CyMath: Helping STEM Students Thrive: The Role of Early Math Skills?

Namrata Vaswani

Director, CyMath K-12 Math Tutoring & Support Program

Professor of Electrical and Computer Engineering

Iowa State University

https://www.ece.iastate.edu/~namrata/

https://cymath.iastate.edu/

Why Should we (univs) run K-12 Math Programs?

- An important barrier to success in STEM is math prep of our students
  - Even correct code writing/deploying requires good K-8 math
  - Practical US issue - STEM entry req Calculus done by 12th grade – requires Alg-1 in MS
  - Poll – what do you see in your classes w algebra/functions?
- Since math learning is cumulative, this disproportionately affects students who have not been able to learn early math well often due to reasons beyond their control, e.g., family income/education/awareness levels
  - Arithmetic (4 operations with integers, fractions, decimals) fluency needed to understand pre-algebra and algebra. Algebra is the basis of all Engineering
- Goal - Reduce the Math learning gap while it is still small
  - Increase fraction of under-served students that succeed in Engineering/STEM
  - Ensure each student reaches their personal best.
    - All improve some; some improve a lot → catch outliers → could be future STEM

CyMath-ISU: Scalable, AI-enabled, Learn-by-Doing

- The program director is an EE Professor
  - Program design informed by the skills needed for future STEM/Engineering success.
    - Need not know 4 ways to multiply; know enough to learn fractions; and so on.
    - College success also needs homework and study skills
  - Occasional STEM activities, Parent workshops, use ALEKS app → borrowed from Ab7G-Purdue
- Engin/Math grad students/faculty - untapped high-quality vol tutors
  - Huge fraction international or immigrant. But language of math is universal.
  - Wellbeing, community, teaching/communication skills, extra mentors.
  - Understand how modern US K-12 math works, learn how best to help ISU students
  - Some of us – nag our child a little less or a little more
  - Supporting 75+ students; some never come but get emails
- Paid undergrads – Math, STEM, Education – Run Sessions & Tutor
  - Tutor, Run the sessions, Motivate/manage kids. Paid from outreach/REU funds of research.
  - **Do math using app/worksheets, then play - playground / LEGO / STEM fun**

CyMath-ISU: Scalable, AI-enabled, Learn-by-Doing

- No one way to teach or improve math skills.
  - No one curriculum either. Any way is better than none.
- Almost no tutor training – attempt to replace parent/sibling support
  - Just observe others tutoring or get feedback from others
  - ML (app) enabled Math tutoring much easier – okay if tutor isn't the best
- Support a lot of kids
  - Put kids as 2 per tutor.
  - All the rest in one big group with one tutor/mentor and worksheets.
    - Even if kids learn nothing – sending the message that math matters & resources
- Encourage at home practice -- use of a math app makes this easier
  - Ability to do homework / study at home → critical for college success
- Texting parents is very helpful – use Google Voice for shared texting
  - Encourage math at home, inform about testing dates/purpose
  - Text during Zoom session – if student is goofing off or if tech trouble

CyMath Impact – Students – Summer 2025

- CyMath now supports 70-75 students in grades 3-10 (about 60 regular)
  - All tutored at least weekly at Sawyer, AMS, ISU or Zoom or all.
  - At-home math practice on **ALEKS** is encouraged. Beast Academy option added.
- **Of the 15 3rd-6-th graders who have spent at least a year at CyMath**
  - **All but one student have shown growth in math scores. A third (6/15) showed very large growth of more than 20-percentiles:**
    - Student AM (grade 3, Fall'23) went up from 46-th to 85-th percentile in a year and has remained at that level or higher
    - Student NW (grade 3, Fall'23) went from 20-th to 55-th percentile in a year and has remained at that level or higher
    - Student GO (grade 5, Fall'24) went from 34-th to 80-th percentile in a year
    - Student MA (grade 3, Fall'24) went from 78-th to 98-th percentile in a year
    - Student TM (grade 4, LateSpring'24) went from 34-th to 55-th percentile in a year
    - Student NH (grade 5, LateSpring'24) went from 7-th to 28-th percentile in a year
  - Few others have moved up about 10-15 percentile points but since the adaptive testing is noisy, we only mention large n sustained changes

CyMath Impact on Graduate/All Tutors

- First survey of all tutors conducted in Summer 2025.
  - We had 18 total respondents -- 12 grad-students/faculty, 6 undergrads
  - 94% said tutoring helped improve their teaching skills,
  - 83% said it improved their communication skills, and
  - 44% said it also helped them find community (➔ improve wellbeing)
  - In comments, many expressed
    - greater confidence and adaptability in working with children,
    - developed empathy, and
    - learning to explain concepts in a simple manner.
- Impact on tutors/leads - Education majors – hopefully
  - Tutoring alongside STEM folks – see a college educator's viewpoint; understand what's critical for future K-12 to college pipeline
- Impact on faculty
  - NSF proposals – math outreach greatly appreciated; NSF CAREER – 2 letters, 1 got.
  - Faculty parents – learn about US schools, algebra-1 n more, nag our own kids less

CyMath for Graduate/All Tutors

- EE 5900 I: 1 or 2 credit course: formalizes mentoring for tutors
  - Monthly meetings with students – discuss/help courses, research
  - CyMath-ML seminar series. Next term – get students to present
  - Reflection on lessons learned from tutoring
  - CyMath idea – fill in learning gaps; e.g., for some grads -- take Math 317
- Advertise tutors' research successes
- Write reference letters for regular tutors – writing 5-7
- Undergrads, grads, faculty all in one room
  - Math, Elem Ed, Engineering undergrads;
  - Math/Stat/ECpE/Engineering grad students n faculty
  - REU experience – learn about courses, future career & grad school options
  - Very diverse group – many languages, races, ethnicities, religions

Details -- CyMath-ISU Sessions – Plan

- Session lead: Education major or Math major who has worked quite a bit with kids
- Math undergrads — trust their math, have more free time (no labs or projects, do fewer clubs)
- Enroll kids assuming 2.5-3 kids per tutor.
- Initially do one-on-one and the rest (youngest or late kids) all in one big group with one Education-type tutor. Slowly move to a 2 kids to 1 tutor model.
- Each week some will be gone/absent and some will stop coming. As long as no serious behavior issues – this is the best model
- Tutors - Combination of Elem Education, and Math / Engineering undergrads (paid) and grad tutors. Grads – volunteers. Paid tutors -- need to enjoy and be good at working with kids
- Elem Ed and Ed tutors – best for those who don't want to do math. STEM tutors – better for willing learners.
- Zoom and in-person steady state – 2 kids with 1 tutor. Extras in a larger group do practice. Find a way to rotate kids into the practice group or keep youngest in it.

Details -- CyMath-ISU Sessions Tutoring Tips

- Chat first few minutes. Popular topics – candy, TV shows, games, school day.
- Give one break when needed – play hangman, computer game, etc.
- End with chat also and/or with encouraging at-home practice.
- How to tutor math in a new country:
  - Read ALEKS.com explanations or watch Khan Academy videos or
  - Have the child teach you what they learned yesterday and how. Interpolate the rest.
- Tutoring
  - Use an app or workbook/worksheet to guide tutoring but feel free to build off of it
  - Require them to explain how they are thinking about the problem. Not every problem but maybe every second or third problem. Going slow is okay and good usually
  - Pretend to be ignorant – I didn't learn it this way or hey I just stepped out of zoom for a minute can you tell me how you did this . Or I learned it a different language/country can you show me how you do it
- Motivate math
  - Use screen time (which do you prefer - take away 15% or 4/10th of TV time), candy, pizza
- Zoom: Some kids sometimes – will be goofing off
  - watching videos while u think they're working and/or using Google/AI to answer questions for them or both. If kid not responding – text cymath number - we text parent – often problem gets fixed by next session
- Math Resources:
  - Use a resource as a starting point or to tell you syllabus/order of topics.
  - Online -- Khan, BeeStar, ALEKS. Worksheets – BeeStar or MathWorksheets.com. Workbooks – Kumon Word Problems or Spectrum Math

Details -- Algorithm to Start Your Own Math Prog

- Email school district superintendent for nearby district(s)
  - Ask to help publicize within entire district or specific schools – connect with Principal
  - Help identify students "in-need" (financial or math scores or both) and get help in encouraging those students' parents to join
- Tutor = one person teaches 1-2 kids for an hour once a week
  - Tutors – volunteer STEM grad students/fac + few paid undergrads – Education & STEM
    - Education student tutors best for kids who struggle in math the most. Also run/coordinate sessions
    - STEM tutors – for everyone else. Undergrad hourly pay – get from outreach funds
  - Use a math app such as ALEKS or Khan Academy or textbook/curriculum used by the school.
  - Encourage at-home math practice also (most critical)
- Start tutoring in grades 3-7 and follow to high school.
  - Start small with 5-10 students, see what works, then expand.
  - After-school at the school weekly (most regular attendance)
  - Saturday sessions - monthly in-person at the university – best but irregular student attendance
  - Saturdays all weeks by Zoom (quite regular, works if some parent support)
  - Find a good Education or Math undergrad to run the after-school sessions.
- More: https://cymath.iastate.edu/

CyMath Open Q's – Education Policy?

- Should K-5/K-8 policies be designed with college & STEM college success in mind
  - STEM is most well-paid. "**M" needs almost no money to teach, has maximum payback.**
  - **Education research studies are very short-term: why do they influence policy**
    - Homework & studying-for-a-test skills – needed for college success
    - Ensure sufficient math practice for arithmetic fluency in K-5 – game-based math is not scalable
    - Work to get more kids joining & thriving in Algebra-1 by 8th grade
- Math-Tutoring-at-Scale Options: In-school tutoring known to be most accessible
  - Use an app (Khan or ALEKS) to "guide" the tutoring – help tutors build teaching off of it
  - Get parent volunteers or retirees or work-from-home STEM volunteers for in-school tutoring
  - Students Tutor-and-Learn: if advantage of tutoring to the tutor can be demonstrated – get older kids (good math knowledge and reliable) to tutor younger ones within the same school.
  - Can untrained tutors help, especially with use of an app to support tutoring?
- Look at how math is taught outside the US.
  - Learn from the world for math
- Making Math fun: is it worth it or is it better to first just do "not so fun real math" and then allow playground/indoor play or other unstructured fun time?
  - Our experience seeing Elem Ed majors try "making math fun" is – it doesn't work. Students are very specific on what's fun for them; you hear a lot of "it's boring"

CyMath Open Q's – Study Impact on Tutors?

Study math tutoring impact on tutors

- Mentoring vs Tutoring:
  - Tutoring is providing a "tangible" measurable math skill to the tutee in addition to the human connection that also may result in mentoring
- Wellbeing / Mental health impact of tutoring.
  - Math tutoring needs to be studied because a much more diverse population comes in volunteer tutor math
- Communication/ Teaching/Presentation Skills improvement
  - Impact of tutor's teaching skills, even college teaching skills.
- Impact on the tutor's own ability to focus and learn better
  - Best way to learn is to teach
- Get people together, reduce political divisions
  - If schools invite parents for math tutoring volunteering -- immigrant parents may get more involved with the schools. Get various people together

CyMath-ISU – scalable, low-cost, learn-by-doing math

- What is CyMath-ISU?
  - Hybrid mode (at least) weekly math tutoring with using ALEKS.com to guide tutoring
    - Start in 3rd-5th grade, follow students to middle & high school
    - At-home math practice resources (ALEKS.com & workbooks) and encouragement
  - Tutors: STEM graduate/faculty volunteers, math/education undergrads (paid) - manage logistics & tutor
    - One tutor helps 1-2 kids usually.
    - Run after-school at 2 schools, at ISU/Zoom Saturdays, by Zoom Wednesdays 6pm
    - Directed and run by Electrical Engineering Professor Namrata Vaswani.
  - Occasional Engineering exposure activities, Parent workshops/meeting, Pizza
- Why? Math learning is cumulative – without basic arithmetic skills cannot understand (scalar) algebra; all Engineering/STEM relies on algebra and the ability to code it right
- Impact: Huge gains for some students; small gains for all. Tutors find community/mentors; improve their own teaching & communication skills
- https://cymath.iastate.edu/
- **Open question: How to equitably graduate better-prepared Engineering/STEM students?**
  - Should K-5 / K-8 math policies be designed with college STEM success likelihood in mind? Do we need more math drills in K-5?

CyMath More Thoughts / Writing

- Parents/Teachers
  - https://cymath.iastate.edu/math-for-all/
- K-5 / K-8 Teachers
  - https://www.ece.iastate.edu/~namrata/CymathWriting/What_I_wish_K5_teachers_did_for_Math.pdf
- STEM Educators and Professionals
  - https://www.ece.iastate.edu/~namrata/cacm_final_2.pdf
  - https://arxiv.org/abs/2409.17304
- How can I help?
  - https://cymath.iastate.edu/how-can-i-help/
- All CyMath Writing including these slides
  - https://www.ece.iastate.edu/~namrata/CymathWriting/

CyMath Schedule

- Summer 2025 May 20 – Aug 20
  - Saturday mornings (10-12) - ISU or Zoom
  - Tuesdays (2-3pm) – at the school closest to ISU
- Fall/Spring:
  - Weekdays: Tues/Thurs 3-4 or 330-430 after-school sessions at Sawyer
  - Weekdays: Monday 4-5pm after-school sessions at the Ames Middle
  - Weekdays: Wednesday Zoom 6-7 or 630-730 for middle/high schoolers only
  - Saturday sessions: 10-11 or 11-12 Zoom. Monthly at ISU – help when you can
- Tutors - ISU STEM graduate or undergrad students.
- Use ALEKS.com as a base for tutoring & encourage at-home math practice
- Signup:
  - short form at https://cymath.iastate.edu/ or email Prof Vaswani namrata@iastate.edu

Collaborations with Statistics?

- AltGDmin for various other problems
- MRI applications

- CyMath research – study impact in a statistically sound fashion
  - Impact on tutors?
  - Game-based learning vs learning then games?
  - Study long-term impact of education policies? Current – all short term

- CyMath – help start at another school; or at a community org