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BLOOMINGTON, Ill.--Freshmen and other math students at Illinois Wesleyan University are applying their analytic skills to real world problems--like the aerodynamics of aircraft, the economic effects of investment vs. consumption, and the performance of shock absorbers in vehicles--in an innovative approach to math education spearheaded by Gamal Elnagar, visiting assistant professor of mathematics.

Elnagar latched on to this teaching technique in an effort to make mathematics more interesting for his students. He also is using it to teach students how to apply mathematics to actual situations.

"There is a big difference," Elnagar explains, "between learning mathematics and its terminology and applying it. When you learn how to apply what you have learned in mathematics, it will never be erased from your memory."

Calculus and analysis courses were the focus of the undergraduate mathematics research group last semester.

Elnagar mentored about a dozen students working on research projects last semester. Weekly meetings were held on Saturday afternoons and sometimes on Wednesday evenings to monitor progress.

Elnagar wrote in a report on the Undergraduate Mathematics Research Group: "Each student would receive individual guidance from me. Through periodic short presentations to the entire research group, however, the students would learn from each other and get some feel for working in an industrial research group. The presentations, together with a written report, would also develop the communications skills that would be required by their future employers."

Among students working on projects were:

• Ashwin Kapur, a freshman math and economics double major born in New Delhi, India, who studied the aerodynamics of non-elastic aircraft. Kapur solved an equation dealing with forces on the boundaries of a non-elastic aircraft. This required use of differential equations and other mathematical tools to describe

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how to minimize stresses and strains on aircraft so they won't fail in flight.

"It took me about 10 days to solve the problem," Kapur said. "This project was extremely helpful to me and I learned a massive amount from it. I'd like to continue to do math research."

• Jeremy Kotter, a freshman physics major from Springfield, Ill., whose examination of oscillation was applied to the behavior of shock absorbers in vehicles. He looked at very rigid shock absorbers, a high performance type used in race cars.

Kotter, whose problem involved linear Duffing oscillation, focused on the amount of energy shocks can absorb and the time it takes for the absorption to take place.

"The day after I received the problem," Kotter recalled, "I worked on it at home until midnight. The next day, I was in Professor Elnagar's office at 9:30 in the morning and worked there until just after 1 in the afternoon. In fact, we were a few minutes late to our one o'clock class. I think it took me about 50 hours to solve the problem."

Kotter, who used paper-and-pencil calculations and a computer to work on the problem, felt a sense of accomplishment when he solved the problem. "I solved the problem," he said, "essentially to make better shock absorbers for cars in a linear world, but, of course, we don't live in a linear world. What I did was to show how a shock absorber on a car that hits a pothole can absorb the most energy in the shortest amount of time to minimize the affect on passengers."

• Ryan Williamson, a freshman math and music (alto saxophone) double major from Herscher, Ill., whose work on a calculus of variation problem described the affects of consumption vs. investment on an economy. Elnagar explained the project this way: "If a country receives one unit of aid--perhaps $1 million--we would like to find a rule in the form of a function that this country needs to follow to maximize investment of that one unit of aid and keep consumption minimal. This could be particularly relevant to developing nations."

Aside from solving his problem, Williamson said he learned much about the research process, noting it is "demanding in terms of the time and effort you have to put into it. You don't have to be the most intelligent person to do research, but you

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do need endurance to stick with it."

Williamson, who wants to teach math at the high school or college level, said it took him a week and a half to two weeks to solve the problem, observing that "When you do research, you're doing new things and taking stabs in the dark."

Kapur, Kotter, and Williamson presented their findings Dec. 9 at a meeting sponsored by IWU's Math Society and the Undergraduate Mathematics Research Group. The program was entitled, "Numerical Solutions of Real World Problems."

"All of these students," Elnagar explained, "were looking for optimal solutions to their problems."

Problem-solving is at the heart of Elnagar's companion interests in physics and mathematics.

"I am a problem-solver," he said, "and mathematics is the most convenient and accurate tool to solve the problems that interest me. For example, I became very interested in aerospace and rocket problems. As an undergraduate, I did solar energy research, working on sun-tracking photovoltaic cells."

As a graduate student, Elnagar's initial interest was in physics.

"In class," he recalled, "I raised so many questions--questions that dealt with mathematics--that I began to understand that I could have a better understanding of physics, if I had more of an understanding of math. Math is a powerful tool. So I switched fields and received a masters degree in mathematics.

"When I was beginning to work on my doctorate," Elnagar added, "I was working in pure math. But, I asked myself, 'Where am I going with all of this abstract math?' so I switched to applied math and started to look at real world problems. I became very interested in industrial work and computational methods to solve industrial problems."

An instructor mentored Elnagar in the interdisciplinary field of control theory, a subject touching diverse fields from economics to aerospace, from agriculture to chemistry. As a doctoral student in mathematical science, Elnagar specialized in control theory and the application of physics and engineering to real world problems.

Elnagar, who was born in Cairo, Egypt, earned a bachelor of science degree in physics from the College of Science and Technology at the University of Tripoli

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(Libya) in 1980. He received master of science (1986) and doctoral degrees (1993) in mathematics and mathematical sciences, respectively, from Mississippi State University.

Between 1984 and 1993, he held teaching posts in mathematics and physics at Mississippi State, Kansas State University, and Mary Holmes College in West Point, Miss.

Elnagar, 36, is the co-author of 17 research publications and has made presentations at various scientific and professional meetings. In December, 1994, he was invited by the Center of Nonlinear Studies at the Los Alamos National Laboratory (New Mexico) to present some of his computational techniques. Elnagar is a member of the Society for Industrial and Applied Mathematics, American Mathematical Society, and the Mathematical Association of America.

Elnagar's father, Noubi, is a philosophy professor at the University of Cairo, and his mother, Samiha, is an ophthalmologist. His brother, Hosam, is an environmental engineer in Detroit, and his sister, Amany, teaches aerospace engineering at the Egyptian Flight Academy in Cairo.

IWU, founded in 1850, enrolls about 1,800 students in a College of Liberal Arts, College of Fine Arts, and a four-year professional School of Nursing. In recent years, the university's endowment has grown to more than $92 million; a $15 million athletics and recreation center opened in the fall of 1994; and a $24 million science building will open in 1995. The Carnegie Commission for the Advancement of Teaching promoted Illinois Wesleyan to a "Baccalaureate I" institution in 1994, a classification that places it among 164 highly selective National Liberal Arts Colleges in the annual *U.S. News & World Report* rankings. *U.S. News* ranks IWU the second most efficient national liberal arts college--a key gauge of the campus' quality academic program and relatively reasonable cost. *Barron's Profiles of American Colleges*, another respected college guide, rated IWU "highly competitive (+)" in its latest edition. IWU's 1994 freshman class scored an average 27.9 on the ACT exam, compared to the national average of 20.7.

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