



MATHEMATICS THROUGHOUT THE CURRICULUM

PROJECT NEWSLETTER

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MATC Workshop: IU BLOOMINGTON TO HOST NATIONAL PARTICIPANTS OF NSF PROGRAM

With the end of the 20th century close at hand, many Indiana University faculty are looking ahead to the future as they seek to introduce new approaches to education.

Academics from across the country will gather in Bloomington on July 9-10 to attend a workshop hosted by IU's Mathematics Throughout the Curriculum (MTC) Project to showcase developments in the interdisciplinary mathematical sciences education.

IU is one of seven institutions that received a major National Science Foundation (NSF) award to "promote systemic improvements in undergraduate education by increasing student understanding of and ability to use the mathematical sciences." The other institutions are Dartmouth College, Rensselaer Polytechnic Institute, the U.S. Military Academy, the State University of New York, the Oklahoma State/University of Nebraska partnership, and the University of Pennsylvania. Together these seven institutions comprise the "Mathematical Sciences and Their Application Throughout the Curriculum" (MATC) program of which IU's MTC project is part.

At the July workshop these institutions and their over 40 award affiliates will

showcase their first three years of work.

The NSF workshop organizers Daniel Maki (IU Bloomington) and Richard



Dr. Richard Patterson, Associate Professor of Mathematical Sciences, IUPUI

Patterson (IUPUI) strongly encourage any IU faculty interested in interdisciplinary course development to attend the workshop and become involved with the IU MTC project. The workshop has been designed to teach others how mathematics and statistics can be integrated into other courses including the liberal arts, engineering and science courses.

Workshop sessions will demonstrate

to the participants how examples from other disciplines can be used to reinvigorate college algebra, calculus and differential equations. Other sessions will be dedicated to sharing the methods by which many MATC faculty are incorporating new technologies into their courses.

The goal of these sessions is to provide insight into the way other institutions have lowered departmental boundaries, working with each other and the administrators to promote systemic changes.

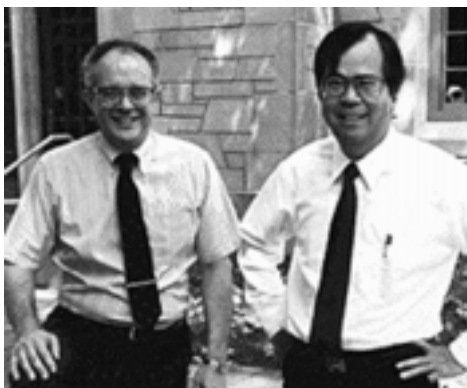
Faculty who have already begun working on interdisciplinary teaching approaches and materials will showcase their results and progress in a poster display that will be open for the duration of the workshop.

To enable faculty to attend the workshop, MTC is providing support grants of \$500 for interdisciplinary teams. These grants may be used to pay expenses of attending the workshop or to help with the costs of course development. Priority will be given to teams comprised of one faculty member from mathematics and one from another discipline. Information about the workshop can be found at

<http://matc.siam.org/workshop/>

A Productive Year

NEW COURSES, EVALUATION, AND A NATIONAL WORKSHOP



IU Math Professors Daniel Maki and Bart Ng

We welcome people to contact us for more information or with suggestions for new courses.

Please see the back page for our mailing address, phone number, website and e-mail addresses.

We look forward to your comments.

The academic year 1998-1999 was a busy and productive one for the MTC (Mathematics Throughout the Curriculum) project. We introduced several new courses, and we made plans to host the first national conference to showcase the seven National Science Foundation projects on Mathematics Throughout the Curriculum.

This newsletter contains two articles on the workshop, and, in addition, there are articles on our evaluation work and on one of the courses, Game Theory by Professor Roy Gardner of the Economics Department at IU Bloomington.

In our next issue of the newsletter we will feature courses from IU Southeast which blend mathematics and biology as well as mathematics and business, courses from Indiana-Purdue at Fort Wayne, and a new math for journalism course at Bloomington. We have now passed the halfway point of our project, and although we will continue to introduce new courses, our emphasis in the future will be largely on materials production, evaluation and dissemination.

Over the last year, several members of the MTC team have given talks about the project at national meetings, and we have also given several faculty workshops on our courses. During the next two years, we hope to establish partnerships with schools that are developing courses based on our interdisciplinary examples. An important aspect of these partnerships will be helping schools to adopt our courses to fit their circumstances.

MTC IN REVIEW: A LOOK AT THE CREATION OF IU'S PROGRAM

In 1994, the National Science Foundation (NSF) issued a call to revitalize undergraduate education. The NSF hoped to increase students' proficiency in the mathematical sciences because it believed a gap existed between the level of students' mathematical skills and the level needed to function successfully in a technology-driven workplace.

Daniel Maki of Indiana University Bloomington and Bart Ng of IU-Purdue University at Indianapolis developed the Mathematics Throughout the Curriculum (MTC) project as a response to the NSF challenge.

NSF was searching for projects that would serve as national models for effectively integrating mathematics with other disciplines. Convinced that the MTC project — which had already received \$300,000 from the IU Strategic Directions Initiative — could serve as such a model, NSF awarded the project with a \$2.8 million grant in late 1996.

Maki and Ng based the MTC program on an earlier project Maki directed at Claremont Colleges in southern California where student teams in a math and engineering clinic worked on math-related problems from local industries. Students

turned abstract equations into tangible solutions.

When the College of Arts and Sciences teamed up with the Business School in 1989 to form the Liberal Arts in Management Program (LAMP), Maki joined with business Professor Wayne Winston to create a new course that applied mathematical tools to projects from local businesses and government agencies.

This hands-on, interdisciplinary approach was just what NSF had in mind when it set out to improve undergraduate mathematics, and the experience helped distinguish IU from a pool of 200 applications. IU is one of seven institutions now involved in the NSF initiative, and the agency hopes to replicate successful courses in institutions across the country.

Since each institution has different ideas and approaches to the NSF initiative, the MTC project will share its successes and failures with the six other programs at July's "Mathematical Sciences and Their Application Throughout the Curriculum" workshop in Bloomington. The workshop hopes to help achieve the NSF's overarching goal: to systematically improve undergraduate education in the nation's colleges and universities.

Playing Games: Mathematics and Economics

BLACKJACK AND POKER TEACH STUDENTS THE RULES OF ECONOMICS

Roy Gardner's approach to teaching economics and game theory does not include high-powered scientific calculators or expensive mathematics software. In the course he developed at IU Bloomington, his teaching tool is a deck of cards.

Using a standard 52-card deck, as well as various modified decks, he provides students with a hands-on way to experience probability theory for themselves. Not surprisingly, students respond more enthusiastically to lessons that explain the concepts behind "Black Jack" than lessons that follow the "theorem, proof, theorem, proof" method of teaching.

The uniqueness of Gardner's approach, however, lies in the way the class has inspired students to embrace mathematics and its related concepts

"I used to hate economics," class-participant Suzy Poor said. "[Without Gardner's class] I never would have been an economics major. He showed how [economics and probability theory] applies to real life." Poor, now a senior, served as an undergraduate teaching intern under Professor Robert Becker, who taught the class in Fall 1998.

Although Poor, who is now considering a career in marketing research, may stand out for her elevation to a teacher's assistant position, her interest in the course is not unusual.

"If attendance is any indication of interest, participation in the course was over

90 percent," Gardner said.

While the class requires a basic-level economics course as prerequisite, separate sections of the course is offered to students who have a background in calculus as well as for those who do not. In class, however, the students' backgrounds were indistinguishable, Poor said.

As Gardner points out, knowledge of calculus is not necessarily essential for an appreciation of mathematics. "A great deal of Western science developed before it had tools to crunch problems down to solutions, and still it found it somehow philosophically satisfying."

In the Game Theory course, students and professor extrapolate broader social implications from the mathematics principles.

Gardner's course syllabus suggests the depths of the course: in one semester students' focus moves from simple chess and the casino industry to price fixing and the credit card industry. The course concludes by examining "the tragedy of the commons," which Gardner defines as "human versus nature interaction."

In other words, students realize how games model natural and social phenomenon.

In the case of the world's fisheries, students learn that the natural impulse is to over-fish the world's waters. Following up this example, however, students learn that fish stocks world-wide have been steadily diminishing. Students see why overfishing takes place, but also that over-fishing will lead to the complete collapse of the industry.

"Students know qualitatively what needs to be done: less fishing," Gardner said.

When every outcome results in a bad outcome for the players, Gardner explained, the natural outcome is to change the game.

In some instances, however, knowing the facts does not change people's behavior. One of Gardner's first lessons of the class shows students the near impossibility of beating the house in casino Black Jack. Based on a small sample taken from 52 factorial (around 10 million) none of the teams are able to report winning. When students consider that the average casino guest bets \$79 against the house in Black Jack, it comes as no surprise that casinos continue to proliferate nationwide.

Poor said that the class provided much insight into current events. Examination of the "prisoner's dilemma" and its consequences for truth-telling informed the class about the Monica Lewinsky scandal. The concept of "brinkmanship" allowed students to analyze the way world leaders reacted during the most recent crisis in Iraq.

Closer to the lives of IU students, Poor noted, was one student's lengthy study of the "matching principle" applied to sorority rush.

"I would even recommend the class to non-econ majors," Poor said, citing the way the course changed countless students' perception of math. "One student this past semester who at the start said 'I hate math' ended up pulling an 'A' in the course. "

Acting as a Pump, Not a Filter

KEYNOTE SPEAKER SHARES LESSONS IN INTERDISCIPLINARY EDUCATION

Gregory Prince, Jr., the keynote speaker at MATC's July workshop, understands the obstacles confronting interdisciplinary educational programs.

He is the president of Hampshire College; a school so committed to interdisciplinary education that it has no departmental divisions of its faculty. "All [disciplines] merge into an integrated whole. We don't see them as distinct and different," he said.

While traditionalists might expect that a college without departments would be chaotic, Prince said Hampshire College fosters an atmosphere that motivates students to learn.

Moreover, he believes that this motivation and flexible educational philosophy can be transplanted into larger universities through programs like "Mathematical Sciences and Their Application Across The Curriculum" (MATC), of which IU's "Mathematics Throughout the Curriculum" MTC program is a part.

Prince, who served as Dean of Interdisciplinary Studies at Dartmouth for 19 years before leaving to preside at Hampshire college, believes his experience with confronting cultural, political and bureaucratic aspects of interdisciplinary education can offer insight for MATC participants.

Hampshire College credits much of its success to a collaboration with four other colleges (the University of Massachusetts-Amherst, and Amherst, Smith and Mount Holyoke Colleges), which allows students to extend their campus beyond Hampshire. Inter-institution cooperation

has already begun among some MATC participants who hope to achieve successes in mathematics education through the use of websites and innovative software.

But to truly change the way students learn, attitudes about education must change as well. Hampshire employs an "inquiry-based learning" approach to teaching. In this approach, students pursue questions for which there are no



"By transforming the environment, the issue of motivation disappears"

—Gregory Prince, Jr.

Hampshire College President

answers.

"By transforming the environment, the issue of motivation disappears," Prince said. Teachers, rather than posing the questions for students, create an atmosphere that encourages them to obtain answers for themselves.

Science and mathematics are not distinct from other disciplines, Prince said, and students benefit from teachers who are able to show how they connect. He likens this process to "creating a pump,"

because it allows students to discover they have a genuine interest in the sciences. In contrast, traditional teaching methods tend to discourage and filter out many students from mathematical sciences.

For example, one of Hampshire's popular introductory seminars on physiology attracts many art and dance students who want to relate the course to skills they already possess. By allowing students to individualize their approach to physiology, however, the course "gets students to do science before they know science," Prince said.

Prince hopes that his involvement with the MATC program will show participants how they can "create a pump" at their own colleges and universities. He said many universities around the country are opening up to Hampshire's approach, some even recruiting Hampshire's faculty because "they are interested in a breed [of teachers] who understand that research and teaching are not opposed to each other," Prince said.

Students are not, however, the only ones who benefit from interdisciplinary programs.

Prince at present is serving on a committee for a student who is examining the relationship between dance and conflict resolution. Prince, whose background is in American Studies, will be working closely with Dance faculty from Smith and UMA.

"I can guarantee that at the end of a year we [the faculty] will be more different and intensely changed than the student who put us together," he said.

Visit the Hampshire College website: <http://www.hampshire.edu>

MTC Evaluation:

THE EVALUATOR'S PERSPECTIVE

By Rajee Amarasinghe

Evaluation efforts are key to the success of the MTC project in achieving its goals.

They are important not only in assuring high quality course development and implementation, but also in documenting the "lessons learned" that can be shared as the faculty disseminate the coursework and concepts of MTC.

The project team has evaluated sixteen courses developed under the MTC project, including multiple evaluations as courses have been offered for the second or third time. As a research assistant for evaluation under the supervision of Professor Diana Lambdin, I have had the opportunity to observe all these innovative classes, talk to students and instructors, and analyze data gathered through surveys and questionnaires. I certainly can describe my experience as both interesting and educational.

Our data documents a class's progress toward MTC's overarching goals. We have focused on evaluating two major MTC objectives: creating interdisciplinary courses and changing student attitudes.

Measures and techniques have included examining course syllabi, samples of assignments and student work, tests and assessments, as well as other documents. Our goal is to find out if courses meet the project's goals of requiring minimal mathematical prerequisites, are problem/project driven, involve student activity and group work, and emphasize communication. Another goal is to determine the extent to which student outcomes in mathematics are specified in the syllabi, taught in the course, and appropriately evaluated. We are using classroom observation to focus on mathematics content, teaching methods, assessment methods, and to triangulate

other measures of course success. We are also examining the uses made of technology in the classroom.

For attitude assessment, we have administered pre- and post- surveys to obtain measures of student expectations, attitudes, beliefs, and satisfaction; interviewed selected subsets of students and all instructors; and performed classroom observations. Our efforts have yielded promising evidence of success even though the initial paper-and-pencil attitude survey was less informative. In its first administrations, it did not detect significant shifts in attitudes from beginning to end of the semester, although other data (student interviews, answers to open-ended questions on end-of-semester evaluations, and interviews with course instructors) seemed to offer clear evidence that many students' views of mathematics had indeed been changed. In the past two semesters, the improved version of the survey seems to show similarly encouraging results.

Students I interviewed in almost all MTC classes described their learning experience as novel and enjoyable when compared to other mathematics courses they had taken. Often they mentioned how much the course had taught them about the usefulness of mathematics in their subject area. They particularly valued the hands-on experience in MTC classes. Quite a few students claimed that before, they thought learning mathematics was merely learning to use formulas through drill and practice. Hands-on experience of solving real-life problems with mathematics helped them understand mathematical concepts better and provided them with a new way of looking at the discipline.

Student projects and presentations (especially real-world projects) seem to be

important in keeping the interest and attention of the class. In MTC courses that utilized them, student enthusiasm remained high throughout the term compared to the decline in interest toward the end of the semester typically found in traditional classrooms. Many instructors noted dramatically lower dropout rates in their MTC classes compared to traditional courses.

Successful courses also featured the use of technology. Beginners in Excel became confident in using it for work in other classes. Students who had used various technologies in parallel classes were gratified to see how these tools could be used in learning mathematics.

Initial MTC offerings are typically team-taught by a mathematician and a faculty member in another discipline. Some classes offered the second time have successfully used teaching assistants in place of one of the instructors. This is important since it is unlikely that interdisciplinary courses can be institutionalized if they require two faculty instructors. TA's facilitated interaction between students and the faculty member, sometimes by functioning as peer tutors. They also took an active part in classroom discussions.

A big challenge for MTC is the lack of teaching materials that would enable someone other than the course developers to teach the course. Efforts are being made to change this situation, but complete sets of teacher materials are yet to be produced. One goal of the project office is to support instructors in the tremendous undertaking of making the valuable experience gained by the MTC faculty available not only to other IU campuses but also to universities nationwide.

For more information about MTC

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PROJECT UPDATE

Sixteen MTC courses have been taught during 1998-99:

- ▶ Art and mathematics
- ▶ Business and mathematics
- ▶ Chemistry and mathematics
- ▶ Criminal justice and statistics
- ▶ Economics and game theory
- ▶ Economics and statistics
- ▶ Elementary biology and mathematics
- ▶ Experimental calculus
- ▶ Finance and mathematics
- ▶ Geography and mathematics
- ▶ History and mathematics
- ▶ Intermediate biology and mathematics
- ▶ Linguistics and mathematics
- ▶ Social and industrial problems and mathematics
- ▶ Social sciences and mathematics
- ▶ Speech and hearing and mathematics

Additional courses have been developed through MTC:

- ▶ Exercise science and mathematics
- ▶ Physical systems and mathematics
- ▶ Nursing and mathematics

Additional courses are being developed during 1999.

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