The Charge to Conference Participants

Myles Boylan, Program Director, EHR/DUE, NSF, Arlington, VA

Welcome to *Invention and Impact: Building Excellence in Undergraduate Education*. I extend warm greetings from my corner of the National Science Foundation, the Division of Undergraduate Education.

I want to start this morning by asking some "yes-no" questions. Please answer "yes" by raising your hand and keeping it aloft long enough for everyone in the room to see.

- Have you been funded by NSF to work towards educational improvement?
- Have you worked on education projects that were financially supported by other agencies or foundations?
- This is a question for those of you who have just indicated receiving previous funding. How many of you *no longer need* additional external grants for your educational improvement efforts?
- Have you worked collaboratively on education projects with colleagues in other colleges, universities, or pre-college schools?
- How many of you have strong beliefs about how to improve undergraduate STEM education?
- How many of you have significant questions and unresolved issues about how to improve undergraduate STEM education?
- How many of you believe that most of your freshmen enter well-prepared for college-level coursework in your discipline, having enjoyed high-quality learning experiences in most of their high school science and math courses?
- How many of you have an invited a state legislator or a Member of Congress to share in your success and achievement in improving undergraduate STEM education — by coming to campus to observe, for example?

Why You?

You have been invited here to both teach and to learn. My DUE colleagues and I are here primarily to learn from you. You were selected because we believe that you have something of real value to offer. Over the next two and a half days we want all of you to have opportunities to highlight and discuss what you have learned in your personal efforts to improve STEM education. We also believe that you will learn from others. Our sincerest hope is that when you leave this conference, it will be with valuable contacts with new colleagues — people who can contribute to your efforts to improve undergraduate learning in STEM.

Conference Themes

As the show of hands indicates, many of you are NSF Principal Investigators who have made significant progress in one of three areas corresponding to the themes of this conference. At least your annual reports tell us that you have made significant progress.

These three areas are:

- Invention — developing nationally innovative modules, courses, curricula, technology, and instructional methods;
- Adaptation — building on as well as adopting exemplary materials, tools, laboratory experiments, or other educational practices developed by others;
- Assessment — developing, testing, and disseminating assessment materials, tools, measures, and practices that have the promise of guiding improvement efforts more efficiently.

How do we determine the success of our support for your efforts to invent, adapt, and assess? The answer is that these will be ultimately judged by the depth and breadth of the *impact* they have on student achievement.

I charge you to help us understand not only the current impact of your successes but also the difficulties that beset your chosen areas of educational improvement that may be hindering further impact. NSF staff will be attending all the workshops over the next several days. We will listen carefully to what you are saying and there is little downside risk to speaking your mind. Nobody will receive a rating of "fair" or "poor" for speaking their mind.

I also charge you to help us refine our core program — CCLI — in order to make it more effective for your needs. To help you get started on this task, let me briefly explain how DUE ended up where it is today.

Background

The need to improve undergraduate education in the STEM disciplines has been on the national radar screen for nearly two decades. A 1986 study sponsored by the National Science Board — *Undergraduate Science, Mathematics, and Engineering Education* — examined comprehensively the need for renewed Federal investments in undergraduate education in STEM disciplines. The findings were shocking in many ways and clearly indicated the need for federal support. They were published in a report known as the Neal Report, named after Homer Neal from the University of Michigan, the Chair of the Board Committee that supported the study and wrote the report.

This study led to the formation of this NSF division — DUE. DUE was deliberately designed to reflect the disciplinary breadth of the entire NSF and to particularly attend to the needs of non-STEM majors. This provided two major benefits: First, this placed DUE program officers in a position to learn from developments in other disciplines, and second, it established an NSF division where educational improvement was the first priority, whereas it tended to be a second priority for other NSF divisions.

The National Science Foundation began to implement the recommendations of the Neal report almost immediately — providing major increases in funding. A major focus was the improvement of undergraduate laboratories, which had been found to be in dreadful condition on many campuses. Good labs are a crucial component of undergraduate STEM education, particularly in the laboratory sciences, and are vital to the education of STEM majors.

NSF also began to expand its summer student research support known as REU. This was done through the research directorates.

Direct support for labs and student research has the advantage of providing almost *immediate* benefits for students. Partly as a result of that funding, we have increasingly grown to understand — or at least *believe* — that building laboratory experiences into undergraduate learning is also a critical component of the limited STEM education of non-majors. There is clear evidence that the half-life of non-majors' knowledge of STEM is significantly improved if it is built on a base of quality laboratory and research experiences. And why should we care about that?

As a geoscientist wrote to us nine years ago, "My attitude about teaching an introductory science course changed dramatically the day that I recognized that for 90 percent of students it is not an introductory course, it is a *terminal* course. It is the last experience they will ever have in science."

As recommended by the Neal report, the NSF also began to provide support for developing improved courses, curricula, educational technology, and improved teaching methods. These programs carried the promise of even larger impacts over a longer period of time — but *only* if, and as, promising innovations became adopted by other faculty in other colleges and universities. A program for faculty workshops was also created in order to provide interested faculty with opportunities to enhance their knowledge in the use of these innovations.

The next — and last — time we sponsored a national conference to discuss core issues in undergraduate STEM education was July, 1996. It was the culmination of two simultaneous and related studies that began in 1995. These were NRC's *Year of National Dialogue* and NSF's *Shaping the Future: Strategies for Revitalizing Undergraduate Education.* These studies recommended further growth in funding of core programs in light of the both new needs and growing opportunities to achieve substantial improvements through increased use of educational technology. *Shaping the Future* recommended redoubled efforts to provide all undergraduates with direct knowledge of the methods and processes of science, in recognition that many non-STEM majors will become "knowledge workers."

That conference concluded that new needs arise in many instances from the tasks of teaching advances in scientific knowledge and new areas of science. Often, however educational research and development itself breeds growing opportunities for follow-on research and development, through the successes and knowledge gained in earlier projects.

In education, there is a second critical path to achieving impact — the adoption (or adaptation) of successful reform methods of teaching and learning at many other institutions. Donald Kennedy, the chair of the NRC study back in 1995–96, observed at the *Shaping the Future* conference that "One of the amazing things about innovation in science education is how poor the contagion is compared to the quality of innovation." Eric Mazur, a highly successful innovator from Harvard University, advised NSF during these studies to devise ways to provide incentives to faculty for adopting clearly superior materials and methods of instruction. Thus, a crucial design issue for our future core programming is how to efficiently support both good innovation and encourage further adaptation and adoption.

Melvin George, the chair of the NSF *Shaping the Future* Committee, emphasized during the conference that "We need to improve dissemination. There are few things the letter-writing community said more strongly — that we need to spread ideas, help people know and get excited about what is happening. Finally, we need ways to provide direct assistance to faculty and departments that struggle with these issues."

Today we realize that program efficiency has become increasingly critical to our operations. Why? Because in the years following *Shaping the Future* we have discovered that, practically and politically speaking, increases in funding for undergraduate education could only be obtained for new programs. [This seems to be true NSF-wide.] We have added several sizable new programs over the last eight years, most of them mandated by Congress, but our core funding has not risen.

This search for efficiency is not new. In the late 1990s, we undertook to improve the efficiency of our core program areas in order to get a bigger impact from the same level of core funding. Three separate core programs were combined into one program — CCLI — with multiple tracks: EMD for major innovation, A&I for minor innovation and for spreading major innovations into use at a growing number of colleges and universities, and ND to inform and prepare faculty about the growing array of new materials and methods of teaching. Three years ago a 4th dimension was added: developing better methods of assessing student learning intended for use by STEM faculty. A major purpose of this conference is to re-examine this model.

To summarize, our Conference goals are to:

(1) **Discuss and demonstrate the effectiveness of a variety of undergraduate STEM curricular improvements and innovations.**

(2) **Facilitate communication, including cross-disciplinary communication, of innovative curriculum ideas.** We ask you to engage in discussion with colleagues from other disciplines at this conference.

(3) Consider ways to **foster greater interdisciplinary interest in emerging science fields.** I have not discussed this so let me say a few words now. There is immense potential in enhancing STEM learning through creating interdisciplinary learning opportunities and courses. Modern learning theory suggests that helping students develop interdisciplinary knowledge and multidisciplinary connections is a powerful learning experience. Emerging science fields provide natural opportunities for doing this. Examples are cognitive psychology, artificial intelligence, bio-complexity, and nanotechnology.

(4) Finally, we want to engage you in **discussions about NSF's future priorities in undergraduate education.**

Student Aspirations and STEM Interests

Before I conclude I want to focus your attention on how objects of our good intentions, the students themselves, have changed since the Neal Report through a set of slides that characterize at the national level First-Time, Full-Time Freshmen at 4-year Colleges and Universities. This group closely approximates what we often call "traditional" undergraduates. Incidentally, even though most of these slides contrast the entering class of 1987 with 2002, these changes have been continuous over this 15 year time period.

- They are increasingly entering with weak study habits. I think you will agree that six hours of studying per week will not get the job done for either the STEM majors or the non-STEM majors.
- Yet, their HS GPAs have risen high that 60% of those

planning STEM majors enter with "A" averages.

- As one might guess from the disconnect between study habits and grades, this is largely grade inflation. Assessment tests such as the SAT II and the NAEP do not indicate a corresponding rise in the achievement levels of high school graduates.
- They are also entering with increased aspirations for more than a just a bachelor's degree, including high levels of interest in PhDs.
- Among this special group of college entrants, there is little evidence of under-representation of minority groups in STEM.
- But there is a large discrepancy in the interest of male and female freshmen in STEM that has persisted and is worsening in some disciplines in the natural sciences and engineering.
- This has unfortunate implications as the female proportion of this population has been growing and is now more than 55%.

I believe that the clear implications of these numbers and trends are that:

- Students need time to learn good study habits; good instructional practices will help them.
- Many students will feel they have failed if they earn less than "A" grades in STEM courses.
- Students from minority groups are just as interested in STEM learning as whites when they enter. The challenge is to believe they can succeed and support and nurture this interest.
- The largest challenge is attracting women to majoring in STEM disciplines. Some have likened the level of women's interest in STEM majors as a measure of success of reform methods of instruction, analogous to the Canary in the mine. Regardless of whether you believe this, improved instructional practices will certainly help attract and retain women in STEM.

Thank you for your attention.