Creating & Growing a Successful Urban Math Circle

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Cambridge Math Circle

Fun, Beautiful Math for All

Задача про демократических пиратов

Дается корабль с 10-ю очень демократичными пиратами. Когда они находят клад, они проводят голосование, чтобы решить, как его распределить. Старший пират — капитан, и он/она предлагает план раздела сокровища.

Если план принимается, пираты делят клад. Если нет, капитан идет по доске, а следующий по старшинству пират становится капитаном, и так далее. Пираты очень жадные и всегда голосуют в своих интересах, но при прочих равных условиях они предпочли бы, чтобы кто-то другой пошел по доске.

В этом сценарии для принятия плана требуется всего 50% голосов.

Как поделить 100 монет между 10-ю пиратами?

Иан Стюарт, Scientific American (1999)

Road Map of the Talk

- ❑ Why an urban math circle?
- ❑ Goals of an urban math circle
- ❑ Obstacles to learning
- ❑ Solutions
- ❑ A sample activity

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Why an urban math circle?

Deep, challenging math is immensely satisfying and fun for all kids, irrespective of their family income, gender or other demographics.

Being strong mathematical problem-solvers helps kids become better citizens because they're equipped to think critically and aren't intimidated by numbers and statistics.

Strong math skills allow kids to pursue well-paying careers that use math deeply.

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Goals for urban math circles:

Kids afraid of math	• Discover areas of math that they are good at • Grow confidence
Kids who already love math	• Engage in deeper, more challenging problems • Experience the joy of math (instead of boredom)
All children	• Practice solving new, complex problems • Ask and answer their own questions (research) • Create community
Children underrepresented in STEM	• Learn analytical skills for upper-level high school and college math courses • Create a feeling of belonging in the math community • Long-term: access to STEM careers

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Obstacles to Learning

- **Math background/foundational skills** differences
- Varied **speed in solving problems**
- Differing levels of: **confidence in math + willingness to share ideas + motivation**
- Varied **abilities to sustain focus**

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Solutions for

a large range of background knowledge/foundational skills

Certain areas of math enrichment require strong computational skills and significant prior knowledge: number theory, geometry, traditional competition math problems.

There are many math topics that form a more level playing field:

- Combinatorics
- Probability
- Statistics
- Mathematical games
- Topology
- Voting theory
- Intro to Proofs
- Logic
- Origami

and many more…

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Solutions for

a large range of speeds in solving problems

Children who are much faster or much slower than their peers can find it hard to fit in.

- ❑ **Place kids into small groups by speed;** during problem-solving let each group progress at their own pace.
- ❑ **Have extra challenging problems on the same topic ready;** giving students who are furthest ahead a hard problem to switch to while the rest of their group catches up.

Solutions for

a large range of confidence in math

Confidence in one's own abilities is only somewhat correlated to current ability. However, it is virtually impossible to succeed in solving problems without confidence.

- ❑ **Bring everyone together through a welcoming project** like building colorful creations or making interesting patterns, so that everyone already has had success before class officially starts.
- ❑ **Select problems with intention,** so that reluctant students have the experience of solving something that seemed impossible themselves.
- ❑ **Call out student successes and progress.**
- ❑ **Share instructors' experiences of struggling with math problems** to show that hard problems require hard work.

Solutions for

great variability in willingness to share

Students, like colleagues, are more willing to share ideas when there's trust and belief in one another's talents.

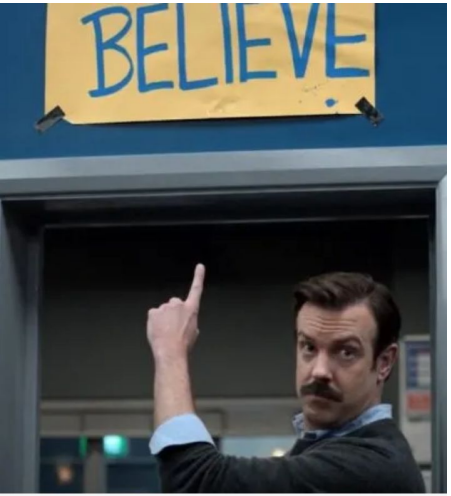
- ❑ **Start with fun ice-breakers** to get students talking, learning about one another, and listening to the contributions of others.
- ❑ **Talk to students as they work on building projects,** so students learn to trust you as the teacher.
- ❑ **Give ample time to think BEFORE answering during group discussions,** so all children have enough time to work out a problem.
- ❑ **Be intentional in having all students take turns sharing.**

Wide Range of Motivation

Address the underlying reason(s) for lack of motivation whenever possible. Some common possibilities include:

- ❑ **Poor experiences with school math classes/teachers**
- ❑ **Being forced to attend the class by their parents**
- ❑ **Lack of belief in their abilities** because they struggle with math
- ❑ **Lack of belief in their abilities** because they're strong in math and are afraid of getting the problem wrong
- ❑ **General fear of math**

Solutions: Motivation



Showing them they can do hard things: break the problems down for them into manageable pieces and ask leading questions so *they* figure out the answers

Encourage everyone to take their time: there's no advantage to finishing first. The goal is to explore, question, and take the time and space they need to fully understand.

Reinforce (or introduce) the idea that just because a child struggles with one type of math doesn't mean they'll struggle with all math. Help them find the math they're good at.

Make math a team activity: and have low-stakes, team based math contests. All members of the winning team get prizes.

Solutions for

staying focused

Hard problems require sustained focus, and not all students can sit for long periods.

- ❑ **Incorporate movement into class**
- ❑ **Break-up class time into shorter modules:**

  e.g. building time, ice-breaker, main activity, games.

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A fun sample activity

Based on Ian Stewart's article, Scientific American (1999)

Ten very democratic pirates find 100 gold coins. They decide to vote on how to divide up the coins. This is how they do it:

1. *The oldest pirate is the captain. The captain suggests a way to divide the coins.*
2. *Pirates are very greedy and want as many coins as possible for themselves.*
3. *Different pirates can be offered a different amount of coins.*
4. *If half the pirates vote for the plan, it is accepted.*
5. *The pirates are very logical. If ан offer benefits them, they will vote for it.*
6. *If the offer isn't accepted, the captain walks the plank (goes away).*
7. *The remaining oldest pirate becomes the captain and suggests their plan, and so on, until the gold is divided.*

Note: *coins cannot be split into pieces. All else being equal, pirates will vote to kick out the captain.*

If you were the captain of these pirates, how would you offer to split the gold so you get to keep as many coins as possible?

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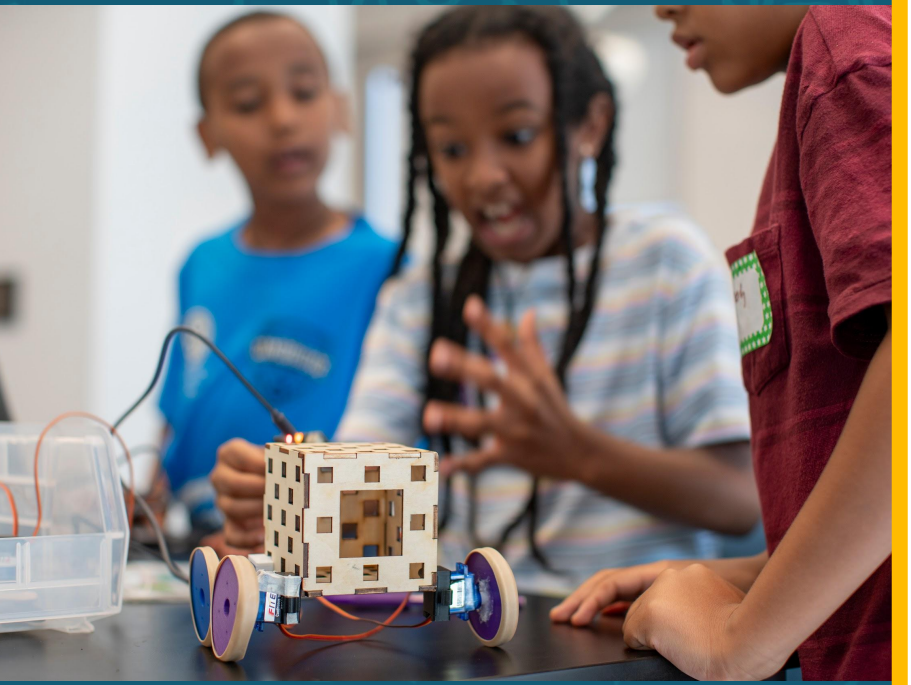

Questions? Comments?

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Supplemental Slides

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Cambridge Math Circle is...

…a math enrichment non-profit, with a mission to **give elementary and middle school students a chance to experience deep, fascinating math** and meet others who like solving puzzles and stretching their minds.

- We create programs where **kids experience math in fun, exciting, and novel ways**, and are solving unusual problems through hands on activities.
- We **center children of color**, children from backgrounds underrepresented in STEM, **and vulnerable learners**.
- Classes are held at Harvard, MIT, online, and in public schools in the Greater Boston region.

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How did CMC start?

The Cambridge Math Circle was established in 2018 by Nataliya Yufa and Mira Bernstein, two female math and physics PhD's with a combined 40 years of teaching experience at K-12, undergraduate and graduate levels.

The idea for CMC evolved from three beliefs:

>> children learn better when they're having fun and are allowed to play and explore

>> math education is a pathway out of poverty

>> all children should be given access to rigorous, high-quality math education – especially children from families historically underrepresented in STEM

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Supplemental Details

Where do the circles meet? Primary location at a local university (Harvard and/or MIT), also in schools and some after-school programs, as well as online.

How do the kids get there? Younger ones are brought by their parents or join classes by Zoom. Older kids commute themselves or are brought by family/siblings. The locations are central and easily accessible by public transport.

What is the kids' motivation? Many love math and want to do more of it, others are scared of math and want to change that. (About 5-10% are forced to come by their parents.)

How do we find the kids? Started with personal friends and classmates of one of the co-founders kids at her local public school, then word spread through the host university's faculty, who also introduced us to local immigrant families from other countries. We're always looking to make as many connections as possible..

What is the family support like for the students? Varied, depending on the family.

Financial model: ¼ of students pay tuition, which covers roughly ½ of costs. The rest is covered through foundation and government grants, and individual donors.

Who are the teachers, how do we find them? Most of our teachers are college students from Harvard and MIT, as well as a mix of Math Camp alums, graduate students, and occasional professors.

Addressing Math Anxiety

Potential solutions:

- **Use humor**
- **Practice reading children's body language;** know when they are feeling anxious
- **Limit time spent passively listening to the instructor**
- **Put a clear agenda on the board with timing** to allow kids to know the flow of the class
- **Start and end on a fun note.** Example: Bookend the class with a silly ice-breaker to loosen student's up and get them in a 'fun' mindset before the lesson, and end by playing games for 10-15 minutes, such as Set, Connect-4, Checkers, Sleeping Queens, etc.

Creative Formats for Classes

While having a typical class structure is helpful, it's also good to spice things up once every few classes.

- **Have guest speakers from a variety of fields** - different areas of math, physics, engineering, biology, art and music.
- **Have team competition days,** which act as review in competitive formats (math quidditch, math carousel, math battle).
- **Dedicate time to math modeling** to help solve a problem in the students' own community. The students come up with their projects.
- **Introduce new topics throughout the sessions:** some of our favorites are: combinatorics, graph theory, logic, statistics, probability, topology, origami, competition math (once kids are ready for it).
- **Use the summer program to refresh the format and test new curriculum ideas.**

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