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Math Gets a Makeover

By Shannon Najmabadi *APRIL 16, 2017*

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Students in this mathematics course at Rutgers U. learn about real-world concepts like loans, repayment, and voting. They often work together in groups to find the solution.

On a chilly evening in March, students in Cecilia Arias's mathematics course here at Rutgers University were learning about a concept called fair division.
More specifically, they were considering the case of Jason, Kelly, and Lauren, three business owners who share a location in the mall. Suppose, Ms. Arias explained, that Jason makes the same amount of money each month, while Kelly gets no business in October, November, or December. Meanwhile, Lauren earns most of her profits during that same quarter.

If only one of them can use the space at a time, Ms. Arias asked, how can the year be fairly divided among the three without an angry standoff?

These kinds of real-world examples are common in Ms. Arias's class, "Topics in Mathematics for the Liberal Arts." The course, designed for students majoring in the liberal arts and social sciences, satisfies a quantitative-reasoning requirement that many of them need to graduate. For those who enroll, it could be one of the few math courses they take in college. Over the semester, students learn about loans, repayment, apportionment, and voting. An online description of the class promises, "You will not be left wondering, What does this have to do with real life?"

The course is representative of a nationwide effort to make undergraduate math more relevant and engaging for students. Classes like Ms. Arias's represent a turn away from a one-size-fits-all approach, and toward providing students with the math skills they'll need in their majors and lives.

The aim isn't to water down math requirements but to provide 'the right math for the right student at the right time.'

The shift is in part a response to a broad realization among math departments that their entry-level courses have become a stumbling block for many students. A 2015 report noted that only half of all students passed their college algebra courses. That year, another study on calculus courses called them "an insurmountable obstacle" and "a great discourager" for students. Too many, the report said, were deterred from pursuing math-heavy majors. An editor of the report said in an interview that he was surprised at "how effective calculus was at destroying students' self-confidence in their ability to do mathematics."

For a long time, the difficulty of college algebra and calculus classes has been held up as a sign of rigor and as an effective filter to certain fields. But that's changing. While there have been efforts in the past few decades to update how math is taught to undergraduates, many observers say the energy for reform has never been as pronounced as it is now. As technological change and market demand call for more quantitative skills than ever, math departments and educators are trying to recast their role.

Reformers now say entry-level math courses should not weed out students. Instead, they say, math should be a steppingstone, providing skills relevant to students no matter their major.

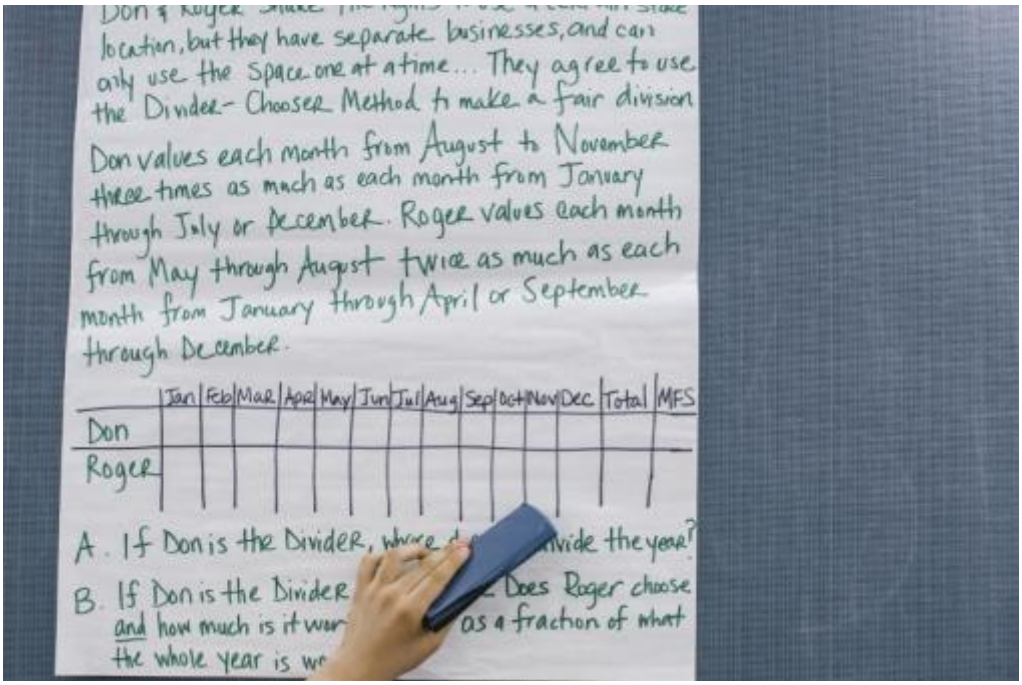
The momentum to improve math education received a push in 2012. A wake-up call came in the form of a report released that year by the President's Council of Advisors on Science and Technology. It said introductory math courses "often leave students with the impression that all STEM fields are dull and unimaginative." And it made a startling recommendation: Faculty members from other disciplines should teach math courses to address a preparation gap in the subject.

Many math educators disagreed with that report and its proposed solution. But many still said they'd rise to the challenges it laid out. "The status quo is unacceptable," a 2015 report by mathematicians repeated several times in bold text.

Uri Treisman, a pioneer in math education and a professor at the University of Texas at Austin, says there was a disconnect between what was described in the council's report and what he saw in classrooms. Local innovations had bubbled up on campuses, and many mathematics associations agreed that the time was ripe for change. Yet broad reform hadn't happened.

"You can't just have one guy developing a new course," Mr. Treisman says now. One reason that previous efforts for reform failed, he says, is because they never became widespread.

Enter Transforming Post-Secondary Education in Mathematics, an organization formed in 2013 to do just that. TPSE (often pronounced "Tipsy") works with other groups to bring awareness, resources, and legitimacy to math reform, and makes it easier for reform-minded faculty members to learn from one another. The organization is led by a prominent mathematician in the field, Phillip Griffiths, an emeritus professor of mathematics at the Institute for Advanced Study. His involvement alone, many math reformers say, validates the effort.



An online description of "Topics in Mathematics for the Liberal Arts" at Rutgers U. promises: "You will not be left wondering. What does this have to do with real life?"

TPSE's aim is broad: to provide "mathematically rich and relevant education for all students, whatever their chosen field of study." But the crux of its work involves changing what is taught to undergraduates, and how. Reformers hope that making content more relevant and delivery more interactive will help students succeed, in class and beyond.

In practice, these changes range from doing more group work to offering a menu of entry-level math courses. One organization TPSE works with, the Charles A. Dana Center at the University of Texas, for example, has led an effort to offer courses on statistics and quantitative reasoning as two such options. (Mr. Treisman, founder and executive director of the Dana Center, is also on TPSE's governing board.)

The aim isn't to water down math requirements but to provide "the right math for the right student at the right time," according to a Dana Center presentation.

Andrew Tonge, chair of the mathematics department at Kent State University, who has worked with members of the Dana Center, says a guiding principle of these alternatives is to teach the students whom colleges actually have, rather than the population that math departments might wish they had.

"A default reaction to mathematics in the U.S. is to say, ‘I can’t do it,’ " Mr. Tonge said, describing students. "That’s absurd. Of course you can."

Melissa Blakeney doesn’t think she’s a math person. "I just suck at all things math," she says.

The sophomore at Radford University is majoring in communications and enrolled in a "Math and Human Society" course to fulfill a general-education requirement she needs to graduate. It’s the only math course she plans to take.

Many students harbor feelings similar to Ms. Blakeney’s, says Erik Sorensen, the course instructor. At the start of the semester, he says, those students regard him with something between disinterest and hostility. Their facial expressions testify to a common experience with math: "Twelve years of bubbling-up frustration," he says.

Mr. Sorensen wants his students to learn useful quantitative skills. But he also strives to change their attitudes toward the subject by helping them see its utility in their lives.

When he introduces a math concept, he’ll refer to a situation it would be used in, or he plays a movie clip in which it’s mentioned. A lesson about projectile motion, for example, is prefaced with a YouTube video of a man being launched off a Slip’N Slide and into a kiddie pool — strategically placed where math determined the slider would land.

For a unit about personal finance, Mr. Sorensen brought in his own home-mortgage paperwork, and students worked backward to determine how much he’d purchased the house for. This chapter stuck out to Ms. Blakeney. "I thought it would really carry over to my adult life," she says.

What makes the course valuable, Mr. Sorensen says, is that it teaches students to solve for x, where x represents a real-world value. When math is framed this way, he says, students often surprise themselves with their interest in the subject.

Rooting math in context better prepares students for their next college classes and, professors hope, helps them get over a knee-jerk fear of numbers. Employers also see value in graduates who not only know how to do math but recognize when it can be

used in real-world situations. Outside the classroom, few problems come with the instruction, "Solve using this function or equation."

Some calculus courses similarly ground mathematical problems in other majors. The University of Maryland at College Park, for example, offers two "Calculus for Life Sciences" courses, which include a lecture, a math discussion section, and a biology section. There, students apply math concepts to word problems like: Solve for the "total blood flow in the ascending aorta of an average man" given the radius of the ascending aorta.

Of course, this approach can pose an extra burden for instructors. A math course taught in the context of another subject means that the instructor must know both math and that second discipline.

Another common complaint is that when courses in statistics, quantitative reasoning, or math for liberal arts are substituted for college algebra or calculus, the alternatives are less rigorous.

But reformers say these courses can be equally demanding of students, just in a different way. "Students taking an algebra or calculus sequence are developing great skill at formal procedures," says Mr. Tonge, at Kent State. The math underlying a quantitative-reasoning course may be less advanced, he says, but the rigor comes from having to apply math to a new and potentially ambiguous situation. "It's different from traditional mathematical rigor, perhaps, but I don't think it's any less valuable," he says. "Students need to come to a deeper understanding than simply parroting what an instructor has told them."

Others say rigor is the wrong metric. Students pursuing math, science, or engineering majors need calculus and will take more math classes. Others won't, but they will still need quantitative skills to be informed citizens and professionals.

"What is the utility of a sociology major knowing how to find the derivative of a function versus pay off a home mortgage?" Mr. Sorensen asks. For students in his "Math and Human Society" course, he says, "I think the answer is pretty obvious."

Altering content is one way to reform math education for undergraduates; another is changing the delivery.

The "Topics in Mathematics for Liberal Arts" course at Rutgers that Ms. Arias teaches, for example, has 10 sections, five of which are taught in a lecture format like hers. The remaining five use a "flipped classroom" model, in which students watch instructional videos on their own and come to class ready to do practice problems.

This model is a form of what's called active learning, which is intended to make class time more interactive than a traditional lecture.

John Kerrigan, who leads one of the flipped-classroom sections, normally begins class by answering students' questions about the videos. He teaches in a new active-learning room on campus that's equipped with large round tables, two desktop computers, two projectors, and six flat-screen TVs. He'll post students' questions on the screens so that everyone can see what's being asked.

On a rainy night in March, Mr. Kerrigan's students were learning about fair distribution. Working at tables outfitted with speakers, USB ports, outlets, and whiteboard easels, the 30 or so students tried to divide an inheritance between two siblings. The two didn't want to share, one problem explained, so who gets what?

One student sketched out a problem on the whiteboards that line the room. Mr. Kerrigan wandered among the groups, encouraging them without giving away answers.

Not all active learning has to take place in such well-equipped facilities. The idea includes a range of activities that vary in intensity but often include students working with others, explaining their thinking, and struggling to answer questions on their own. Professors can cover more ground using a lecture, but research suggests that students retain more information using this kind of pedagogy.

Students at Rutgers U. work in groups in a math class geared toward humanities and social-science majors.

In fact, math departments that use these methods have sometimes seen lower rates of failure and marked improvements in student persistence. A project organized by the

Association of Public and Land-Grant Universities is studying a handful of these departments. Project members hope the experience of these institutions can shed light on how to support and encourage active learning, and make it easier for other colleges to find similar success.

David C. Webb, leader of the project and an associate professor of mathematics education at the University of Colorado at Boulder, says active learning is sometimes met with resistance, at least initially.

Professors may feel that they've perfected their teaching style after years of doing it the same way. They probably succeeded in lecture-style courses as students and sometimes question why pedagogical change is even necessary. The size of many classes, especially at large public universities, can make group work feel like chaos. And assessing students' conceptual understanding and ability to apply math does not always lend itself to multiple-choice exams.

It's more work for students, too. It's easier to zone out or surf the web during a lecture. Some students don't like group work or feel they're not getting their money's worth if an instructor isn't providing immediate answers.

For all of these reasons, some faculty members and administrators say curricular change in math is advancing in front of pedagogical change. Though the two often go hand in hand, changing teaching strategy can be harder, says Doug Ensley, deputy executive director of the Mathematical Association of America. "Curriculum change is often more about policy," he says. "Pedagogy is something that has to be changed in the hearts and minds of every instructor."

But even modest changes can make a big difference.

Professors can start small and adapt active-learning activities to whatever teaching style they're most comfortable with. They can spend a portion of class connecting calculus to a real-world application, or having students talk with a neighbor about a problem or concept. "There are very accessible starting points," Mr. Webb says. "You don't need to throw out the textbook."

The cost to train faculty members or kick-start curricular change doesn't have to be exorbitant, either. Advocates for change say it can be covered by a grant, or by a one-time investment from a college or outside group. Organizations like TPSE hope to help by legitimizing requests for resources and sometimes providing their own. The group focuses on math-department heads as potential agents of change because of their unique ability to affect both culture and resource allocation. But it also works with faculty members, administrators, policy makers, funding agencies, and the

professional community. The support and coordination of each group, TPSE leaders say, is necessary for broad change to take root.

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While many efforts have centered on active learning and introducing new entry-level classes, other colleges have found success bringing technology into the classroom, adding student support, or using an Emporium model, in which software tailors each student’s learning material to his or her pace and understanding.
But nearly all of the reforms, and efforts to scale them, can be defined by two tenets: using practices that make sense in the context of a department, and making math instruction more centered on students.

Perhaps no one person encapsulates this student-centered philosophy more than Mr. Treisman, who teaches a freshman calculus class at the University of Texas at Austin. Before each semester, he studies a roster of students’ names and faces so he can greet them personally. He holds at least eight optional study sessions that sometimes last all night. He’s also written to many of his students’ high-school math teachers to thank them for their role in educating his students. "We all share responsibility for the development of students in our care," he says.

Not every instructor has to teach the way he does, he says. In fact, he expects to always be outside the norm: "It’s not realistic nor is it important that people emulate exactly what I do." What’s important, he says, is making average practice better.

"Mathematics is an extraordinarily powerful tool for bettering society, bettering the world. It’s not just a beautiful art form," he says. There are problems in math education, he says. "But we’re owning it now in a way that we really haven’t before."

Shannon Najmabadi writes about teaching, learning, the curriculum, and educational quality.

http://www.chronicle.com/article/Math-Gets-a-Makeover/239789?cid=trend_au&elqTrackId=e618caf537ec476882bb2d23c1d8b372&elq=96bff062a1154295b2c4f323c822a946&elqaid=13537&elqat=1&elqCampaignId=5626