White Paper

NSF Northeast Workshop on Integrative Computing Education & Research

W. Richards (Rick) Adrion, University of Massachusetts Amherst

Scope: **Transforming undergraduate computing education in the USA**

Issues

What is "computing education"?

ABET and its affiliates now accredit (or plan to accredit) programs in Computer Science, Information Systems, and Information Technology (Draft), Electrical and Computer Engineering, Software Engineering, Computer Engineering Technology, Information Engineering Technology (Draft), and Telecommunications Engineering Technology. On the other end of the spectrum, "literacy" courses and programs have moved towards "fluency" as defined in the FITness Report[1]. Recently, there is a movement to expand the scope of computing programs, e.g., the Cornell's Computing and Information Science program (includes Computer Science Department, Computational Biology Program, Computational Science and Engineering Program, Department of Statistical Science and the Information Science Program), Indiana's Informatics program (which requires "cognates" from multidisciplinary areas including biology, business, chemistry, cognitive science, etc), the CMU School of Computer Science (including Center for Automated Learning and Discovery, Computer Science Department, Human-Computer Interaction Institute, Institute for Software Research, Language Technologies Institute, Robotics Institute, Entertainment Technology Center), etc. A related, but distinct approach is "IT Across the Curriculum (ITAC)" that increases IT fluency by situating learning in the context of other disciplines (programs at NCSU, GMU, ASU, Depauw, UMass, and statewide in Massachusetts through CITI), typically implemented as IT minors, certificates, etc.

Questions:
- Is there a common core?
- Is our focus on CS (or CISE) or should it address a broader "computing" or "informatics" context, ITAC, IT Fluency?
- Is there an opportunity to attract more and diverse students by taking a "broad spectrum view"?

What is the implication of focusing on undergraduate education (as opposed to "K-20" i.e., primary through postgraduate study)

Enrollment in computer science and engineering programs has declined dramatically in recent years[2]. Only 5% of high school graduates indicate an interest in computing majors, and only 4% of the undergraduates in public higher education are computer science and computer information systems majors. Some[3] argue that the focus on programming is one cause. Others point to the dominance of "males" and "geeks" in high school programming courses as a factor in the decline in interest among women and other groups underrepresented in computing. On the other hand, is seems clear that high school graduates, regardless of their intended college major or job interests, must be fluent in computing. Will the ACM's Computer Science Teachers Association[4] (CSTA) be effective in introducing "dynamic computer content, connected to students' interests, into K-12[5]" or will some other FITness or

Question:
- Will extending IT Fluency and, perhaps ITAC education to middle and high school address the need for earlier exposure to computing capabilities, concepts and skills and prepare students for higher education and increase the interest in CISE programs?

[1] Larry Snyder, et al, "Being fluent with information technology," Washington, D.C., National Academy Press. (1999).
[2] Maria Klawe and Ben Shneiderman, "Crisis and opportunity in computer science," Communications of the ACM, Volume 48 , Issue 11 (November 2005)
[3] Peter J. Denning and Andrew McGettrick, "Recentering computer science," Communications of the ACM Volume 48 , Issue 11 (November 2005)
[4] David A. Patterson, "President's letter: Restoring the popularity of computer science" Communications of the ACM, Volume 48 Issue 9 (September 2005)

ITAC approach be more effective.

While enrollments of women and underrepresented minorities in higher education are rapidly growing, traditional computing programs have seen a drop to single digit percentages. Over the last decade, considerable research has been devoted to issues around recruiting and retaining women in information technology and in engineering. Substantially fewer projects address the concerns of underrepresented minorities. The causes of underrepresentation are complex and vary over different groups, however the following issues are commonly reported in the literature (and most equally apply to majority and male students): knowledge of career opportunities in information technology; negative stereotypes of IT as a profession, the need for early and equitable access to computing and computer applications; the need for role models, mentoring and community, and a nurturing and understanding teaching and learning environment.

Experience shows that ITAC programs (and perhaps IT and IS programs) attract a more diverse student population than traditional CS and CE programs. For example, in the University of Massachusetts Amherst IT Minor program (now enrolling almost 300 students with a 80% increase in enrollment in AY05-06), 42% of IT minors are women (campus enrollment is 51%), 7% are African-American (4%) and 5% are Latino(a) (4%). These data are consistent with those reported in for CS, IS and (traditional) IT programs in Georgia where they saw 19% women in CS, 31% in IT and 36% in IS, with state colleges having more women in IT programs. In Massachusetts, the Salem State College IT minor program reports an enrollment in excess of 80% women.

Questions:
- Will an aggressive outreach program help dispel stereotypes and develop appreciation for the opportunities in IT careers?
- Will a wide-spectrum approach to IT education and a reinvention of the introductory/core curricula increase the flow and diversity of high school graduates into higher education and the IT workforce?
- What is the role of K-20 public education in addressing these issues and how can the infrastructure be strengthened to increase its effectiveness?

Is there a Need for Computing Curriculum Change?

The questions raised for the outward-looking" discussions include: "How can we reach out to other disciplines? What relationships are possible/effective with IT programs, IT minors, IT fluency, computational science, multimedia, art and other discplines? How can/should CS faculty best participate? How can we retain the 'core' concepts and skills of computer science in our major, while shaping a curriculum in which many students taking our courses will be majoring in some other subject, yet will want to acquire deep knowledge of and skills in computer science? Etc." In the "inward-looking" discussion, questions include: "What are effective "gateway" courses into the CS major? How we do we do a better job at emphasizing 'conceptual knowledge' not skill building in our entry courses?" What might be missing, is the traditional use of CS1 as a filter ("look to your right, your left … one will survive") and the rigidity of CS curricula.

Questions:
- Is there a "kinder and gentler" approach to introductory courses, i.e., that recognize differing levels of preparation?
- Is there a multiple entry strategy that would allow students who develop an interest in CISE majors later in their academic program to avoid the penalty of extending their education to meet major requirements?
- Should special courses be developed to attract women and underrepresented minorities?

[5] CRA Computing Leadership Summit. Washington, DC (February 28, 2005)