Drop-In Mathematics Help Centers

The University of Michigan's Math Lab (Math Learning Center)

Robert Megginson

University of Michigan

Department of Mathematics

The setting and problem at U-M

- Thousands of students taking introductory precalculus and calculus courses every year
- Smart students, but preparation varies greatly
  - No national precollege mathematics curriculum
- Get into trouble in those courses due to some gaps in that preparation (but could likely succeed with some help)
- *Also*, students just overcommit, and find themselves in difficulty in mathematics courses for that reason

Most student responses to the problem at U-M in the mid-1980s

- Mainly would do one of these three things:
  - Change career plans and head for some other career that did not require much mathematics
    - Still a national problem in the U.S.
  - Drop other courses to try to carve out additional time to focus on that aggravating mathematics course
    - Problem: Delays graduation, often does not work
  - Find help (tutoring), perhaps in combination with the preceding item

U-M tutoring options in the mid-1980s

- Get help from classmates
  - Studying with classmates is a great idea, *but* …
  - **Problem:** For building basic missing skills, of widely variable quality
- Over-use instructor's office hours
  - **Problem:** Instructor time, and inability to service large numbers of students; availability may be inconvenient for student
- Hire a tutor
  - **Problems:** Discriminates against students without the money; widely variable quality; tutors may not know emphasis in particular course

University of Michigan Mathematics Professor Peter Hinman's solution (circa 1984)

- Established the U-M Math Lab no-cost tutoring center (name very recently changed to "Math Learning Center")
- Served exclusively precalculus and calculus
- Staffed by trained undergraduates who kept track of what was going on in courses and how the material was covered
- Students could make appointments or could just drop in to see a tutor

General model

- Tutors were stationed in offices, working one-on-one with students who waited in an anteroom; a Math Lab manager was in charge of registering students and other logistics
  - Theory: Students would be embarrassed to reveal gaps in knowledge to other students; generally not true, but there is a cultural component
- General way it went (with exceptions)
  - "How do you do this exercise?"
  - "Like this…."
- Popular, helped many students

Problems

- Research shows that students learn better with more active involvement in seeking solutions than just being shown them
- Single-streaming the students to tutors reduced capacity to serve many students
- By early 1990s, Math Lab was over capacity

My involvement as director, 1992–2002

Math Lab, ca. 2000

Change 1: Emphasis on a more Socratic tutoring method

A manufactured example of a student who has been given $f(x)=(x^2+5)^{143}(x-1)^5$ *and cannot find* $f'(x)$.

Tutor: What have you tried?

Student: Well, the previous exercise had $g(x)=(x^2+5)(x-1)^2$, and I just multiplied it out to get $g(x)=x^4-2x^3+6x^2-10x+5$, so $g'(x)=4x^3-6x^2+12x-10$; no problem. But I don't think I want to try multiplying out with this new exercise.

Tutor: I agree. That seems like way too much work. What would you have done if you had just been given $(x^2+5)^{143}$?

Student: Oh, that's one of those chain rule things, so you would get $143(x^2+5)^{142}\cdot 2x$.

Tutor: How about just $(x-1)^5$?

Student: Well, let's see, I can use Pascal's triangle (scribbling), and get, uh, $(x-1)^5=x^5+5x^4+\cdots$

Tutor: (Seeing what the student intends to try, with an immediate mistake) Hold on, there's a mistake there already, but are you telling me that this is harder than differentiating $(x^2+5)^{143}$?

Student: Well, I guess I could do the same thing as before, so I'd get $5(x-1)^4$.

Tutor: (Wanting to make sure the student knows that there is an implicit 1 as the inner derivative.) Now in the other example you ended up multiplying $143(x^2+5)^{142}$ by something. Why didn't you do that here?

Student: Well, it's 1, so I didn't write it.

Tutor: So can you just find $f'(x)$ by taking the product of those two derivatives you just found, or do you have to do something more? (The use of the trigger word "product" was deliberate, to link the exercise to a word the student heard in class or read in the text.)

Student: You have to use the product rule, don't you?

Tutor: What do you think?

Student: You have to use the product rule. (Which the student now does correctly.)

Tutor: So was there an easier way to find the derivative of $g(x)=(x^2+5)(x-1)^2$? (etc.)

And the tutor then makes the student work additional examples.

One issue that arises with the Socratic method

- Some students will insist, "I just need you to show me how to do this."
- Tutors have to stand fairly firm in insisting on making sure the students have internalized the learning.

Change 2: More extensive tutor training

- Help from our Center for Research on Learning and Teaching
- Six to eight hours of training, with practice sessions using experienced tutors pretending they're students
  - It's an art for them not to overdo playing student, but if warned not to do so they can usually manage it.
- A day or two working with experienced tutors and real students

Change 3: Emphasis on group tutoring

- Fairly large tables (labeled Math 105, Math 115, etc.) accommodate four or five students, with a tutor
- Students often have the same question
  - Even if they don't, they can benefit from listening in on the exchange
- Good exchanges often happen between students waiting to ask a question
  - But the tutor should debrief those exchanges

Change 4: Physical layout

- Old tutoring center: Small space, subdivided into individual tutoring rooms with a waiting area, somewhat dark, not inviting
- New space: Large open room, well lit and climate controlled, with artwork on the walls
  - *And* sound conditioning; that should not be forgotten

Change 5: Graduate teaching assistants required to hold one office hour weekly in the Math Lab

- Can give preference to their own students, but must also be willing to work with others
- Some graduate students really like this, others do not; be ready for that
  - In rare cases it may be necessary to extract a graduate student from these duties and assign different ones, but the student should know that it was not a good career move
- Faculty will sometimes volunteer to help out

Change 6: Extended hours

- Be ready to change dynamically from term to term as student needs change
  - Keep track, hour by hour, of student usage
- But be aware of issues that may affect when it is reasonable to be open
  - Students would have liked us to stay open until midnight, and occasionally we would, but there are safety issues with that, particularly for unescorted women

Change 7: Willingness to *try* to help all students with math questions

- Primary emphasis still on precalculus, calculus through ordinary differential equations, and introductory linear algebra; those students get first priority
- *But* an engineering student struggling with a PDE IBVP involving a finite vibrating string might (and often would) find someone who could help with that

Change 8: Students encouraged to meet in Math Lab for general study

- Particularly helpful given our team-based introductory mathematics courses
- A quick primer on those
  - Students have both individual and team homework
  - Team size: 3–4 students
  - Reassigned twice per term
  - Attention paid to demographics, ability, residential location

Ongoing challenge: Help with graded homework

- Team homework in precalculus, differential calculus, integral calculus:
  - Tutors will know what those exercises are.
  - Tutoring is not prohibited, *but*:
    - At least three team members must come together to seek help
    - Tutors are trained in how to give less help than with other exercises in those courses; sort of a super-Socratic algorithm, focusing strongly on how to think about such an exercise

On other types of homework

- Faculty generally understand that the value of having the Math Lab there compensates for the loss of certainty that students did certain homework all by themselves
- It is easier for students to be dishonest in this regard using the Internet than to do so in the Math Lab.

Another challenge: Tutors drumming up business for off-site paid tutoring

- Forbidden that Math Lab tutors do student-paid tutoring in the Math Lab itself
- We decided we cannot actually forbid Math Lab tutors from also having their own for-pay tutor operation
- Often student-initiated: Find a tutor they think especially helpful, want to hire the tutor for private tutoring

Yet another challenge

- Instructors can see the Math Lab as an ideal place to have their students take make-up tests, and will ask that Math Lab personnel proctor them
  - Ultimate decision: They are welcome to use the Math Lab for administering such tests, but they are not to expect a private table or proctoring, and the students cannot expect a quiet setting

And a further challenge

- Students miss an exercise on an in-class test, then blame it on the Math Lab
  - "It is not my fault! The Math Lab people told me to do it that way!"
- Instructors are sometimes just wary of students learning mathematics for their class from someone besides the instructor

Computers in the Math Lab?

- Only for administrative purposes, not student use
- Students generally bring their own laptops
- No reason not to have them, though

Statistics

- Currently about 20,000 student contacts with the Math Lab each academic year
  - 1980s: Varied from year to year, but a few thousand most years
- Gateway testing is under the administration of the Math Lab, but not done directly in it, and those numbers are not included in the above

An unexpected benefit

- Tutors generally start work in the Math Lab because they would like the money
  - Many are mathematics undergraduates, but a significant minority come from other fields
- After working so closely with students and getting positive feedback from students they have helped, surprisingly many make a deliberate career change into the teaching of mathematics at various levels
- Several have become mathematics teachers on American Indian reservations

For more information

Irina Arakelian, Director

arakel@umich.edu