The Math Emporium: Student-Paced Mathematics 24/7

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The Math Emporium: Student-Paced Mathematics 24/7

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Why use technology?
We had three compelling reasons for bringing learning technology to the Math Department and creating the Math Emporium here at Virginia Tech. First, an enrollment increase that was supposed to occur gradually over a six-year period occurred in one year, in 1994. We suddenly had an increase of about 1,800 students, and at Virginia Tech nearly every single entering student takes mathematics. At the same time, the school was going through a budget crisis and our department was going to lose 6 percent of its budget.

Second, in the 1980s a major calculus reform movement was sweeping the country. The reform called for a leaner, meaner calculus curriculum. Instructors needed to spend more time with students, helping them understand what they were doing rather than teaching them all these computations. And the Virginia Tech Math Department jumped right into that stream.

Third, Virginia Tech wanted to be known as a leader in using technology. The school instituted a program in which every faculty attended workshops every three or four years and received a high-end computer, configured to their choice, after each workshop. The Math Department was the first guinea pig, and that was when the idea of teaching math in a computer-enhanced environment got its start.

The strategy
During that first workshop, we were introduced to the computer program Mathematica. Then, in the spring of 1993, we began using Mathematica in two of our first-year calculus courses. With only 78 computers and nearly 2,000 students taking the new classes each semester, assessments that included a common final exam showed that students in this new information technology initiative were performing at or above the level of students taking the traditional course. The “IT” students’ final grades were half a grade higher that the “traditional” students, and later longitudinal assessments showed that IT students taking other mathematics or engineering courses were doing better than students who had taken traditional math classes.

When I became department chair in 1994, the math department was teaching calculus the “Baskin-Robbins” way—if there was any way of teaching calculus, somebody was doing it in the department. I believe in innovations like that. You have to have the big bang, and then after the big bang, and everybody’s excited about it, you try to steer, try to figure out what’s really working and steer them in that direction. I hired an assessment coordinator in the department, and I issued the edict that every freshman and sophomore course has a common final exam. I was getting all kinds of differing views about what’s appropriate for technology—I still get that today—and I decided we need to have some way of judging what students are learning. I also stated that the exams would not be used in faculty evaluations; faculty had always voted down
common exams in the past, because they were fearful that they might be evaluated by how students are learning.

Now each course has a list of objectives and goals that were set up and improved by the Undergraduate Program Committee, so for every common exam, each question is coded against objectives and goals.

Three hundred out of the 1,600 students in the fall took the self-paced math courses, and they did a lot better on the common exam and a lot better in the following course than the traditional students. So that sets the stage for the Math Emporium, because at this time I was teaching 300 students; the math department had control of two labs, one with 40 computers in it and one with 38 computers. Between the self-paced course and engineering calculus, we were teaching classes on those machines from 8 in the morning until 11 at night. There was no room for professors to just go around and do open-ended sessions with them.

We also saw that another class, a differential equations class taught to civil engineering students, always outperformed every other differential equations class—we called this class “Green Math,” and this class was set in the context of civil engineering and polluted lakes and other kinds of applications. The higher performance was because the math they were learning was set in a relevant context.

So the labs were full, and we were teaching calculus to several different audiences: biology and dairy science, business, and architecture, as well as math and engineering students. The business and architecture calculus courses were absolutely terrible, not at all relevant to the students. In all, we calculated that our enrollments were, and still are, 12,000 to 16,000 students per semester. When we told the other deans that we would have to split the business and architecture courses unless we built this Math Emporium idea we were developing, we had all the deans in favor of the project.

The core idea was that the best time to teach mathematics is when the student wants to do it. We needed a place—with computers, software, and roving instructors—that is open all day for the students to come in and do their self-paced study. We found an empty department store near campus, and the landlord did the entire infrastructure for us, the T1 and phone lines and such, incorporating the cost into the rent. We signed a 10-year lease with him. The concept was sold to the deans in March, and we moved into the building in August. The University supplied the computers.

**The learning technology**

*The Math Emporium:* The Emporium is open 24 hours a day, seven days a week. The facility holds 500 workstations, with other specialized spaces and equipment included. Instructors are available Mon.-Thurs., 9 am to 12 midnight; Fri., 9 am to 4 pm; Sun., 4 pm to 11 pm. The tutoring lab is staffed by peers and open Sun.-Thurs., 6 pm to 9 pm.

Information Systems takes care of the students, checking them in and out, and also making sure the computers are running. The Math Department takes care of the curriculum, helping the students learn. One faculty member has the teaching assignment of being the Emporium Coordinator, overseeing all the courses and making sure that the trains don’t collide into each other. It runs smoothly. A couple of instructors in the Department just teach four courses a semester each for us; they don’t have a research assignment. They’re out there 40 hours a week, and they are in seventh heaven. It’s what they want to do. In total, we have 94 faculty in
the department, and during the semester, about 60 faculty have some sort of assignment in the
emporium.

Students can still move through the course in a traditional way; there’s a lecture hall and an
area for traditional tutors. Students can go to lecture, do their exercises at the end of the
section, and then go to a tutor lab. The tutors look over their work, and the students take their
test. But although some students start with the lecture format, because that’s the way they were
taught, very few students continue that way. They see their peers having successes and they
say, “Why am I going to lecture when I can do it this way?” We have a safety net for the
traditional students, a focus group that’s required, in which their progress is monitored.

Each class provides worksheets on the Website, with detailed instructions for the students to
follow; this includes homework and quiz assignments.

For more information, explore the Math Emporium Website at http://www.emporium.vt.edu.

Mathematica: With this well-known math software, students can do numerical computations,
extensive simulations and prototyping, and prepare clean reports and presentations. The

MATLAB: For our engineering students, the primary software is MATLAB, per the engineers’
request. This offers a technical computing environment with numeric and symbolic
computational abilities; data analysis and visualization; engineering and scientific graphics;
modeling, simulation, and prototyping; and programming capabilities. The MATLAB URL is

The Geometer’s Sketchpad—Geometry Software for Euclidean, Coordinate, Transformational,
Analytic, and Fractal Geometry: We use this software for our architecture students; they wanted
a lot more geometry in their sequence. The URL is http://www.keypress.com.

Excel: The course for business majors uses Excel like crazy—they wanted to learn how to use
spreadsheets in a variety of ways. They talk about revenues, incomes, module derivatives; the
business people are in love with the course now.

We also have an online course, Linear Algebra (Math 1114), which is a course for which we
wrote the technology ourselves. The students don’t see the technology; they just work through
the material online. You can access the worksheets for this course via the Emporium Website.

The funding
We funded the Math Emporium with money from the National Science Foundation and FIPSE
grants; but our primary source of money was the University. This was a painful process,
because the money for technology had to be carved out of the budget. We also received funds
from the University’s Center for Excellence in Undergraduate Teaching (CEUT); they give out
grants to help faculty renovate courses. There’s another body on campus called the Center for
Innovative Learning (CIL). Their budget is used to entice faculty to rethink what they’re doing
with the use of technology, and they have supported us as well.
The results
The Emporium has been so successful that a lot of institutions are building these facilities now. The universities of Alabama and Idaho are each building one, and a couple of other projects are in the works around the country. Math departments are catching on to this way of solving the “Math Problem”: Is there a better way to help students learn the math they didn’t learn in high school?

As for the students, there’s a lot of leeriness and jeering at first. You have to picture an 18-year-old walking into this building saying: “I’m going to do what?” We spend the first two weeks holding students’ hands. We tell them, “First of all, the most important thing you can do at Tech is become an active learner and know how you learn.” Then we make them do all kinds of exercises so they see all the resources within the building. At first the students are not real impressed. Some are excited about being on their own, but others feel that we’re abandoning them to a sea of computers. By the end of the semester, after they’ve had successes and such, their attitudes have changed some.

To go to the scale we have gone, if the institution is not committed to it, I would tell any department chair to not even think about doing this. Even within the Math Department faculty, I really have critics, a small group that believes this is not the right way and they want to go back to the old way of teaching. You need a group that really believes this is the way for students to learn and it’s the faculty’s job to protect the students and nourish them and encourage them to do this. You need the group that is focused on student learning and not on “casting pearls among swine,” on being the stars of the show. Student learning is a lot different than that. You have to be willing to think on your feet—you walk into this building and you never know what you’re going to face.

If you have any questions, you can contact me at math@math.vt.edu.

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