

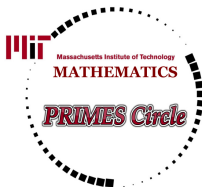
PRIMES: High School Math Enrichment at MIT

Isabel Vogt
Department of Mathematics, MIT
ivogt@mit.edu

November 9th, 2015



The work here is supported by National
Science Foundation Grants 1519580 and
1238309.



Mathematics in two contexts

Typical High School Students	Working Mathematicians
A problem takes 2-30 min to solve	A problem takes 2 mo - 10 years to solve
There is a clear formula that can be used	No one has solved the problem before
Being stuck indicates something is wrong	Being able to solve a problem immediately means it's not interesting

MIT PRIMES

Goal: address this disconnect and better prepare high school students for careers in STEM requiring the skills exercised by working mathematicians.



PRIMES Circle student Jessica Huynh explaining her project in knot theory.

MIT PRIMES

PRIMES (Program for Research In Mathematics, Engineering, and Science) is an umbrella organization: **research** and **outreach**

Four school-year programs:

- Local PRIMES: **research** on MIT campus for local students
- PRIMES-USA: **research** for students not in the Boston area
- PRIMES Circle: **enrichment** program for high school students from urban Boston public high schools
- PRIMES STEP: new **enrichment** program for middle school students

New summer program:

- $\sqrt{\text{Math}}$ ROOTS: **enrichment** program for underrepresented high school students

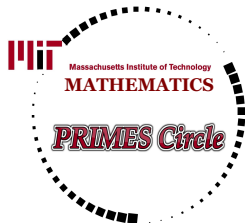
Research in PRIMES

Students are given tractable but substantial projects, not toy projects.

The research timeline:

- **January:** Admitted students are paired with graduate student mentors and do background reading
- **Spring:** Work on research problem, meeting weekly with mentor
- **May:** Two-day conference at MIT
- **Summer:** Work continues informally and students are free to do other programs
- **Fall:** Students write up results (and often apply to competitions)

PRIMES Circle



- Pair 2-3 high school students with an undergraduate mentor to do directed reading for a semester
- Requirements:
 - Individual groups meet once a week for 2 hours
 - Three whole group meetings
 - A 20 minute talk at a “mini-conference”
 - A 5-7 page paper on a topic related to their reading

Students presenting at the conference



Emily Chan



Wilkin Rivera



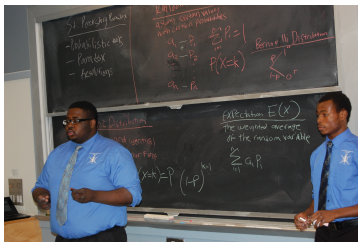
Natalia Vigorito



Sheinya Joseph

Philosophy of the program

- The reading topic is meant to be a *vehicle* for learning about the mathematical process:
 - Reading formal exposition
 - Chipping away at a problem you can't immediately solve
 - Communicating mathematics with your peers and mentors
 - Formally presenting in oral and written form



Cicle students Omotoyosi Oyedeki and Tyreik Silva talk about probability theory.

Successes of PRIMES Circle

- In anonymous surveys, over 90% of students say they would definitely recommend the program to their peers
- Students cite PRIMES Circle for encouraging them to continue with mathematics:

“PRIMES Circle affirmed my interest in math and exposed me to a college math setting, which I liked a lot. After this program, I know for a fact that I will want to major in some kind of math.”

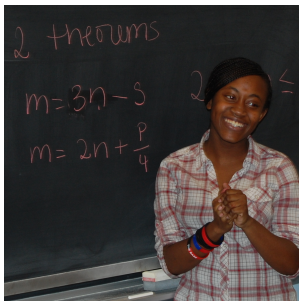
- Students build lasting relationships with their mentors:

“At the end of every meeting I felt like I had actually learned a lot. [My mentor] made my experience being on a campus as huge as MIT very welcoming. He is a good teacher and an even better friend. He was sociable and caring and for that I plan on keeping in contact down the road.”

Successes of PRIMES Research

- In 2011-2014, **98 research projects** completed by PRIMES students
- **77 research papers** posted online, many of them submitted to academic journals, and **17 already published**
- **44 students** invited to present at the MAA Undergraduate Student Poster Session of the Joint Mathematics Meetings in 2012-2015
- Students have won:
 - **1st Prize** in Intel ISEF
 - **1st, 2nd, and 5th Place** in Siemens Competition
 - **1st, 2nd, and 3rd Place for Basic Research** in Intel STS
 - **Davidson Fellow Laureates**

Looking Forward



Medgine Joseph explaining her project in game theory

The PRIMES model can be replicated:

- In large urban centers, mathematical mentorship in the style of PRIMES Circle has a great potential
 - Emphasis is on *how* not *what*
 - Students work closely with a partner and mentor to build confidence
 - Projects are genuinely fun

Thank you!

If you want further information:

`ivogt@mit.edu`

`http://math.mit.edu/research/highschool/primes`



2015 $\sqrt{\text{MathROOTS}}$ students and mentors.



Next Generation STEM Learning for All

A Forum Supported by the NSF

NSF STEM Forum | November 9, 2015 | Washington, DC

#NSFNextGenSTEM

Partnerships for Pathways to STEM Workforce

PRESENTERS:

Jacqueline Crisman, jackiecrisman@mail.sunyjcc.edu

Karen Tingley, ktingley@wcs.org

Teresa Mourad, teresa@esa.org

Isabel Vogt, ivogt@mit.edu

John Ristvey, jristvey@ucar.edu

G. Brock Williams, brock.williams@ttu.edu

Reed Stevens, reed.stevens@northwestern.edu



This event is funded by the National Science Foundation, grant #1312022. Any opinions, findings, and conclusions or recommendations expressed at this event or in these materials are those of the author(s) and do not necessarily reflect the views of the National Science Foundation