Magic Squares:

Equipping Students & Anticipating Responses

Doug O' Roark

AGENDA

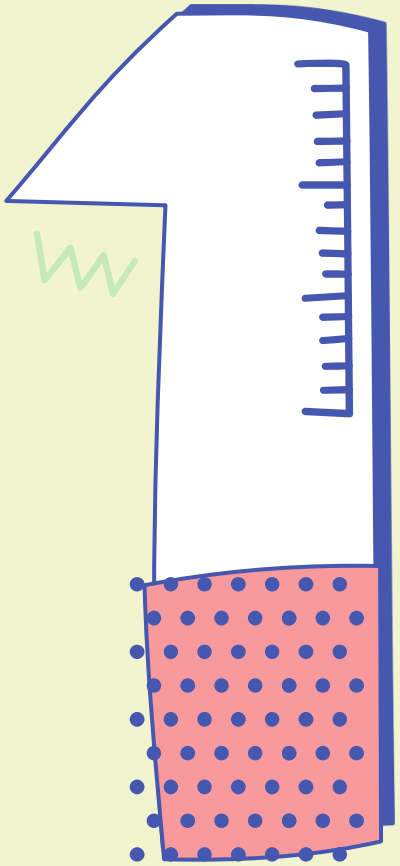
Doug O' Roark

he/him

1. MC2: Context for math circle access

1.5. TRU: A Common Language

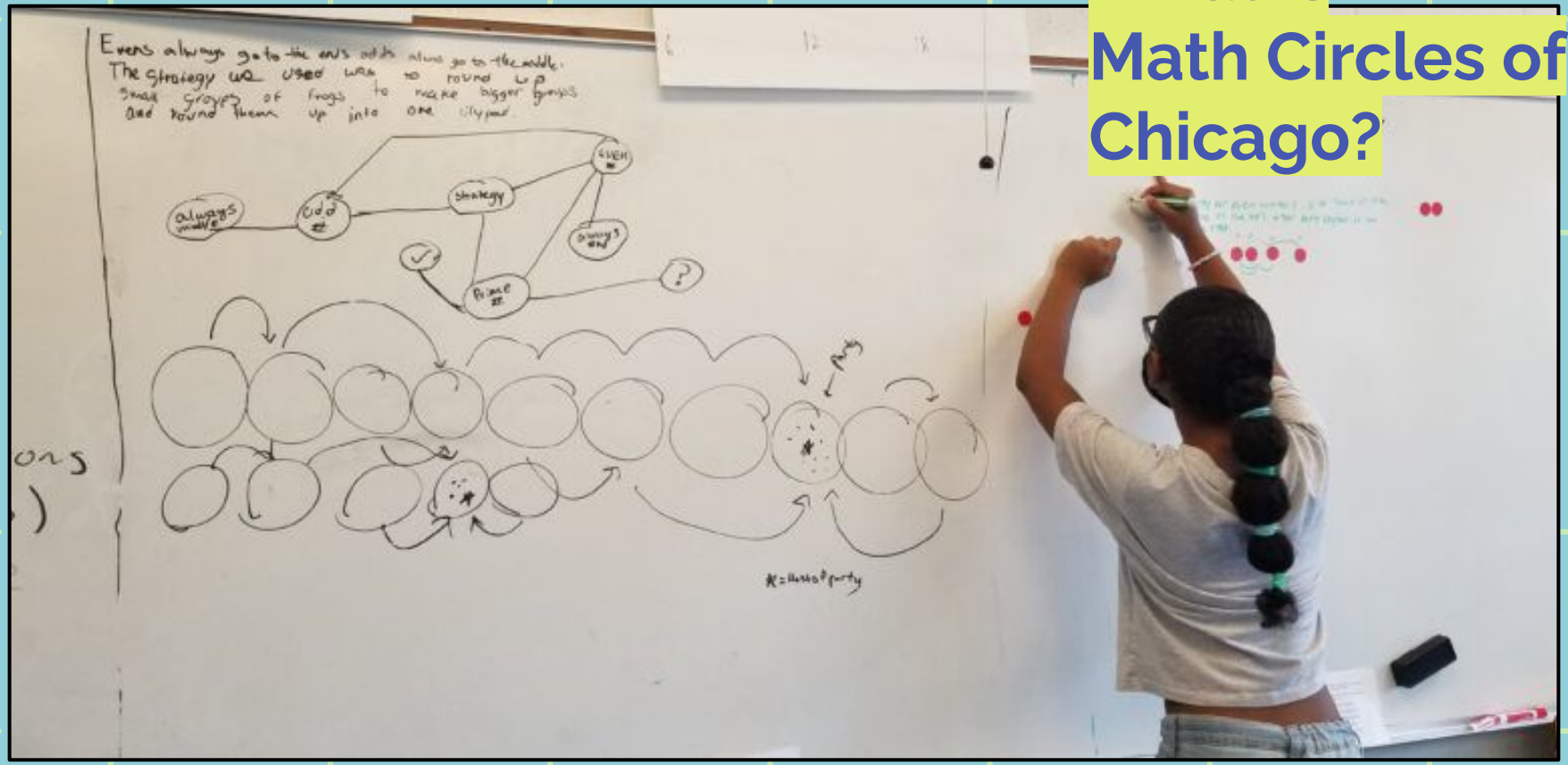
2. Magic Squares: Before & After



01

Math Circles of Chicago

What is Math Circles of Chicago?



Level 1: Julia Robinson Math Festivals

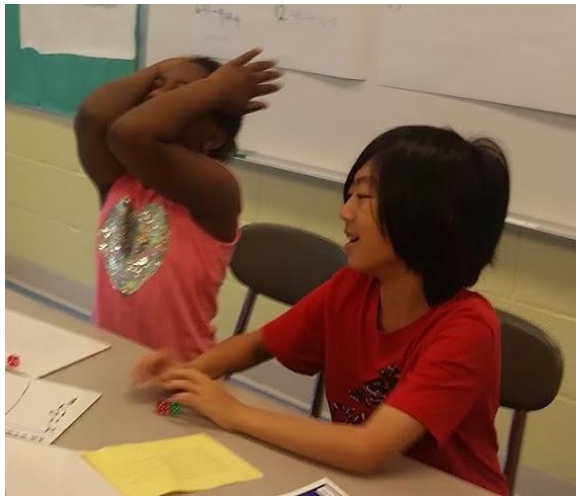
- 40 Festivals in SY 2024-25, serving 3,000+ children

Julia Robinson Mathematics Festival

Level 2: Math Circles at Hubs

- 3rd to 12th grade Students from any school
  - UChicago (South), Back of the Yards (Southwest), Old Town (North), Bridgeport (near South), Lane Tech (Northwest), Austin (West)--opens today!
  - 400+ students
- Sessions typically led by two adults, who may be classroom teachers, professors, grad students, or community members

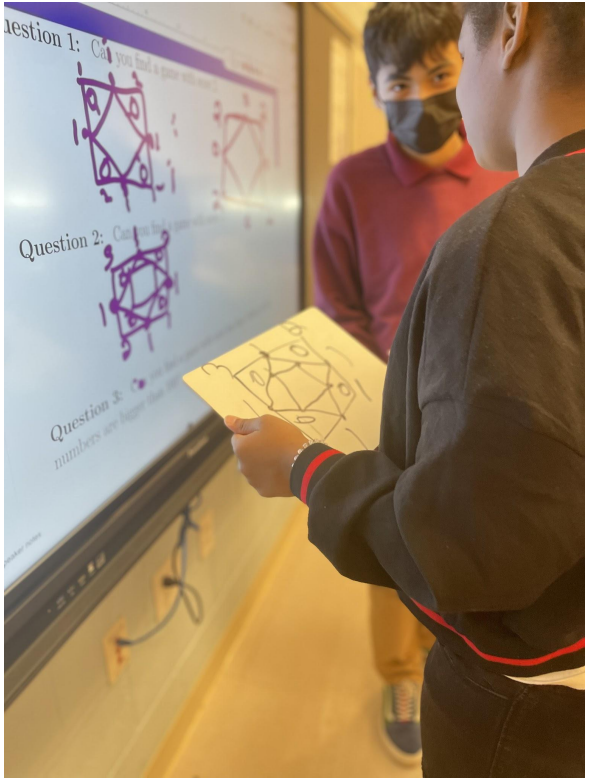
Testimonial: Hub Parent



“**My daughter used to love math** and was highly/profoundly gifted in the subject. ‘I’m a math girl!” she’d proudly declare’. **Then in 4th grade** she ended up with a teacher that was “developing”. She would come home crying, “He’s ruining math!” Since the school was trying to find a “fit” for the teacher they moved him up twice. **She had this teacher 3 years** and ended up hating math. So much busy work way below her skill level. We switched schools **and started math circles. She’s a math girl again!** She couldn’t be happier. What kid enjoys going to a math class on a weekend? Mine! Math circles makes math a fun and engaging challenge. Thank you!”- An MC2 Hub Parent

Level 2: Math Circles at ASPs

- After School Programs that serve children from a single school
- Led by 1 or 2 middle school math teachers from that school
- MC2 supports these teachers with supplies, snacks, tshirts, activity plans (same plans used at Hubs), stipends--teaching, professional learning
- 300+ students



Testimonial: After School Program

“**One of the former Math Circle students asked me today if we were going to have Math Circles this year. When I said that I was hoping to start it, she said 'Yes!' enthusiastically. This student cried anxiously about an upcoming division unit last year and was reluctant to speak in math class at the beginning of fifth grade**." -An MC2 Afterschool Teacher

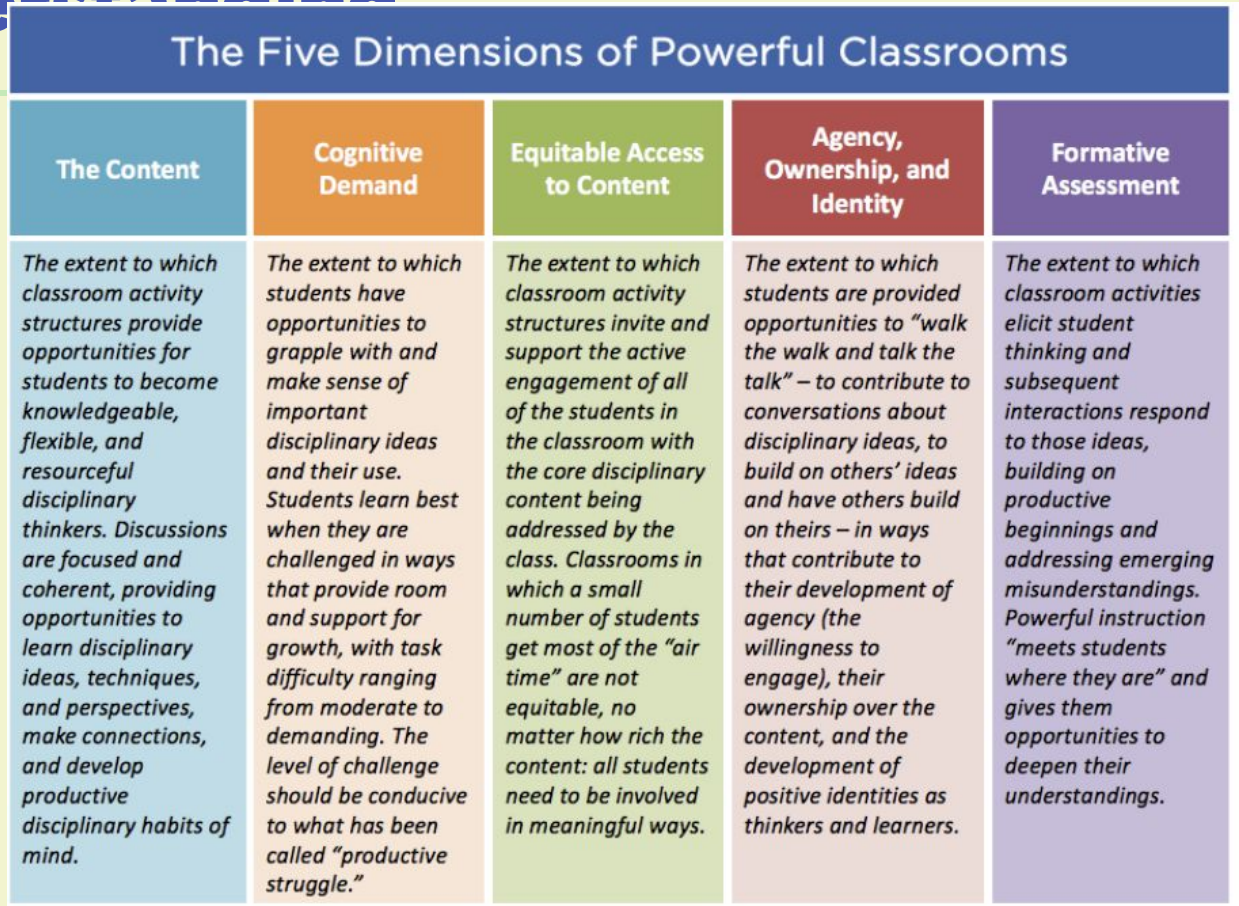
Level 3: QED, Chicago's Youth Math Symposium

- QED is a Math Symposium that is like a Science Fair except the projects are base in math or computer science.
- 140 students

Level 3: Summer Camps

- Summer Camps run both at sites analogous to our Hubs (serving all students) and ASPs (serving students from a single school)
- Two weeks, free
- More sites for professional learning--to teach, to develop programming, to observe
- 250+ students

TRU: Teaching for Robust Understanding



The Five Dimensions of Powerful Classrooms

The Content	Cognitive Demand	Equitable Access to Content	Agency, Ownership, and Identity	Formative Assessment
The extent to which classroom activity structures provide opportunities for students to become knowledgeable, flexible, and resourceful disciplinary thinkers. Discussions are focused and coherent, providing opportunities to learn disciplinary ideas, techniques, and perspectives, make connections, and develop productive disciplinary habits of mind.	*The extent to which students have opportunities to grapple with and make sense of important disciplinary ideas and their use. Students learn best when they are challenged in ways that provide room and support for growth, with task difficulty ranging from moderate to demanding. The level of challenge should be conducive to what has been called "productive struggle."*	*The extent to which classroom activity structures invite and support the active engagement of all of the students in the classroom with the core disciplinary content being addressed by the class. Classrooms in which a small number of students get most of the "air time" are not equitable, no matter how rich the content: all students need to be involved in meaningful ways.*	*The extent to which students are provided opportunities to "walk the walk and talk the talk" – to contribute to conversations about disciplinary ideas, to build on others' ideas and have others build on theirs – in ways that contribute to their development of agency (the willingness to engage), their ownership over the content, and the development of positive identities as thinkers and learners.*	*The extent to which classroom activities elicit student thinking and subsequent interactions respond to those ideas, building on productive beginnings and addressing emerging misunderstandings. Powerful instruction "meets students where they are" and gives them opportunities to deepen their understandings.*

Our Mission

Math Circles of Chicago (MC²) achieves its mission by providing free, unique enrichment programs for 3rd – 12th grade students of diverse backgrounds

Math Circles of Chicago creates meaningful and fun experiences that enable every student and educator to develop their mathematical power and build a sense of belonging to choose their own mathematical pathway

Our Values

Math Circles of Chicago

All Chicago. Every Kid. Amazing Math.

Our Core Values

- Math should be fun and empowering
- Every child can and should do math
- Every child deserves access to these experiences
- Students should be the agents of their own learning
- Math can and should be a collaborative endeavor

02

Magic Squares: Before & After

Notice & Wonder Protocol

- What do you notice about the numbers in the 4x4 grid?
- Turn & Talk: What do you notice about noticing & wondering?

7	12	1	14
2	13	8	11
16	3	10	5
9	6	15	4

Notice & Wonder Protocol

- No wrong answers.
- No wrong answers → *really* establishing this culture, getting kids to believe it. This can be transformative to the learning community. [Cohen: Talking in the 1st 5 minutes]
- Very low floor; very high ceiling
- 4x4: Wow factor
- Opportunity for students to recognize Connections/build Habits of Mind:
  - Parity
  - Symmetry
- Asking for extensions → leads to the main question! (Agency)

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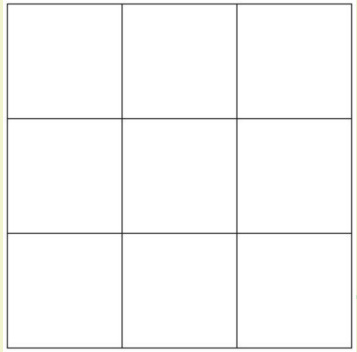


Before Magic Squares: Take 2

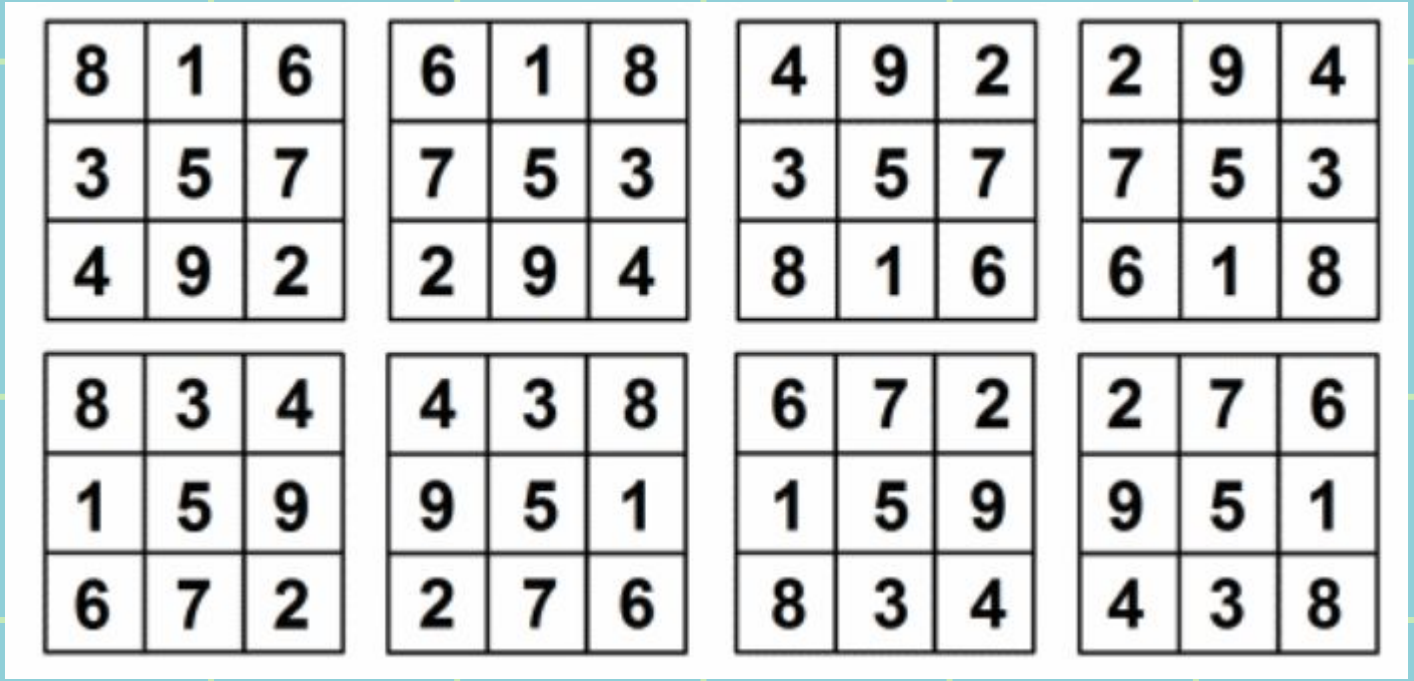
(Please Note: You can't use a number more than once for each question.)

- How many ways can you select numbers from 1-9 such that they sum to 7?
- How many ways can you select numbers from 1-9 such that they sum to 10?
- How many ways can you select numbers from 1-9 such that they sum to 50?
- How many ways can you select numbers from 1-9 such that they sum to 45?
- How many ways can you select numbers from 1-9 such that they sum to 14?

Before Magic Squares: Take 2

- How many ways can you select numbers from 1-9 such that they sum to 7?
- How many ways can you select numbers from 1-9 such that they sum to 10?
- How many ways can you select numbers from 1-9 such that they sum to 50?
- How many ways can you select numbers from 1-9 such that they sum to 45?
- How many ways can you select numbers from 1-9 such that they sum to 14?
- Scaffolding/seeding the activity
- Do these questions reduce agency? We don't think so. For the students who need it, this allows for greater autonomy in the main task
- These questions are carefully designed, and allow for engagement for a wide range of student preparedness [CME vs. Back to Basics]
- Habits of mind: Making an organized list
- Formative assessment:
  - The bad habits students pick up from Algebra class--vicitms of 'one way teachers'
  - Example: For the very first question, do they only respond with pairs of numbers?

3x3 Squares: Connections Emerge



3x3 Squares Anticipating Student Responses 5 Practices → Wrap Up

Finding 15 as the Common Sum	Who did it? Notes on their method	Sequence
Trial and error/experimentation: • observes + explains why some sums are not possible to make in each row/column/diagonal, i.e. 11 - can only use each number once, 9 + 1 + 1 not possible; must use 3 numbers, 9 + 2 not possible • makes 15 in one row and extends that make 15 in all 3 rows		1
Balancing numbers: trying 9, 8, 7 in different rows/columns, as well as 1, 2, 3 to find a common sum		2
Notes the total sum (45) to figure out 15 as the common sum, magic number first (or later); provides justification for why this must be the common sum		3

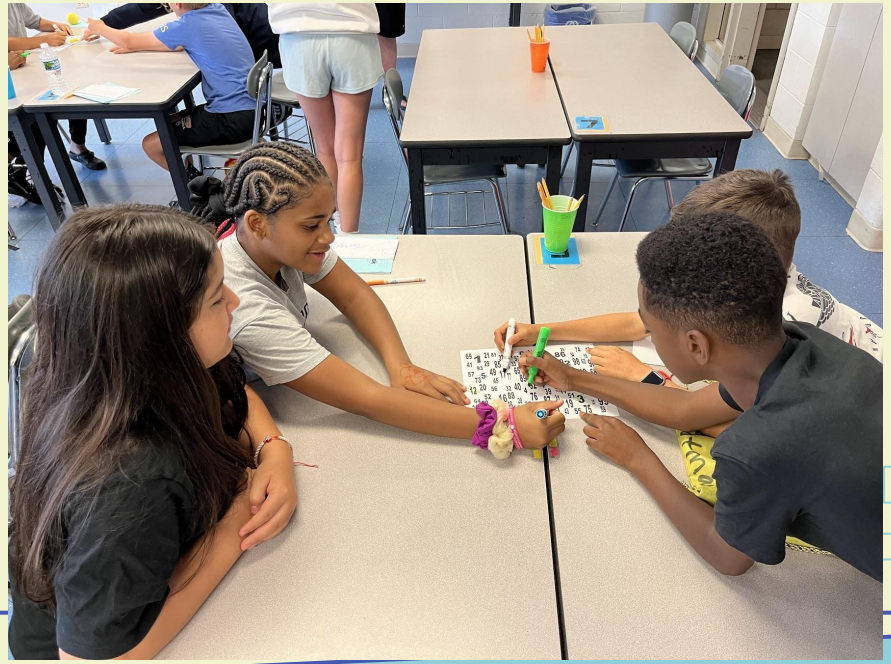
Making the Magic Square	Who did it? Notes on their method	Sequence
Using the first arrangement with rows of equal sums, switches cards and balance numbers to make columns and diagonals that also sum to 15.		1
Arranges numbers to make sums of 15. 8 + 1 + 6; 9 + 1 + 5 Uses mixture of trial and error and patterns to help arrange these 3 addends in magic square.		2
Makes sums of 15; more systematically uses these to solve the magic square: for example, Using 1, make 15 two ways: 1 + 9 + 5 or 1 + 8 + 6. So 1 can only go in a 'side' square, and 9 in the opposite square (Similar arguments for 9 only making two sums) 8 1 6 5 9 May recognize that 5 goes in the middle.		3
Makes sums of 15; recognizes that 5 must go in the center because it's part of 4 sums. Makes similar observations about placement of other numbers. And/or notes that all the pairs around 5 sum to 10, connecting it back to sum of consecutive numbers, 1-9.		4
Uses parity while arranging numbers that sum to 15 • *even + even + odd* and *odd + odd + odd* will work • *odd + odd + even* and *even + even + even* won't work		Extra insight; could go with other strategies

Closing Thoughts

- There are many pedagogies/protocols/routines that great classroom math teachers have developed that math enrichment spaces should leverage: Notice & Wonder; Scaffolding questions, 5 Practices/Anticipating Responses, 3 Reads, Math Talks, etc.
- These pedagogies should be employed for the reasons embodied in the TRU Framework--to promote Access, Agency, appropriate Cognitive Demand, connected Mathematics, and Formative Assessment
- Moreover, spaces like math circles, that often include more connected, cognitively demanding, *interesting* mathematics than school classrooms, are ideal spaces for the TRU framework to be realized and to build lifelong love of math--if we do it right!

Q&A

doug@mathcirclesofchicago.org



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