

Math Emporium

The use of technology has changed the way Virginia Tech's introductory math classes are taught

Photos by Jay Paul, Black Star, for CrossTalk

By Kay Mills

BLACKSBURG, VIRGINIA

IT IS 8:30 on a Tuesday night. Students pile out of the shuttle bus from the nearby Virginia Tech campus and head into the University Mall. But this is not what you think—they are going there to do course work, take quizzes or study at the Math Emporium, formerly a Rose's department store anchoring one end of the shopping center.

The Math Emporium is both a place and a concept. It has changed the way nearly a dozen Virginia Tech math classes are taught, while saving the university money. On this particular evening, 314 students have checked in to use some of the 531 computers in the cavernous room.

Three courses—mostly for first- and second-year students—are now online and are based at the emporium. Unlike the experience of taking courses entirely online, these students can meet with their teachers if they wish, and all graded work must be completed at the emporium, not on students' own computers.

Enrollment in these courses totaled 4,000 last fall. One reason for the large numbers is that every Virginia Tech student must satisfy a "Quantitative and Symbolic Reasoning" requirement, and 98 percent do so by taking a math class.

Eight years ago such huge enrollments led the math department at Virginia Polytechnic Institute and University (the school's full name) to explore better ways of teaching than simply "putting anyone with a pulse in charge of a class," as John Rossi, the current math department chairman, put it. Since then, several other universities—particularly the University of Alabama and the University of Idaho—have established similar programs.

The math emporium was part of the first round of course redesign projects assisted by a grant from the Pew Charitable Trusts, through what is now called the National Center for Academic Transformation, in Troy, New York. Carol Twigg, the center's executive director, said the Virginia Tech project was so successful that it has been adopted as a model for future efforts to utilize technology in the teaching of large introductory courses.

Some Virginia Tech students have complained about not having a teacher in a classroom. But Chuck Hodges, math emporium manager and a former math instructor, responds, "No, you've got a dozen." Help is available from math faculty, graduate students or other undergraduates, most days and nights. The emporium itself is open 24 hours a day, seven days a week, during the academic year. To summon help, all a student needs to do is place a very low-tech red plastic cup on top of the computer.

"Before, students had me 50 minutes, three times a week, plus my office hours," Hodges said. "If a student for some reason did not mesh with my teaching, he was sort of stuck.



Most Virginia Tech students take introductory math classes at the Math Emporium, a computer lab located in a former department store near the campus.

Here, there is an enormous opportunity for different styles of help."

Asked why the emporium approach works, math department chairman Rossi said, "I hate to use jargon, but I think it's active learning. We are forcing them to do the work. If they don't do the work, they'll flunk. It's not like sitting in the back of a class of 500 and doing your e-mail." Nonetheless, Rossi still receives messages from parents who complain that they are paying all that tuition (undergraduate in-state tuition at Virginia Tech is \$5,838 this year), yet their child doesn't have a teacher. "I reply by asking, 'How much personal attention do you think your child gets in an introductory psychology class?'"

Three courses are taught entirely at the emporium: college algebra and trigonometry, differential calculus and introductory linear algebra. Another half dozen math courses have an emporium component.

Before going to the emporium, students can check its website to see how many computers are in use. Sometimes there are lines, so the website warns, "It is your responsibility to arrive early enough to meet your deadlines."

Students entering the emporium show their university identification cards and are assigned a computer if they want to use one. However, many students come just to study, because the emporium is quieter than their dorms or because parking is more plentiful.

"A typical math emporium session consists of logging into a computer, then logging into the testing system to take a quiz or exam," said Terri Bourdon, the instructor who manages

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department chairman**

both the college algebra and trigonometry course and the differential calculus course. Many students also do their course work at the emporium. They log onto the computer and click the link for their course on the emporium homepage. Students can take practice quizzes to prepare for the graded quizzes. “Most of the questions that the emporium staff answers come from the practice quizzes,” Bourdon said.

Bourdon does not put the entire course online immediately, so students will pace themselves. But after the first few weeks, all aspects of the course are available all the time.

Exams are proctored and are given at the back of the former department store,

in an area where garden tools once were sold. Quizzes are not proctored, and students are expected to follow the same honor code policy on quizzes as on exams. Bourdon explained that proctored exams are weighted much more heavily in the students’ grades than the quizzes, “so there is not a serious concern about cheating on the non-proctored quizzes.”

Bourdon, a math instructor at Virginia Tech since 1977, has managed the college algebra and trigonometry course for two years, the differential calculus course for three. Last fall about 2,100 students were enrolled in her classes.

“I did have misgivings,” she said. “I said I would do it for one year, because I expected to lose what I went into teaching for”—that is, personal contact with students. “I also enjoy explaining concepts in a lecture format, so I was afraid that I would miss that even more. As it turns out, I have been pleasantly surprised. I have even more personal contact with students, primarily due to the fact that students seem more comfortable asking for help at the math emporium than they do in a faculty office. And I enjoy explaining concepts in this environment since I am talking to students who have already worked through the materials beforehand.”

Student reaction to the math emporium is mixed. On the plus side, Soly Alvarez, from Bogotá, Colombia, a junior in industrial and systems engineering, took linear algebra there in fall 2002 and was pleased with the experience. “I think the math emporium was a positive experience, because I was able to work at my own pace, go back, reread the material, take the practice quizzes as many times as I wanted to,” she said. “And I was able to work from my dorm room or go to the math emporium if I preferred.”

“Also, it served as an opportunity to develop self-discipline skills, letting me organize my time and not having to attend class at a certain time but rather move around my schedule to accommodate other assignments,” she added. Once Alvarez completed linear algebra, she continued to go to the emporium to study for other math classes or to get help from the aides.

Not everyone has such positive reactions. Said freshman Hunter Simmons, of Fincastle, Virginia, who is taking linear algebra and calculus, “It is saving money, but I don’t think the savings are worth what it does.” Simmons said he had a great math background in high school and thinks the software computing program used in his emporium classes is “a complete waste of time.” He would like another day in the classroom, to reinforce concepts, rather than use that program.

In theory, Simmons said, the emporium “really works well. But it’s hard to get to, it’s depressing to be in, and quite often you can’t get help when you need it.” He said the huge room, which is painted a shade of white, could be made more attractive. “We’re at Virginia Tech—make it orange and maroon, everything else is orange and maroon. You could make it more inviting.”

One of the biggest gripes is the emporium’s location, across a busy street and a long hike from the center of campus. The university regularly runs shuttle buses to the emporium—theoretically it’s a ten-minute ride, but sometimes it takes longer, and the buses are crowded.

Christie Roark, from Alpharetta, Georgia, a senior engineering major, objects to having courses “taught completely on the computer at the math emporium. It takes up a lot of time to ride a bus out there, sit at a computer and do something that really you should have been able to do from a computer anywhere else on campus.” For on-campus students “it’s really inconvenient,” she said. Roark never took a course that was entirely emporium-based. “That was by design,” she said. “I planned it that way.”

Roark and some other students do not like the fact that all the computers at the emporium are Macintoshes. “Engineers are required to purchase and use PCs for school, so having to switch over to a Macintosh at the math emporium is really just an annoyance and doesn’t make sense,” Roark said. Software incompatibility sometimes makes it impossible to write a paper at the emporium and e-mail it to a professor, she added.

Chuck Hodges, the emporium manager, explained that Macs are used because they are cheaper, “considering the whole package—security (fewer virus problems), maintenance” and so on. He said there were complaints about an earlier Mac version but few now.

Matthew Vetting, a junior industrial engineering major from Harrisonburg, Virginia, summed up the feelings of many students: “I think the emporium is a good idea but one that



John Rossi, chairman of the Virginia Tech math department, thinks students learn more at the Math Emporium than in traditional classrooms.

could be greatly improved by locating it on campus.”

Virginia Tech professors and administrators say there was neither time nor money to build an on-campus facility in 1997, when the acute need for a large space developed. Had the computer-based courses taken over existing on-campus space, they say, other classrooms would have been displaced. By fall 1998, the emporium’s second year of operation, it had freed up space in 64 classrooms, each with a 40-student capacity, and another 12 classrooms with a 100-student capacity.

Also, officials say, an on-campus facility would have cost about \$19 a square foot to build, while the mall department store could be leased for about \$1 a square foot.

State budget cuts also played a role. Virginia Tech’s state support was reduced by \$72 million during the 2002 and 2003 fiscal years. “The pressures, forces and influences that led to this are at least 15 years old,” said Mike Williams, a math

professor and a former university associate vice president. “We’ve not been treated very well by state financing.” With personnel cutbacks, “the faculty was being squeezed big time in what they had to deliver,” Williams said. So some administrators and faculty members started looking at ways to make better use of technology.

Among academics, Williams said, “change comes hard. Everything is fought over. The smaller the issue, the bigger the fight.” In the early 1990s the university started to prepare faculty for transitions in technology. Once the math department saw what could be accomplished with computers,

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UPDATE

Math Instruction at Virginia Tech

May 2008

ALL OF THE COMPUTERS at Virginia Tech’s Math Emporium have been replaced, some of them a couple of times, since *National CrossTalk* published an article about this program in January 2005. “We replace about a third of them each year,” said Michael Williams, a Virginia Tech math professor, and the director of the Math Emporium.

Featuring 550 Macintosh workstations, the cavernous facility is still housed at the same location, a former department store across the street from the campus. And it has reached the limits of its size. The number of students who take a complete emporium course (one that has no formal classroom component) has increased about ten percent. But because so many other classes make use of the emporium, and because students also like to use it on an informal basis, limits have been put in place to prioritize the availability of the computers.

“When we were giving final exams,” Williams said, “we had a line out the door, for a 45 minute wait, for those free-use computers, which are used commonly for group work and other kinds of studying. But we had to limit the amount of free-use time in order to make sure computers are available for test takers.”

Do students generally like the emporium? “Some love it; some hate it,” Williams said. “Probably more of them dislike it, but they’ll tell you things like, ‘I don’t like to have to teach it to myself. What they’re missing is that, in the end, you teach everything to yourself. That struggle is what changes your mind and makes for learning. In the emporium that connection is painfully obvious. In essence, it amounts to hard work.”

In the last few years several courses have been added to the emporium’s offerings, which included college algebra and trigonometry, differential calculus and introductory linear algebra. “We also run a two-semester business calculus course, and a two-semester

Virginia Tech’s Math Emporium was a trailblazer, of sorts, and has been much imitated in the decade since it was established.

course for architectural students,” Williams said. “We also have another course, like the linear algebra, that’s first-year multivariate calculus. We generally take on a course over the summer, and then rewrite it for the emporium.”

That will change this summer, however. “We are at a limit, and cannot support any more students, so we have to put a freeze on converting more courses, though there are certainly more candidates,” Williams said. “Virginia hasn’t been kind to higher education through the years. Our staffing is way down, and it continues to fall!”

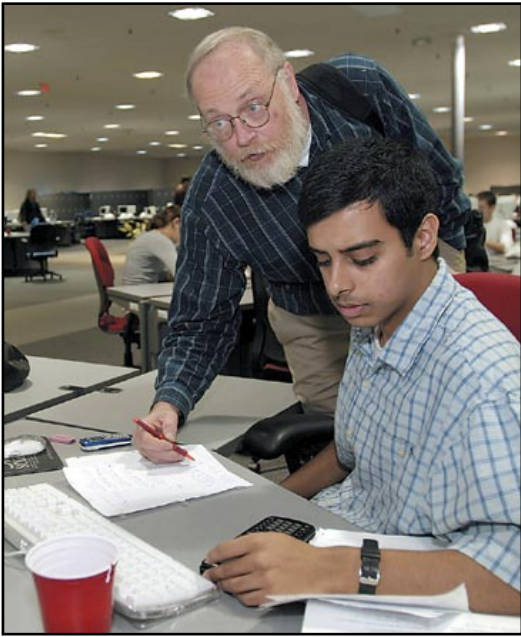
Although there is often resistance, particularly among faculty, to converting courses for the emporium, it all comes down to cost, according to Williams, who would like to see to it that savings realized from the emporium remain within the math department. “It’s such a total change in the way you approach education, and it requires a substantial effort to make the switchover,” Williams said. “The thing that makes the emporium go economically is critical mass—it’s scalable. And that leads you to large enrollment classes. We tend to look toward specialty service courses with high enrollments. Cutting costs on them will result in real savings.”

The recently implemented course for architectural students, which is a mix of calculus and geometry, is a good example. “We’ve had such a squeeze, and it was next on the chopping block,” Williams explained. Noting that there were a number of instructors who were upset about the change, he added, “It’s not a happy thing.”

Perhaps the most important benefit of this approach is that these courses become more available to students. “There’s a real emphasis around here about not putting capped enrollments in place for math classes,” Williams said. “When you start capping courses, that’s when graduation times lengthen significantly, because students can’t get spots in the courses they need.”

Virginia Tech’s Math Emporium was a trailblazer, of sorts, and has been much imitated in the decade since it was established. Carol Twigg, executive director of the National Center for Academic Transformation, cites the emporium as a prime example of the positive results that can be achieved through technological transformation in higher education. “It was the first such program,” said Twigg, whose organization has assisted in the development of many more. “We based our approach on what they did at Virginia Tech,” she added. “The two stories are like the micro and the macro.”

—Todd Sallo



Math professor Mike Williams says state budget cuts are one reason Virginia Tech turned to the computer lab solution for large-enrollment math classes.

its labs began to be crowded. That was a good pressure but one that had to be relieved, Williams said.

Virginia Tech, with a current enrollment of about 25,600 at the Blacksburg campus, promised the state to take more students by 2010, with no increase in state funding, said Anne Moore, associate vice president for learning technologies. From 1992 to 1995, the additional students did not arrive. But in 1996 enrollment jumped, whether through admissions office miscalculations or other reasons, and the math labs were overflowing.

“People were wanting to get off a burning platform” and knew something had to be done, Moore said. The math emporium was the answer.

Comparing costs of traditional classroom teaching and emporium-based classes is difficult, math professor Mike Williams said. For example, when math faculty wrote the software for the college algebra and trigonometry course, they made it a bit more difficult than before, so comparing results would be like comparing apples and oranges.

Student performance has improved since the emporium opened. In fall 1997, the first year for the redesigned linear algebra course, 68 percent of the students received C grades or better. By fall 2002, 90 percent were earning at least a C.

The student success rate also has improved at the University of Alabama, which established a Mathematics Technology Learning Center, modeled on the Virginia Tech emporium. In fall 1999, only 40 percent of students taking traditional math classes were earning grades of C-minus or better, but after three years of the technology-based approach, that has increased to 60 percent.

Early on, some Virginia Tech math professors were skeptical about computer-based courses. “I think they saw it as something that would change the ultimate outcome, that it was more of a gimmick than substance,” said Robert Bates, then dean of arts and sciences at the Blacksburg school, now provost and academic vice president at Washington State University. “Some would

say that our classes had gotten too big, and if we would just go back to smaller classes we could educate students.” But “some students need individual attention; some don’t,” he

added. “Some can move faster through the material. If we can individualize the students’ experience, we can teach them better.”

“What is (traditional) teaching?” asked Mike Williams. “It’s 40 to 80 students in a room. A broadcast, not unlike watching TV. A very passive act. The majority are zoned within 20 minutes. My view is that the lecture is not worthwhile. But there are those who are very prideful about their material, being the ‘sage on the stage.’”

One instructor with many students is highly inefficient, Williams added. “What we have now is one-to-one. We train our helpers to be good listeners, not to solve the problem for the student but to figure out the right question to make the light go on. The work of discovery changes a person’s brain. We try to understand exactly what it is the student doesn’t understand.”

Teaching methods have not changed in upper-level courses, according to Williams. “I am not sure this would be worth doing for courses of less than 500 students,” he said. “There are about eight courses for which this works. Of 11,500 math enrollments, 8,000 are registered at the emporium for some activity that requires grading.”

Virginia Tech has been in one financial crisis after another in the last decade because of state budget cuts and tuition freezes. Meantime, said Provost Dixon Hanna, the math department was struggling because of the university’s large engineering and science enrollments. “The math department here is much larger than at most institutions, and it was struggling getting its classes taught.” Under these circumstances the department was willing to take a chance on the emporium.

In order to succeed with the emporium approach, “you really have to have people who believe in it, who are willing to do almost anything to keep it from falling on the floor,” said Monte Boisen, who helped start the project at Virginia Tech and now is math department chairman at the University of Idaho. “It requires an amazing amount of commitment.” Frustrations can abound when software doesn’t work as it is supposed to, or, as happened soon after the Virginia Tech emporium opened, someone plugged in a vacuum cleaner and shut down the electrical power supply completely.

The emporium project could not have succeeded without strong support from top campus administrators, including then-President Paul E. Torgersen. “We’ve always been very innovative about anything having to do with technology,” said Torgersen, who was president from 1993 to 2000 and now teaches industrial engineering. “We were the first university to require PCs of all engineering freshmen.”

Some other departments thought that math was getting undue attention—and money—and were not happy, Torgersen recalled. “Anytime you do some initiative, it comes at the expense of somebody else,” he said. “If you just sit around and hand out money evenly, you’ll never make progress. Once you decide you’re going to do this, you just do it. This was a train on a fast track and there was no way we were going to stop it.” ♦

Kay Mills is the author of “This Little Light of Mine: The Life of Fannie Lou Hamer,” and four other books.

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—Mike Williams, a Virginia Tech math professor