

## NSF Integrative Computing Education & Research (ICER) White Paper

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1. *Preparing undergraduates for computing careers: What are the biggest challenges that you face in your role (i.e., as an educator, employer, administrator, leader, other)?*

I'll address this primarily from the perspective of a campus administrator and director of a multidisciplinary institute. I believe the biggest challenge is the difficulty of change at universities: the lack of incentives for faculty to change educational approaches, the relatively limited discussion of educational issues at research universities, the inherent resistance to change at universities that is enforced by elaborate processes, and the even greater difficulty of instituting any change that involves the collaboration of multiple disciplines (as I believe this one does, at least in part). In the case of computing education, this is exacerbated by the staggering pace of change in the computing field, which may be making unprecedented demands upon the abilities of universities to adapt. Coupled with this is an understandable lack of awareness by many faculty members of the challenges that CS/IT education is facing, and alternative approaches that are being tried elsewhere.

2. *Transforming the educational experience: What might the community do to address the challenges you identified above?*

I believe that it is crucial that the community articulate a vision for the future of computing education, that others will respect and consider following. To have this impact, the vision will need to come from a broad and influential national group that causes it to have influence in various academic communities ranging from research universities to four year colleges to community colleges. For example, to have influence at research universities, the group will need to include leading universities and leading researchers. This vision will need to explain clearly why change is needed, and give concrete indications of steps that can be considered. It should bolster the courage to challenge standard assumptions (controversial examples could include the role of calculus as a filter, or the culture of CS = programming and individual work) to provide support for such discussions at individual departments. The community also needs to make it easy to share promising and effective educational practices, in a way that allows replicability and adaptability.

3. *Models for transforming computing education: What might the ideal undergraduate model for computing education look like in five years?*

I should mainly defer to others who are more directly involved in the classroom than I am now. I looked recently at the undergraduate computer science curricula of a number of leading research universities, and was struck by how similar they appear to curricula of 20-30 years ago, with a primary emphasis on programming, formal foundations, and computer "innards" such as compilers and operating systems. It seems desirable that we consider much greater flexibility in what students may study within CS/IT: core versus applications, lower versus higher level programming, applications in areas ranging from business to

sciences to the arts. It also seems crucial that students' education prepares them well for a global economy and a collaborative workplace.

4. *Inhibitors and strategies: Can you identify inhibitors that might prevent the nation from achieving goals its sets of computing education? Can you identify strategies that may enable the transformation of undergraduate computing education in the USA?*

It is, unfortunately, too easy to identify well-known inhibitors, including: the relatively low preparation of U.S. high school students in math and science; the underdevelopment of computing curricula in our high schools; the lack of participation by women and underrepresented minorities in computing starting before the high school level and continuing thereafter; the poor image of computing as a profession; and the lack of broad appeal of current university computing curricula to many students.

I believe that the strategies for transforming undergraduate computing education in the USA begin with the influential national vision suggested in #2 above. Beyond that I believe that the community will need to make it easy for faculty and institutions to change by providing materials that explain the issues and suggest specific approaches, and support such as through regional workshops. The approaches being used by the National Center for Women & Information Technology (#6 below) may provide a possible model.

5. *Who might participate: What stakeholders should be involved in designing strategies to catalyze the transformation of university computing education throughout the nation? What is the role of government in this process? Professional societies? Universities and faculty? Others?*

Ultimately this is a very broad discussion involving universities, employers of various types, K-12, government, professional societies and others. I suspect it is important that it not sink under its own weight; that is, that a representative but streamlined group initiates this national discussion and produces a vision and suggested directions that others can discuss, react to and improve. I think it also will be important that at the same time there is national debate about that vision, that a small cadre of departments or institutions takes the lead on beginning to implement change in ways that provide experience and examples for the community. The initial process should include identification of potential "early adopters".

6. *Additional comments:*

Two activities that I am involved with may provide some useful perspective:

- The ATLAS Institute at CU-Boulder runs a campus-wide certificate program in Technology, Arts and Media. This six-course minor, involving both hands-on project based courses and critical thinking courses, enrolls 200-250 students; students come primarily from arts, humanities and social sciences and over 60% are women. This is an example of alternative forms of IT education that draw in different student populations.
- The National Center for Women & Information Technology has given considerable attention to processes for effective change at universities (and beyond). Its infrastructure, which includes a variety of national (and ultimately regional) alliances (academic, workforce, K-12) and structures that support the identification and active dissemination of promising and effective practices, may be relevant to this broader discussion.