Broadening Participation in Computing: K12-Community-College-University-Graduate Pathways

W. Richards Adrion, Sharon Biskup, Deborah Boisvert, Jane Fountain, Priscilla Grocer, Sue Mackler, Alan R. Peterfreund, Kenneth A. Rath, Adrienne Smith, Diane D. Snyder and Alana Wiens
adrion@cs.umass.edu, sbiskup@hcc.mass.edu, deborah.boisvert@umb.edu, clarke@cs.umass.edu, fountain@polsci.umass.edu, pgrocer@erols.com, smackler@hcc.mass.edu, alan@peterfreund.com, ken@peterfreund.com, AYSmith@stcc.edu, dsnyder@stcc.edu, alanawiens@gmail.com

Abstract - The Commonwealth Alliance for Information Technology Education (CAITE) is designing and carrying out comprehensive programs that address under-representation in information technology (IT). CAITE focuses on women and minorities in groups that are under-represented in most aspects of the Massachusetts innovation economy – economically, academically, and socially disadvantaged residents – and supports multiple points of entry into a broad spectrum of IT educational programs that provide multiple opportunities for learning and careers. Community colleges are the linchpin of the CAITE approach and strategy because of the central role they play in reaching out to underserved populations and in serving as a gateway to careers and further higher education. CAITE focuses on high-school-to-community-college-to-university-to-graduate school pathways, but also reaches out into middle schools and to adult populations. We report on our progress in the three CAITE regions (Boston, southeastern Massachusetts, and western Massachusetts). We describe the challenges of carrying out a multiple region, nine-institution project, our outcomes, and the assessment data collected on the CAITE programs.

Index Terms – broadening participation, recruiting and retention, gender issues, IT education

INTRODUCTION & OVERVIEW

The Commonwealth Alliance for Information technology Education (CAITE) is an NSF Broadening Participation in Computing (NSF BPC) alliance of community colleges and universities working to increase the participation of under-represented groups in information technology, particularly in lower income/high minority areas of Massachusetts (Boston, the Southeast and Pioneer Valley). CAITE focuses on community colleges as the gateway to economically, academically, and socially disadvantaged residents – groups that include large numbers of women, minorities and immigrants.

The CAITE Alliance includes the University of Massachusetts campuses at Amherst, Boston and Dartmouth, and Bristol, Bunker Hill, Cape Cod, Holyoke, Roxbury and Springfield Technical community colleges. CAITE works closely with a number of other initiatives: the Boston Area Advanced Technological Education Connections (BATEC), the Commonwealth Information Technology Initiative (CITI), the Urban Massachusetts and New England Louis Stokes Alliances for Minority Participation (UMLSAMP, NELSAMP), the New England Alliance for Graduate Education and the Professorate (NEAGEP), the CRA Committee on the Status of Women (CRA-W) and the National Center for Women in Technology (NCWIT).

The CAITE approach emphasizes broadening participation in information technology education across K20 public institutions, with the goal to increase the roles of and opportunities for traditionally under-represented groups in the IT workforce. We take a broad view of information technology, which includes traditional technical education in computer science, computer engineering, information technology and computer information systems, the unique CITI Information Technology Across the Curriculum (ITAC) program [1], and general “IT fluency” [2] – an inclusive definition that addresses the workforce changes brought about by the Massachusetts Innovation Economy and that, when begun early in the educational process, creates a broader pipeline into the traditional technical programs. The CAITE focus on broad spectrum IT programs that offer multiple points of entry and multiple opportunities for learning is in recognition that women and other under-represented groups often enter information technology careers through diverse pathways.

The CAITE strategy has two primary components: outreach and pathways. We are reaching out to high school, community college and four-year college and university students to attract them to, prepare them for, and support them to succeed in broad-spectrum high-school-to-community-college-to-university-to-graduate school (2 + 2 + 2 + 4) IT education pathways. In addition, CAITE is reaching out to those that influence and support these students (parents, families, teachers, counselors) as well as to middle schools and adult populations. We describe examples in the following sections.

In addition to the intrinsic value of achieving equity in information technology education and the workforce, several realities in the local landscape drive the CAITE strategy: the demands of the innovation economy of Massachusetts and the accompanying need to develop and
retain a diverse workforce; and the challenges of the educational pipeline given the Massachusetts demographics.

The Demand of the Massachusetts Innovation Economy

A “New Economy” [3] has emerged in the United States that is transforming the workplace in Massachusetts and nationally. Massachusetts ranks first among states in developing this new economy as well as first in knowledge jobs and fourth in the educational attainment of the workforce, but these traditional advantages are threatened. The state has traditionally depended on non-resident college students remaining in state upon graduation (most at private colleges) and degree-holding immigrants to meet its new economy workforce demand, but these numbers are declining. While 81% of female Massachusetts’ high school graduates go on to higher education, in contrast with 69% of males, the percentage of women enrolling in traditional technical IT fields is declining.

Information technology is undeniably a part of the new (knowledge/innovation/information) economy and computer and mathematical occupations are among the fastest growing disciplines [4]. A recent study [5] of the Massachusetts economy identifies the decline in the creation of new high tech jobs as the biggest threat to the state economy, with most new jobs being low-wage positions in the service sector. Alarmingly, “one in five women in Massachusetts is a low-wage worker and women account for 59 percent of the low-wage workforce.” While women appear to be a larger percentage of the Massachusetts IT workforce than is reflected by undergraduates enrolled in IT education, we believe this is partly due to the availability of alternative pathways into the workforce. Consider three pathways [8]: traditional (holding an undergraduate degree in IT), transitional (holding an advanced degree in IT, but a BS/BA degree in another field), and self-directed (holding no IT degrees). When the high demand for IT workers disappeared after 2002, the “transitional and self-directed pathways used by so many women to enter IT virtually closed.” Leventman, et al [8] argue that women will not change careers and train for jobs that do not exist, and that there are fewer openings into which people can slide. This suggests that the traditional pathway will become the primary route to technical and technical management positions.

There are signs of improvement in the Massachusetts economy – growth in manufacturing, professional services, health services, medical devices, biotechnology and educational services are offsetting losses in other areas including the IT sector. Demand for workers in sectors that depend on IT is surging as the economy recovers, increasing the need for interdisciplinary technical education coupled with creative, cognitive, teamwork, communication and learning skills [6]. Interdisciplinary programs are attracting more women. For example, while the University of Massachusetts Amherst has had a sharp decline in enrollment of women in CS/CE, 42% of those enrolled in the campus IT program are women – data that are consistent with those reported in [7].

Educational and Workforce Pipeline Challenges

The K12/Higher Ed/workforce “pipeline” in Massachusetts begins with over a million students enrolled in public and private Pre-K-12 schools. Approximately 55,000 high school students graduate annually, joining a large number of non-resident students attending colleges and universities, which enroll over 400,000 undergraduate and graduate students. An increasing number of the Massachusetts high school graduates are choosing public higher education and 85% of alumni of public higher education choose to live, work, raise families and pay taxes in the state. [9]. Demographics show some disturbing trends. The state ranks 28th in HS graduation rates and behind all northeast states except New York with a 72% graduation rate [10]. Success on the Massachusetts Comprehensive Assessment System (MCAS) Mathematics exams – a key indicator of readiness to learn 21st Century Skills – shows a significant imbalance between suburban (often 85% or better) and urban/rural areas (often under 60%) on the percentages of students performing at the “proficient” or “advanced” levels. Figure 1 [11] maps similar demographics – the percentage of HS students going on to four colleges. Note that in our three regions, several towns send less than 40% of HS grads to 4-year colleges – giving weight to our strategy to reach into high schools and community colleges to encourage and prepare students.

These economic and pipeline factors suggest an increased focus on resident students, and specifically women and URM, attending public institutions, who stay in state in large numbers upon graduation. Of great concern, is whether the number of high school students who go on to higher education, particularly minorities, women, and those from families living at or below the poverty line, will be prepared to enter IT programs. The challenge is to determine characteristics of our programs that make IT
attractive to women and minorities and to ensure that students are adequately prepared to enter them.

**Gender & Minority Issues in IT Education**

Over the last decade, considerable research (literature summaries, syntheses and analyses include [12]-[17]) has been devoted to issues around recruiting and retaining women in information technology and in engineering. The causes of underrepresentation of women are complex.

**TABLE 1**

<table>
<thead>
<tr>
<th>Gender &amp; Minority Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of career opportunities in Information Technology</td>
</tr>
<tr>
<td>Social, school (teacher, counselor), parental attitudes [13]-[14], [18]</td>
</tr>
<tr>
<td>Lack of recruiting materials, brochures, visible role models, familiarity with the IT workplace, etc. [12], [19]</td>
</tr>
<tr>
<td>Perceived “narrowness” of IT careers [20]-[21], [23]</td>
</tr>
</tbody>
</table>

**Negative stereotypes of IT as a profession**

The “nerd/geek” stereotype and, as above, the perceived “narrowness” of IT careers [14], [20]-[23]

**Need for early and equitable access to computing and computer applications**

Early and equal exposure to and adequate preparation in computing and associated skills (e.g., mathematics, IT “fluency”) [2], [13]-[14], [22] Increasing confidence in IT skills [14], [19]

**Gender differences in the use/application of computing**

Impact of electronic games [12], [14], [24]

**Need for role models, mentoring and community**

Same-sex and same-ethnicity role models [13]-[14], [20]-[21], [25]

**A nurturing and understanding teaching and learning environment**

Improving teaching, learning and pedagogy [12], [21]-[22], [25]

Creating a hospitable and sensitive learning environment [14], [22], [25]-[26]

Overcoming diverse preparation through multiple points of entry, support systems, adequate preparation [12], [14], [21]-[22], [25]-[26]

Cohoon and Aspray [16] caution that much of the research on gender issues in computing is not adequately grounded in empirical evidence, however they do report that recent results hold the promise of “alter[ing] the academic, social, and institutional landscape for women’s educational and career aspirations in computer science fields.” [17] These factors have strongly influenced the design of CAITE interventions, and we have the opportunity to evaluate these in a carefully designed process as described below.

**OUTREACH**

Our outreach program is designed with a number of interventions we hope will address the issues identified in Table 1. Our events and print/web materials address career opportunities, stereotypes, the need for preparation and role models.

**Events**

Since the project began in March 2007, CAITE has sponsored a number of events targeted at middle school, high school, community college and four-year college students – college and career fairs, seminars, topical workshops, contests, etc. Each of these has been carefully evaluated as a measure of efficacy and to promote a continuous process improvement.

We lack the space to describe these many events. As an example of outreach to community college and university students, CAITE held an all-day workshop, "Mind the Gap! Career Summit for Women & Technology," at UMass Amherst in September 2007. Students and others from the University, Greenfield Community College, Holyoke Community College, and Springfield Technical Community College interacted with 28 panelists drawn from academia, industry and government. In December 2007 a similar event, the Information and Communication Technology Careers Day, was held at the University of Massachusetts, Boston. 472 teachers and students from Boston area high schools, from Bunker Hill and Northern Essex community colleges, and UMass Boston attended the Boston meeting. A third event will be held in April 2008 in Fall River.

The first two meetings began with an inspiring keynote speech by Mary Finlay, Deputy CIO of Partners Healthcare that chronicled her journey as an IT Professional. She talked about the jobs that are available in the IT field including healthcare and the importance of networking with other professionals. Later discussion moved among topics such as the challenges facing women in the IT field, the benefits of IT skills in today’s varied workplace, and how to bring more women into IT and retain them. Said one member of the audience, " … I did not realize the extent of the problem." Others responded, "I actually gained confidence to pursue a career in IT, possibly make my own company," and "I am now thinking more about a career in IT in relation to what I want to do." From the discussion, the audience said it became much more clear about “the interconnection of IT and all jobs." This response was especially relevant, because, as one panelist mentioned, women in general are thought to be particularly interested in a blend of careers as opposed to being a “specialist” in a given field. That IT relates to essentially any career path is actually a great feature by which to attract more women to the field.

**Session T1A**

**Figure 2**

Opening Panel and Audience for "Mind the Gap"
The summits were a great success. At Amherst, two-thirds of the student attendees were female, 25% were Hispanic or African American, and half came from community colleges. At Boston, 30% were female, and 69% male. Over half were from minority groups, 85% were under the age of 18, and 99% were in high school. Almost all left with an increased interest in information technology.

The CAITE lead partner in southeastern Massachusetts, Bristol Community College, is helping laidoff workers from Quaker Fabrics in Fall River to develop IT skills and increase their job opportunities. Approximately 900 Quaker Fabric employees in the Fall River area lost their jobs – most of whom had not completed high school and are working toward their GED. Beginning with an initial IT fluency class, the effort has expanded to include GED preparation and encouraging interest in college – all led by BCC student Christina Janzekovich together with BCC and UMD students and a BCC faculty member who come each week to offer the students support in mastering basic computer applications.

The Quaker Fabric students love the class and because of their strong interest the original four weeks were expanded to six. Fourteen people (3 males and 11 females) signed up for the class in response to invitations generated following a Quaker resource fair in the late summer of 2007. This class has opened the Quaker Fabric students’ eyes to the possibility of college and to careers in technology. There have been no dropouts and their enthusiasm remains strong.

In the summer 2008, CAITE will be sponsoring events that include new approaches to teaching introductory computing courses and K12 workshops to support IT and CS AP curricula.

Web and Print Materials

To reach out to the target communities, CAITE has created a number of print materials (brochures, flyers, etc.) and arranged with organizations such as the ACM and CRA/W to distribute materials on career opportunities.

In addition to the usual websites for the project, CAITE has developed a site (takeITgoanywhere.org) specifically targeted to the populations we hope to attract into IT programs. Figure 4 shows this website. We are working with “focus groups” in the various CAITE regions to evaluate this site and to add more meaningful information and links. One of our primary goals is to have this site link to an “advising site” that will provide information on IT majors, minors, entrance and background requirements, transfer agreements and the like.

Pathways

While CAITE hopes to attract more students into IT programs at the participating institutions, it is essential that we provide a supportive infrastructure to ensure that students are attracted and retained in these programs. Our strategy is two-fold. We are developing “transfer pathways” that begin with online materials as described above, agreements on course equivalents and articulation agreements across the partner institutions. Secondly, we are putting in place advising and mentoring structures – where community college faculty will work with regional middle and high schools and university faculty will work with community college students. These efforts are designed as interventions to address the need for a nurturing teaching and learning environment, early access to computing, and role models as detailed in Table 1.

Articulation Agreements

Our first step towards uniform articulation agreements was to hold two “summits” – the first was held in eastern Massachusetts in February 2008 and the second in western Massachusetts in March 2008. At these summits, we began to: catalog IT courses and syllabi; create a map of course equivalents between institutions; and identify links to program and degree requirements.

We will follow up the two summits with another meeting to integrate the results from each. Our goal is to create a database of IT and CS courses, curricula and degree/certificate/career programs that will serve as a resource for students, faculty and advisers and made available as an “advising link” on the primary CAITE website and on the “takeITgoanywhere.org” site.
Mentoring and Advising

CAITE is building on the BATEC and CITI networks to develop mentoring and advising on the primary pathways in the three regions. Our strategy is to have faculty and students from 4-year colleges visit community colleges on a regular basis, and for community colleges to take the lead at high and middle schools in their area.

EVALUATION

The CAITE Evaluators have gathered extensive data on outreach activities (events, print and online materials) through surveys, questionnaires, interviews, focus groups, etc. Typically, we have found measurable differences in attitudes and understanding among those attending events.

To measure the impact of CAITE interventions on the targeted populations, the evaluators are collecting a substantial amount of data on participation in IT courses and IT majors. Baseline data is being collected now and will be compared to data collected in two-year intervals following the initial data collection. We hope to be able to see changes in the targeted communities (by region, gender, ethnicity, age, high school, community college, etc.).

Collecting Baseline Data

In Fall 2007, CAITE evaluators began to collect data from the nine CAITE institutions and “control groups” from the Urban-Massachusetts LSAMP project and the Northeastern STEP project. The evaluators for another BPC Alliance (Georgia Computes!) are collecting similar data.

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>POPULATION OF STUDENTS PARTICIPATING IN IT MAJOR FROM THE COHORTS STARTING AT MCC BETWEEN FALL 2000 AND SPRING 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students starting in IT</td>
<td>IT majors w/ ≥ 48 credits by Sum. 07</td>
</tr>
<tr>
<td>Total F00-S07</td>
<td>371</td>
</tr>
<tr>
<td>URM students</td>
<td>72 (19%)</td>
</tr>
<tr>
<td>- Am. Indian</td>
<td>3 (1%)</td>
</tr>
<tr>
<td>- Black</td>
<td>33 (9%)</td>
</tr>
<tr>
<td>- Hispanic</td>
<td>36 (10%)</td>
</tr>
<tr>
<td>- Cape Veridian</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Male</td>
<td>299 (81%)</td>
</tr>
<tr>
<td>Female</td>
<td>72 (19%)</td>
</tr>
<tr>
<td>Transfer students</td>
<td>141 (38%)</td>
</tr>
<tr>
<td>≤ 19 at entry</td>
<td>178 (48%)</td>
</tr>
<tr>
<td>20-23 at entry</td>
<td>100 (27%)</td>
</tr>
<tr>
<td>24-39 at entry</td>
<td>76 (21%)</td>
</tr>
<tr>
<td>≥ 40 at entry</td>
<td>16 (4%)</td>
</tr>
<tr>
<td>Began as non-IT major</td>
<td>NA</td>
</tr>
</tbody>
</table>

At each institution, data were requested for groups of students who had participated in IT courses and in IT majors. Students were determined to have participated in IT courses if they received a grade (including F, but not W, etc.) during their time at each institution. Students were counted as having been part of an IT major if they declared in any IT majors, either at their time of matriculation or in their last semester for which data were available. Students were also broken down into cohorts based on the year during which they entered. Thus “Cohort 1” was counted as those students entering from Summer 2000 to Spring 2001, “Cohort 2” from Summer 2001 to Spring 2002, etc. Time spent was calculated as the number of years (in half-year pieces) from their entrance to their last recorded semester.

As an example, Table 2 (above) examines the students in IT majors at Middlesex Community College in four cohorts (2000-01, 2001-02, 2002-03, and 2003-04). Most students in these cohorts have already left IT, either having graduated or not taken courses in 2007.

We also have data on the progression rates of IT major – those students who were IT majors either upon entry into an institution or during their most recent semester there (or both) – in terms of their progression in earning credits at the institution. At MCC, 231 students had taken 48 or more credit hours. Of these, 149 had received degrees, 2/3 in IT programs. 20% of the graduates were female and 10% came from underrepresented minority (URM) groups. Interestingly, 28% transferred in to IT programs. Of those remaining 82 students, who left without or have yet to complete a degree, about a 1/3 had dropped out of an IT program and about 20% were female – both outcomes similar to those who completed the degree. The number of URMs was greater than 20%, twice the percentage of those getting degrees.

These data are preliminary – we are in process of refining and mining them – and Table 2 is from a single institution due to space. However, they offer important indicators that will help us form measures of success for CAITE.

SUMMARY & RECOMMENDATIONS

While CAITE has been in existence for only a single year, we have accomplished a lot. We will not see the impact of our interventions in the data we are collecting for a few years, but the data are an important resource for researchers and for the project management.

Our initial evaluation of outreach events and materials suggests that the communities we are addressing, while subject to the issues summarized by Table 1, are considerably disadvantaged with respect to family and community knowledge of IT careers, role models, preparation, and support. They are older with more family and economic constraints than the average 4-year college student. It is clear that we will need to address these issues in developing the “pathway” infrastructure we hope will provide the needed mentoring and support to increase retention.

Finally, managing a 9-institution project has been a challenge, made somewhat easier by the experiences and networks of CITI and BATEC.

ACKNOWLEDGMENT

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REFERENCES


AUTHOR INFORMATION

W. Richards Adrion, Professor, Department of Computer Science, University of Massachusetts Amherst, Director, CAITE & Co-Director, CITI

Sharon Biskup, Department Chair, Computer Information Systems, Holyoke Community College

Deborah Boisvert, Director, BATEC, University of Massachusetts Boston

Lori Clarke, Professor, Department of Computer Science, University of Massachusetts Amherst & Co-Chair, CRA/W

Jane Fountain, Professor, Department of Political Science, University of Massachusetts Amherst & Director, National Center for Digital Government and the Women in the Information Age WITIA) Project

Priscilla Grocer, Professor & Chair, Department of Computer Information Systems, Bristol Community College

Sue Mackler, Dean, Business Division, Holyoke Community College

Alan R. Peterfreund, Principal, Peterfreund Associates

Kenneth A. Rath, Principal, Peterfreund Associates

Adrienne Smith, Dean, School of Engineering Technologies, Springfield Technical Community College

Diane D. Snyder, Professor in the Electronics Systems Engineering Technology Cluster at Springfield Technical Community College

Alana Wiens, Former (as of 02/08/08) CAITE & CITI Project Manager, Department of Computer Science, University of Massachusetts Amherst