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ABSTRACT

Needs of collegiate mathematics across the nation are considered, and suggestions are offered to the National Science Foundation (NSF) by a professor of Mathematics at St. Olaf College (Minnesota). Changes in mathematics content, scope, and applications have implications for the college curriculum. Problems and challenges are posed by: increased enrollments in elementary courses and decreasing numbers of mathematics majors; inadequate access by faculty to computing resources; and providing mathematical courses appropriate for liberal education. The curriculum is largely elementary and out of date at most two- and four-year colleges, excluding research universities and selective liberal arts colleges. While there is a shortage of math teachers, industrial demand for mathematics graduates is high. Faculty involvement in scholarship and professional development, not only traditional research, is important to revitalizing collegiate mathematics. Recommendations include: providing a competitive system of NSF Faculty Fellowships in areas such as curriculum development, student projects, and research support; providing each mathematics faculty a high-powered computer work station; utilizing the expertise and outreach of existing professional organizations to increase leverage of limited NSF resources; and making sure that NSF staff are selected to provide balanced, informed advice. (SW)

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RESTORING SCHOLARSHIP TO COLLEGIATE MATHEMATICS

Lynn Arthur Steen

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Restoring Scholarship to Collegiate Mathematics

Lynn Arthur Steen

The National Science Board, the policy council of the National Science Foundation, has undertaken a study of undergraduate science and engineering education to determine what initiatives, if any, would be suitable for future NSF programs. On November 20, former American Mathematical Society President Andrew Gleason and current MAA President Lynn Arthur Steen presented testimony about the needs of collegiate mathematics. What follows is a condensed version of Steen's presentation on behalf of the MAA.

I am very pleased that the National Science Board has undertaken a study of undergraduate education. As President of the Mathematical Association of America, I am especially pleased to have been invited to testify about collegiate mathematics. Most of our 20,000 members teach college mathematics, and most of the undergraduate mathematics education in this nation is provided by members of our Association. We applaud your interest in collegiate mathematics and in its relation to science and engineering education.

I am a Professor of Mathematics at St. Olaf College in Northfield, Minnesota, one of the science-intensive liberal arts colleges referred to by Frederick Starr in his earlier testimony to this Committee. St. Olaf has 3,000 students;

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MAA Committees Featured in Center Section

Starting with this issue, readers will find *FOCUS* bigger and better! Every issue will contain a center section featuring some aspect of the work and activities of the MAA.

The special "focus" in this issue is the MAA committees. Center sections in future issues will detail the MAA's accomplishments during the past year, the activities of the 29 MAA Sections, the MAA Publications Program, and the summer and winter national meeting programs. As a special one-time feature, the March-April issue will focus on the 1986 International Congress of Mathematicians to be held in August at the University of California at Berkeley.

Employment Ads

If you are looking for a job be sure to check the employment ads which start on page vi of the center section. Advertisers will find rates and deadlines on page vi. Note the *50% discount* offered to advertisers in the March-April 1986 issue of *FOCUS*.

The Children's Television Workshop (CTW), creators of *Sesame Street*, *The Electric Company*, and *3-2-1 Contact*, has assembled $16 million—the largest sum ever raised for a single children's television project—and will begin production immediately on a new, daily mathematics series aimed at the nation's 14 million 8-to-12-year-olds. In the above sketch from the series, "Bandanas," Beverly Mickins plays a schoolmarm and Larry Cedar, a farmer, as they discuss how much fencing he will need for his newly-purchased land. For more information, see the article by Peter Hilton on page 3 of this issue.

Scholarship *(continued from page 1)*

about 10% of each year's graduates major in mathematics The quality of our program, and of those at many leading liberal arts colleges, was strengthened during the last decade by former collegiate programs of the National Science Foundation. These NSF programs accomplished good things in their time, and I can say from first-hand experience that they helped enormously to strengthen the mathematics and science programs at my institution. Today, however, I intend to speak not about these programs or about liberal arts colleges, but about the needs of collegiate mathematics across the nation.

Collegiate Mathematics

As I'm sure you know, mathematics is both an enabling force and a critical filter for careers in science and engineering. NSF policy for science and engineering education—both precollegiate and collegiate—must be built on this central fact: mathematics is not just one of the sciences, but is *the* foundation for science and engineering.

Mathematics today is changing dramatically in content, in scope, and in application; it is not only being applied, but is being continually created. Whereas in the past only theoretical science required advanced mathematics, today all science-based fields use sophisticated mathematical models. These changes force fundamental rethinking of the mathematics curriculum. Yet because mathematics education is a continuous sequential process from primary school through graduate school, changes in any part have important consequences both for other parts of mathematics education and for subsequent courses in science and engineering.

The record suggests, however, that our mathematics faculties are increasingly unable to meet these important needs. Remedial, elementary and service courses drain faculty time and energy. Increased elementary enrollments combined with decreasing numbers of majors have simultaneously unbalanced the curriculum and depressed faculty morale. In too many departments, the result is a downward spiral of withdrawn faculty, uninspired teaching, and uninterested students.

Moreover, with few exceptions, mathematics faculty do not have access to appropriate computing resources. As a consequence, computing has had very little impact on the mathematics curriculum—neither on what should be taught nor on how it is taught. Computers are important tools for scientific and engineering modeling precisely because they enable effective applications of mathematics: what formerly existed only in theory now occurs in every laboratory right before our eyes. The computer revolution is just the visible tip of a much deeper revolution in applied mathematics. Undergraduate mathematics today must be conducted in active symbiosis with powerful computers—for symbolic manipulation, for graphical display, for numerical analysis, and for simulation.

Equally demanding and even more neglected are the challenges of providing mathematical courses appropriate for liberal education. For students in the arts and humanities, mathematics is an invisible culture—feared, avoided, and consequently misunderstood. Too often such students are forced to retake high school courses whose only purpose is to master skills that now can be performed far better by a computer. Illiteracy in mathematics breeds illiteracy in science and technology, driving deeper the wedge that separates the two cultures In a society dominated by complex systems we need to do far more than we now do to convey to our society's future leaders—our present students—that mathematics is not magic, and that even those without advanced technical training need to know how to ask appropriate questions and demand responsible answers.

Left behind by the dramatic impact of computing and cut off by lack of time for professional development from the rapidly advancing frontiers of their own discipline, the mathematics faculties preside over a curriculum that is predominately elementary or out of date. Although this portrait is not typical of research universities and selective liberal arts colleges, it is, I believe, a fair assessment of collegiate mathematics at most of the nation's two- and four-year institutions where the vast majority of our students are educated.

Mobilization for Mathematics

The urgency of the need for revitalization of undergraduate mathematics is underscored by manpower needs. there is a serious and continuing shortage of school teachers in mathematics, sure to get worse since both the school age population and school teacher retirements will rise rapidly in the

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Scholarship *(continued from page 2)*

next decade. On top of this, industrial demand and salaries remain high for students with bachelor's or master's degrees in the mathematical sciences: the academic focus of these "mental" or "artificial" sciences (as distinct from the "natural" sciences) resonates with the needs of industry for employees trained to work with abstract, quantitative, symbolic models. Finally, at the doctoral level, the number of new doctorates entering college and university mathematics departments has declined continuously for fifteen years, and is now as low as in the pre-Sputnik era. Moreover, over 40% of the Ph.D.'s, and in some departments over two-thirds of the graduate students, are not U.S. citizens.

We need a nation-wide mobilization to attract the best young minds to undergraduate mathematics, not just to replenish the Ph.D. pipeline, but to support all fields of science and engineering that build on solid training in undergraduate mathematics. The only effective way to do this is to make sure that across the country, in every college, large or small, there are mathematics teachers who are knowledgeable about recent advances in the mathematical sciences and conversant with the many interesting problems yet to be solved. Students in every institution—not just at Berkeley or Harvard, St. Olaf or Swarthmore—need to see mathematics as an active, growing discipline with challenging unsolved problems worthy of their serious attention. This applies to future scientists and engineers as well as to future mathematicians; it applies as well to future lawyers and doctors, educators and ministers. Educated people need to know that mathematics is active, and that its applications really matter.

Maintaining Intellectual Vitality

Typically, good undergraduates glimpse the frontiers of science from association with faculty research projects. However, research in mathematics is not like research in the laboratory sciences. Whereas undergraduates can become apprentice scientists in chemistry research laboratories, research in mathematics is so far removed from the undergraduate curriculum that little if any immediate benefit to the undergraduate program ever trickles down from faculty research. As a general rule, undergraduates can neither participate in nor even understand the research activity of their mathematics professors.

The key to revitalization of collegiate mathematics is a faculty that is actively engaged in scholarship and professional development far broader than traditional research. What matters is that faculty develop an environment in which students can encounter mathematics as a living, growing discipline.

Others in these hearings have argued that the crucial needs of science and engineering education are support for faculty, facilities, and instrumentation. For collegiate mathematics, I would put it differently: our need is support for faculty, faculty, and faculty. Nothing is more important to college education than a faculty that is intellectually alive: no amount of bricks, mortar, or silicon can substitute for lack of faculty energy, imagination, or will.

A rapidly advancing discipline together with steadily increasing teaching loads leave most faculty with no time for necessary professional development. But lack of time is not the only issue; so is lack of compelling professional incentive. Continued NSF emphasis on research grants reinforces the natural tendency of deans and tenure committees to emphasize traditional published research above almost all else as a measure of individual worth in the academic world. If we want to improve undergraduate education, we have to readjust the academic reward system to provide a better balance between research and professional development. Scholarship in the service of education builds bridges between the two fundamental missions of our educational system and leads indirectly to research of the future. In mathematics especially, we need NSF programs that build these bridges.

Suggestions for Action

First, I'd suggest a competitive system of NSF Faculty Fellowships, sufficient in number to invite large numbers of applicants and sufficiently varied in purpose to promote a wide variety of accomplishment: curriculum development, student projects, professional travel, research support, computer needs.

Second, in one move NSF could make an immediate dramatic impact on the ability of the nation's mathematics faculty to offer a challenging, modern curriculum: put a high-powered computer work station on the desk of every college and university mathematics instructor. I do not propose this as an equipment program, but as an innovative means of making an immediate and much-needed impact on faculty development. Once mathematicians have access to powerful computers, forever afterwards they will teach their students differently and more effectively.

Third, to increase leverage of limited NSF resources, take advantage of the expertise and outreach of existing professional organizations. They already have in place national networks of meetings, publications, and professional support activities, and can readily reach a majority of faculty who never have dealings with governmental agencies.

Finally, recognize that mathematics is different from science, and that undergraduate education is different from research. The relation between research and teaching in mathematics is not the same as it is in science; the role of mathematics as a foundation for science and engineering is unique; and the sheer magnitude of mathematics education (precollege and collegiate) sets it apart as distinctive. Research expertise is no guarantee of good judgment in collegiate issues, nor is experience in laboratory science a good guide for the needs of the mathematical sciences. Thus my fourth and most urgent recommendation: make sure that NSF proposal reviewers, members of advisory committees, and staff members are selected so as to provide balanced, informed advice, including appropriate numbers of individuals with substantial experience in undergraduate mathematics.

The mathematics community itself has recognized the need for coordinated action based on the recognition that mathematics is fundamental to science, that it is changing rapidly, and that is a seamless fabric from grade school to graduate school. Unfortunately, the traditional separation of education from research continues in foundation funding practices as it does in university tenure and promotion proceedings. This division is both an anachronism and an impediment at a time when the mathematical organizations themselves are working hard to bridge the gap between research and education in the mathematical sciences. The greatest contribution NSF could make to undergraduate mathematics would be to help close this gap.