Harvey Mudd College's Successful Systemic Approach (Case Study 2)

Attracting Students through an Engaging Introductory Computing Curriculum

Undergraduate

Curriculum is one of the factors that contributes to the spectacularly successful pre- and early-computing major redesign carried out at Harvey Mudd College (HMC). Since Fall 2006, with faculty support, their introductory course separates students according to prior computing experience, takes a breadth first approach, and includes a faculty-led lab. Together with early student engagement in research, participation in the Grace Hopper Celebration of Women in Computing, and the presence of a prominent high-level champion for women in computing, these steps have held student performance steady while skyrocketing women's representation from consistently less than 20% all the way to 50% of the incoming computer science majors. See Figure 1.

Almost all of the women responding to a survey question about influences on their desire to major in CS indicated that this first course influenced them. For example, students wrote:

- "It was surprisingly fun, and I learned I could do a lot with computers."
- "I knew basically nothing about CS when I came to Mudd, so CS1 was really my first look at it. After [the introductory course], I really wanted to take [the next course], which eventually convinced me to major in CS."
- "[The introductory course] was the first programming course I'd ever taken and it opened my eyes to the fun and challenges that CS could provide for me. Future classes served to reinforce this first impression and convince me it was something I enjoy and do well."

KEY ELEMENTS IN THE COURSE'S SUCCESS

Broad but Tracked Enrollment

All incoming HMC students, typically around 200, enroll in the first computing course, so everyone, regardless of intended major, gets exposed to computing. Experienced and inexperienced students enroll in different sections, which minimizes mistaking familiarity for aptitude and the negative impact that mix-up has on inexperienced students' confidence.

Faculty-led Labs that Assist Students

Faculty lead weekly 2-hour labs. The labs give students the option of getting structured help from a faculty member. The labs also give attending students full credit for one of the three or four assigned weekly homework problems.

Breadth-first Content that Capitalizes on Existing Interests

The new CS1 course immediately provides students with tools for writing engaging and useful programs and aligns assignments with students' existing interests. At HMC, that interest is science or engineering, so the course begins with science and engineering task-specific functions. A summary of the course content is provided in Figure 2 (Dodds et al., 2008).

FIGURE1. INCREASE IN WOMEN CS MAJORS AT HMC

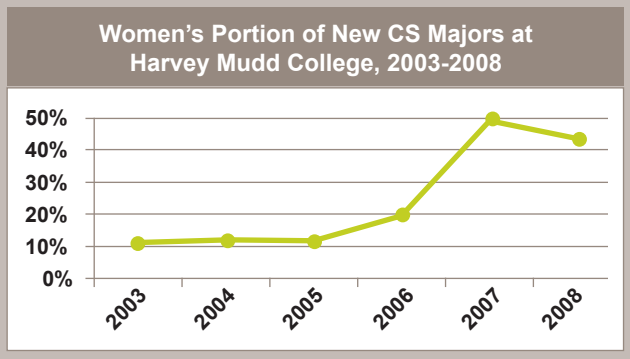

FIGURE 2. CS1 CURRICULUM FOCUSES ON STUDENT INTERESTS IN SCIENCE & ENGINEERING

Weeks	Paradigm	Samples of the Labs and Assignments
1-3	functional	integration, random walks, ciphers
4-6	low-level	recursion in assembly, 4-bit multiplier
7-9	imperative	Markov text generation, game of life
10-12	object/classes	Connect Four player, sudoku solver
13-15	CS theory	uncomputability, finite-state machines

Support from and for Faculty

The department chair reports that computer science faculty believed that the "old" CS1 course reinforced negative stereotypes of computer science (i.e., "CS is all about programming," "CS is about machines," "CS is not creative"), saw the need for improvement, and encouraged a working group to design a new course. The demonstrated success of the new model and the existence of tested and complete course materials (e.g., assignments, lecture slides and notes, other resources) make it relatively easy to recruit additional faculty members to contribute to the teaching of this course.

RESOURCES

Alvarado, C. & Dodds, Z. (2010). *Women in CS: An evaluation of three promising practices*. Paper presented at SIGCSE 2010.

Dodds, Z., Libeskind-Hadas, R., Alvarado, C. & Kuenning, G.(2008). Evaluating a breadth-first CS 1 for scientists. *Proceedings of the 39th SIGCSE Technical Symposium on Computer Science Education, Portland, OR,* 266–270.

NCWIT offers practices for increasing and benefiting from gender diversity in IT at the K-12, undergraduate, graduate, and career levels.

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How Does Engaging Curriculum Attract Students to Computing?

with Case Study 2

Undergraduate

The content of computing curriculum, especially introductory courses, is believed to contribute to the under-representation of women in information technology (IT). Research suggests that women are more interested in using computing as a tool for accomplishing a goal than they are in the workings of the machine. For example, certain IT instructional programs enroll higher proportions of women than do others. Data from a five-university study showed that women's average representation was lower in computer science than it was in management information systems, informatics, instructional systems technology, and information science/studies, though it was still below parity in these fields. Similarly, reports suggest that women's participation in computing might increase when media applications are used for teaching fundamental concepts (e.g., see the Media Computation approach on the reverse of this page).

In addition to more relevant and meaningful curricula, the greater participation of women in these IT disciplines and curricular programs may be due to the social climate. More women are present, so it is easier to develop an identity as a technical woman in a technical social context. These research findings show great promise for increasing the appeal of computing to women.

Establishing alternate pathways into IT study is another way that female under-representation has been addressed. According to Margolis and Fisher in their 2002 book, Unlocking the Clubhouse, introductory courses at Carnegie Mellon University that were tailored to different experience levels resulted in higher satisfaction for both more and less experienced students and for both male and female students.

Special accommodations for women? No. Most educational research shows that interventions that are better for women are also better for men. For example, collaborative learning environments lead to improved learning outcomes for all students, not just women. And bridge courses make it possible for a much larger and more diverse pool of students to "try out" computing, beyond those who elected to take computer science in high school.

MAKING IT MEANINGFUL

Educational researchers emphasize the importance of linking educational materials and curricular programs to students' existing knowledge and experiences. When class syllabi list topics and assignments that focus on unfamiliar concepts with limited, if any, relationship to a student's life experience or interests, she or he is unlikely to take that class. Under the existing educational policy of election, computing is rarely required in secondary school. This means that students are likely to have a narrow and inaccurate view of what IT study involves, what careers are possible, or what kind of people "do" IT. Given the very small proportion of females who study computing in high school, this means that females are less likely to choose IT in college.

The challenge to educators at all levels is to develop engaging assignments and curriculum that can appeal to a variety of students with different learning styles, interests, socio-cultural backgrounds, and abilities while maintaining the rigor of the discipline. Putting the concepts of computing in appealing contexts and building on existing competence can reduce the barriers of entry and level the playing field for those with limited experience.

As the Joint Task Force for "Computing Curricula 2005" points out, computing is no longer a monolithic area of study. The different curricula of the "family of computing-related disciplines" (p. 1) should be studied for their potential to attract high-quality male and female students and produce highly qualified computing professionals.

RESOURCES

Cohoon, J. M. & Aspray, W. (2006). A critical review of the research on women's participation in postsecondary computing education. In J. M. Cohoon & W. Aspray (Eds.), *Women and Information Technology: Research on underrepresentation*. Cambridge, MA: MIT Press.

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