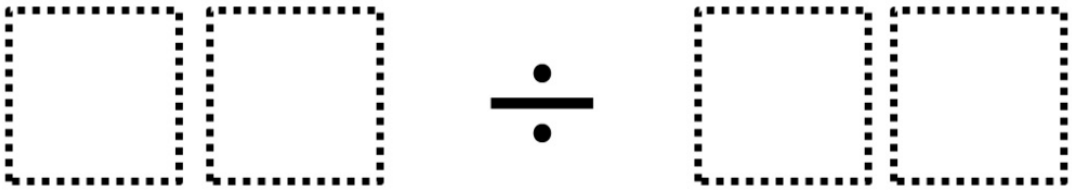
Open Middle

Make the largest quotient by filling in the boxes using whole numbers 1 – 9 no more than 1 time each.



Open Middle, http://www.openmiddle.com/dividing-two-digit-numbers-elementary/ 37

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Fluency Games

Why use games?

- Are engaging.
- Provide opportunities for strategy discussion and assessment.
- Should be sequenced developmentally.
- Can be targeted practice or general practice.
- Lend to differentiation.

Developing and Assessing Fact Fluency, Amanda Ruch and Gina Kling, NCTM 2015 38

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Salute

Phase 2 – 3

- 3 students: 1 leader, 2 players
- The leader hands each player a card.
- The leader says "Salute!"
- The players put their cards on their foreheads.
- The leader says the sum/product of the cards.
- The players work to determine the number on their forehead. Once both players have done so, they look at their cards and then students rotate roles.

"Enriching Addition and Subtraction Fact Mastery Through Games" by Gina Kling and Jennifer Bay-Williams, Teaching Children Mathematics Volume 21, No. 4, November 2014

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Multiplication Game

Race to the top!!

1	2	3	4	5	6	8	9	10	12	15	16	18	20	24	25	30	36
1	2	3	4	5	6	8	9	10	12	15	16	18	20	24	25	30	36
1	2	3	4	5	6	8	9	10	12	15	16	18	20	24	25	30	36
1	2	3	4	5	6	8	9	10	12	15	16	18	20	24	25	30	36
1	2	3	4	5	6	8	9	10	12	15	16	18	20	24	25	30	36
1	2	3	4	5	6	8	9	10	12	15	16	18	20	24	25	30	36
1	2	3	4	5	6	8	9	10	12	15	16	18	20	24	25	30	36
1	2	3	4	5	6	8	9	10	12	15	16	18	20	24	25	30	36
1	2	3	4	5	6	8	9	10	12	15	16	18	20	24	25	30	36
1	2	3	4	5	6	8	9	10	12	15	16	18	20	24	25	30	36
1	2	3	4	5	6	8	9	10	12	15	16	18	20	24	25	30	36

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Questions to Ask During Fluency Games

Use questions such as the following to encourage good mathematical thinking during and after game play:

- How did you figure it out?
- Can you say out loud how you thought about it in your head?
- Is there another way you could figure it out?
- Can you think of another fact that strategy would work well for?
- If someone didn't know the answer to____, how would you tell them to figure it out?
- What are you hoping for next?
- What are all the possibilities?

Discuss

- What connections have you made between our approach to developing fluency and work you are doing?
- What new ideas do you have based on what you have heard?

Assessing Fluency

What can we learn assessments about student thinking?

Assessing Fluency

Procedural fluency is "skill in carrying out procedures flexibly, accurately, efficiently and appropriately" (CCSSO 2010, p. 6).

CCSSO 2010, p. 6. 44

Assessing Fluency using the Phases

Phase 1 Counting	Phase 2 Deriving	Phase 3 Mastery
Student using counting strategies to solve. The student counts or counts on with objects or mentally.	Student uses reasoning strategies to solve. The student uses strategies based on known facts to solve for a given problem.	Student knows the fact from memory or uses a procedure efficiently and accurately to solve for an answer.

- On-going use of formative assessments.
- Each Quarter, students will receive a score for each fluency standard assessed indicating their current phase of fluency.

2.NBT.5 - Assessing Fact Fluency

Procedural fluency is "skill in carrying out procedures flexibly, accurately, efficiently and appropriately" (CCSSO 2010, p. 6).

Grade Level Fluency Standard:	2.NBT.5 Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction.

Mastering Basic Facts

Phases of Fluency

Phase 1 Counting	Phase 2 Deriving	Phase 3 Mastery
Student counts or counts on with objects or mentally.	Student uses reasoning strategies based on known facts.	Student has efficient strategies to produce answers.

Adapted from Baroody, 2006, "Enriching Addition and Subtraction Fact Mastery Through Games" by Gina Kling and Jennifer Bay-Williams, Teaching Children Mathematics, Vol. 21, No. 4, November 2014

Assessing Fluency

Our fluency assessments need to assess all four components of fluency in order for us to be able to determine the phase of fluency that each student is currently in.

Four Components of Fluency	Ways to Assess Fluency
Can our students demonstrate their fluency in these four ways? ❑ Flexibly ❑ Accurately ❑ Efficiently ❑ Appropriately	What evidence do we have that students are in a particular phase of fluency? • Observation • Interviews • Writing prompts • Strategy quizzes • Fact assessments • Self-assessment

Quarterly Fluency Reporting

For each student, record which of phase of fluency they are currently at based on assessing all four components of fluency. Enter these scores into Illuminate each quarter.

Student Name	Q2	Q3	Q4
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			

Grades K – 2

Grade	Fluency Standards to Develop, Assess, & Report
K	K.OA.5 Addition, K.OA.5 Subtraction
1	1.OA.6 Addition, 1.OA.6 Subtraction
2	2.OA.2 Addition, 2.OA.2 Subtraction, 2.NBT.5 Addition and Subtraction

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Grade 3

Grade	Fluency Standards to Develop, Assess, & Report
3	3.NBT.2 Addition and Subtraction
	3.OA.7 Multiplication (All Quarters)
	3.OA.7 Division (Q3 and Q4)

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Grades 4 – 5

Grade	Fluency Standards to Develop, Assess, & Report
4	3.OA.7 Multiplication, 3.OA.7 Division 4.NBT.4 Addition and Subtraction
5	3.OA.7 Multiplication, 3.OA.7 Division 5.NBT.5 Multi-digit multiplication

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Ways to Assess Fluency

- Observation
- Interviews
- Writing prompts
- Strategy quizzes
- Self-assessment

Developing and Assessing Fact Fluency, Gina Kling and Jennifer Bay-Williams, NCTM 2015

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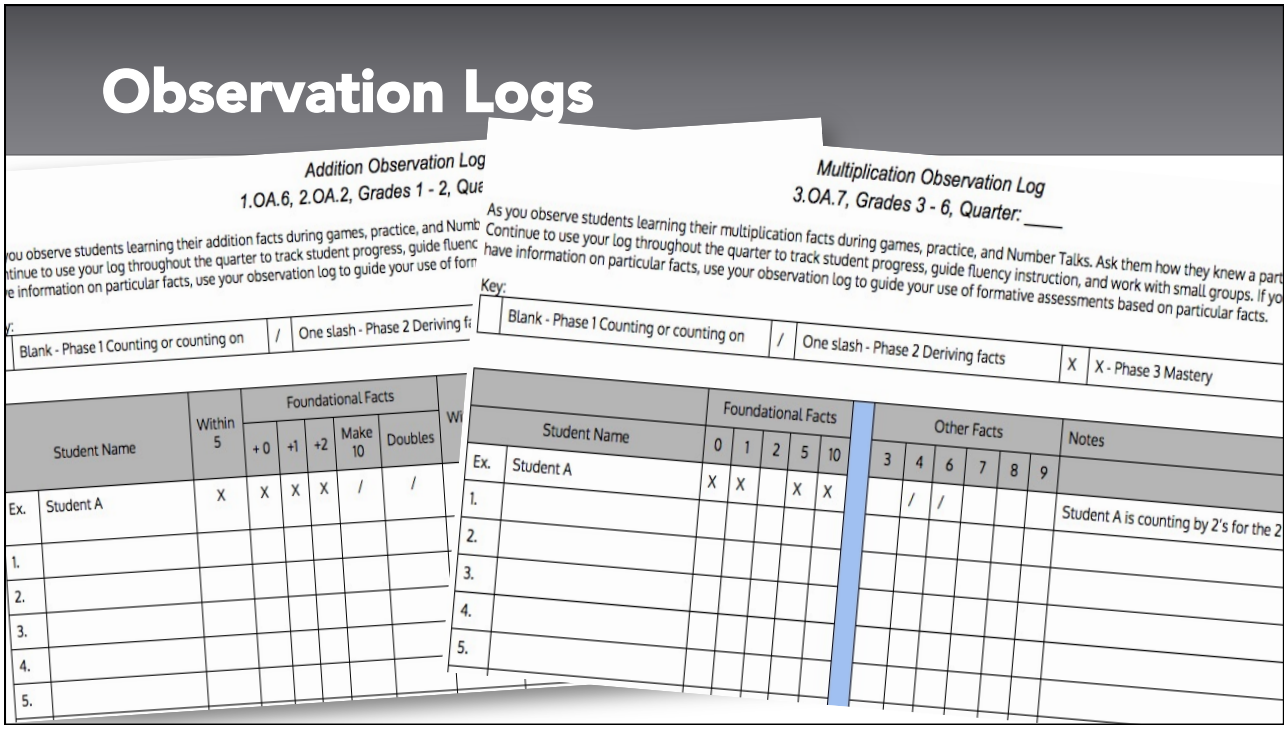
Observation Logs



Addition Observation Log

1.OA.6, 2.OA.2, Grades 1 - 2, Que

ou observe students learning their addition facts during games, practice, and Numb
ntinue to use your log throughout the quarter to track student progress, guide fluenc
e information on particular facts, use your observation log to guide your use of form

y:

Blank - Phase 1 Counting or counting on	/	One slash - Phase 2 Deriving fa

Student Name	Within 5	Foundational Facts					Wi
		+0	+1	+2	Make 10	Doubles	
Ex. Student A	X	X	X	X	/	/	
1.							
2.							
3.							
4.							
5.							

Multiplication Observation Log

3.OA.7, Grades 3 - 6, Quarter: ____

As you observe students learning their multiplication facts during games, practice, and Number Talks. Ask them how they knew a part
Continue to use your log throughout the quarter to track student progress, guide fluency instruction, and work with small groups. If yo
have information on particular facts, use your observation log to guide your use of formative assessments based on particular facts.

Key:

Blank - Phase 1 Counting or counting on	/	One slash - Phase 2 Deriving facts	X	X - Phase 3 Mastery

Student Name	Foundational Facts					Other Facts						Notes
	0	1	2	5	10	3	4	6	7	8	9	
Ex. Student A	X	X		X	X		/	/				Student A is counting by 2's for the 2
1.												
2.												
3.												
4.												
5.												

Observation Logs

- Use you observation log as you monitor students during fluency games, practice, and math tasks.
- Mark the facts that students know indicating which level they are at.
- Make notes about what students say they are thinking or doing as they solve.
- Use your log to decide which games to play, facts to practice, and small groups to work with.

How do we know what they're thinking?

https://flic.kr/p/djaFxZ

Interviews/Journal Prompts

1. What does 4 + 3 mean?
2. What is your solution to 4 + 3 ?
3. How did you find your solution? Can you find it another way?
4. If your friend was having trouble solving this problem, what strategy might you suggest to him/her?

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Interviews

Flexibility	Accuracy
Solve 6 + 7 using one strategy. Now try solving it using a different strategy.	What is the answer to 7 + 8? How do you know it is correct? How might you check it?
Efficiency	**Appropriate Strategy Selection**
Which facts did you just know (know in your mind)? Which facts did you use a strategy? Which strategy did you use and why?	Emily solved 6 + 8 by changing it in her mind to 4 + 10. What did she do? Is this a good strategy? Tell why or why not?

Developing and Assessing Fact Fluency, Gina Kling and Jennifer Bay-Williams, NCTM 2015

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Video: Gr.2 Fact Fluency Assessment

https://www.youtube.com/watch?v=yBMXxiAzd3I

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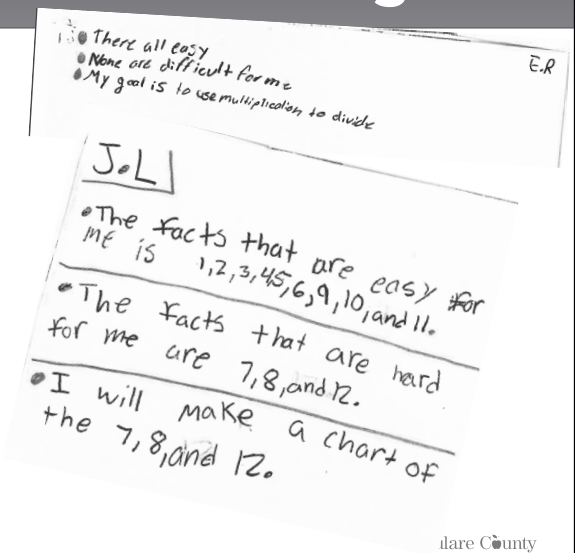
Self-Assessment and Self Monitoring

- Self Assessment 3x5 Card:
  - Which facts are easy for you?
  - Which facts are difficult for you?
  - Write a goal you have for learning your facts.



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Fact Assessments

- Repurpose traditional fact assessments as strategy quizzes or gather more information by including a writing prompt.
- No visible timing (This does not mean they have all day to finish, so you can ask students to stop and collect the papers when you are ready to move on.)
- You can connect these to strategy quizzes. For example,
  - Solve all the facts you know in your mind. Skip the others. ☺
  - Only solve the ones where you can use double or near doubles.
  - Solve the facts that make ten.
  - Solve only the facts you need to work out.
  - Solve only the products that are greater than 36.

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Supporting Fluency School & District Wide

- Develop fluency 5 – 15 minutes daily using:
  - Number Talks
  - Routines
  - Games
- Assess fluency 1-2 times per month using formative assessments.
- Use these assessments to guide your on-going fluency instruction and support.
- Report student fluency phases quarterly.

What have we learned? What were the results?

Teacher Feedback

- That fluency is important for all grade levels.
- Games can help students become more fluent.
- Questioning is an important component of playing games.
- Discussions after a game are very important.
- Students must be flexible, accurate, efficient, and appropriate to be fluent.
- There are 4 aspects of fluency (above) and our curriculum only assesses one.
- Understand the three phases of fluency.

Conversations Shifted . . .

SBAC Claims

1. Concepts and Procedures
2. Problem Solving
3. Communicating Reasoning
4. Modeling and Data Analysis

Where does fluency fit?

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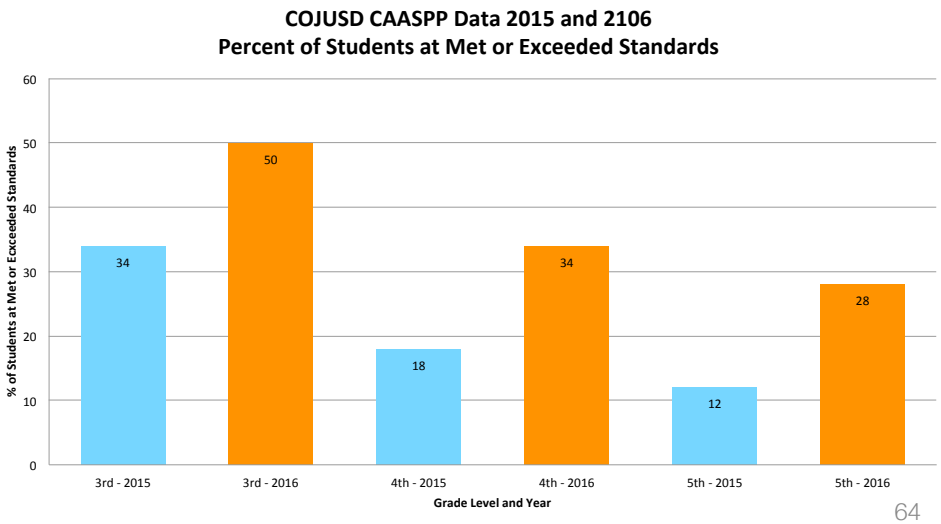
CAASPP Data 2015 and 2016



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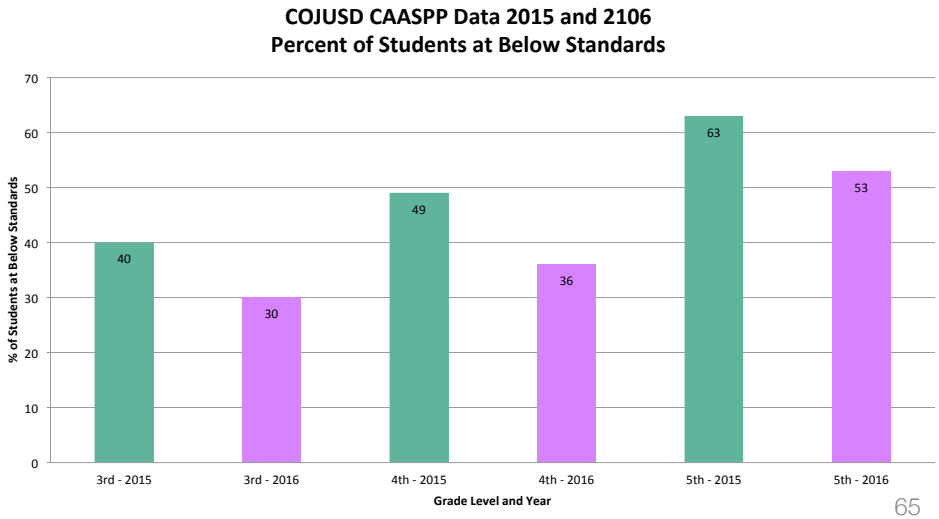
CAASPP Data 2015 and 2016



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Outcomes

- Understand our COJUSD district approach to developing and assessing fluency.
- Gain a deeper understanding of how our district plan is supporting students in increasing their fluency with numbers and operations so that they can better meet the rigor of the CCSSM.
- Discuss shifts in teacher knowledge of student thinking gained through their work with the phases of fluency and formative assessments.

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Discuss

- What are your next steps with fluency?
  - Write it down.
  - Share your next step with your table.

Resources

- Bay-Williams, Jennifer M. and Gina Kling. 2014. Enriching Addition and Subtraction Fact Mastery Through Games. Teaching Children Mathematics, V. 21, N. 4, 238-247.
- Boaler, Jo. 2015. Fluency Without Fear: Research Evidence on the Best Ways to Learn Math Facts. https://www.youcubed.org/fluency-without-fear/
- Developing and Assessing Fact Fluency, Amanda Ruch and Gina Kling, and Gina Kling and Jennifer Bay-Williams, NCTM 2015
- Kling, Gina and Jennifer M. Bay-Williams. 2014. Assessing Basic Fact Fluency. Teaching Children Mathematics, Volume 20, Number 8, 488-497.
- Kling, Gina and Jennifer M. Bay-Williams. 2015. Three Steps to Mastering Multiplication Facts. Teaching Children Mathematics, Volume 21, Number 9, 548-559.
- NCTM, *Principles to Actions: Ensuring Mathematical Success for All, NCTM*

Resources

- TCOE Common Core Connect, http://ccss.tcoe.org/
- You Cubed, https://www.youcubed.org/
- Open Middle, http://www.openmiddle.com/
- Estimation 180, http://www.estimation180.com/
- Mobile Puzzles, http://ttalgebra.edc.org/puzzles
- Find the Factors, http://findthefactors.com/
- Which One Doesn't Belong?, http://wodb.ca/index.html
- North Carolina Math Games, http://maccss.ncdpi.wikispaces.net/Elementary

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Thank you and enjoy the conference!

Contact us.

Cutler Orosi Joint Unified School District

Tulare County Office of Education
Jim Vidak, County Superintendent of Schools

Marla Olson
maolson@cojusd.org

Christine Roberts
croberts@ers.tcoe.org

@tcoechristine

Your feedback is appreciated.

Send your text message to: 37607

Type: 580620 SPACE (0-3)(0-3)(0-3) SPACE other comments or feedback in words

Session matched description

Engaging and effective

Well prepared and knowledgeable

Strongly Disagree	Disagree	Agree	Strongly Agree
0	1	2	3

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