Making Computer Science Minority-Friendly

Computer science programs neglect diverse student needs.

By Roli Varma

In the last decade, the debate on underrepresentation of minorities[1] in computer science (CS) academic programs, and the expected shortfall of candidates from the traditional source (18-year-old white males), has resulted in various measures to increase minority participation in CS education. Despite these efforts, these groups remain underrepresented in the CS field at the undergraduate level; that is, a significantly smaller proportion of certain minority groups are found in CS than in the total student-age population. African Americans, Hispanics, and American Indians are considered underrepresented minorities whereas Asians are not. For instance, in 2000, African Americans earned 3,497, Hispanics earned 2,155, and American Indians (or Native Americans) earned 172 of the CS bachelor degrees awarded; the figures for whites and Asians were 21,719 and 5,401, respectively [5].

To improve the underrepresentation of minorities in CS education, the pipeline metaphor has been proposed. It is believed that if sufficient minorities are encouraged to enter the CS field, the racial disparities will disappear. Though important, such a focus tends to neglect the persistence of barriers to entry and retention of minorities into CS.

This article examines undergraduate students' experience with CS classes, faculty, advisors, teaching assistants, and fellow classmates. It is based on a case study conducted at a public research university that is also designated as a minority-serving institution. In-depth interviews were conducted with 40 subjects: 34 undergraduate students majoring in CS, and another six students who switched to a different program of study, namely management information systems. These students were in their junior and senior years and came from different ethnic back-

[1]The term "minority" includes all groups other than white; the term "underrepresented minority" includes African Americans, Hispanics, and American Indians—whose representation in science and engineering is less than their representation in the population. Here, the term minority refers to underrepresented minority.

grounds: 11 white (7 females, 4 males), 11 Hispanic (7 females, 4 males), eight Asian (4 females, 4 males), seven American Indian (4 females, 3 males), and three African American (3 males).

Making Courses Relevant

In a typical public research university, the faculty decides what will be taught, how it will be taught, and the standards of evaluating what has been learned. Most CS faculty tend to be aware of emerging research on improving classroom instruction through problem-based learning, hands-on experience, use of new technology, and critical thinking. However, very few faculty are aware of race issues other than the underrepresentation of minorities in the CS field. Faculty members seldom implement changes to update classroom instruction and are not proactive in making CS curricula race inclusive [2]. This is partially because faculty may not know how to make changes or may not have enough resources to implement change. Further, faculty may not have time to invest to change their teaching practices due to full-time teaching, research, and service responsibilities. Also, while classroom teaching style may be dependent on the individual faculty, some changes in content and curriculum require the department, school/college and university's support. As a result, the CS classroom is not attuned to the emerging needs of students and lacks new ways to make use of diversity brought by minorities.

Students interviewed liked their CS classes, which required creativity and design skills and showed how new information could be applied to the real world. Students noted the importance of actually doing something tangible and seeing the outcome. Despite their appealing aspects, many students found some required classes to be difficult. There was a perception that some junior-level classes could only be passed after taking them repeatedly. More minority (11 out of 21) than white (5 out of 11) and Asian (1 out of 8) students gave the impression of being intimidated with some classes. One Native American student said: "There is so much talk about how hard [X] is, and you can't just take it once, you have to take it many times before you can pass it. And, it is very intimidating when you start, and you are all scared already." Another Hispanic student indicated: "I have to take [X] class next semester. I have been avoiding taking [it], but I can't avoid it anymore. I don't think I can finish it in one semester."

This intimidation results partly because many minority students had limited access to computers, local area networks, the Internet, and high-speed connections in high school. Further, in high school, computers were used for word processing, Web design, networking, and graphics rather than for simple programming or solving mathematical problems. Most importantly, many minority students did not receive strong mathematics training to prepare them for CS in college. Consequently, they differed in self-confidence about their computing, problem-solving, mathematical skills, and logical thinking from the white and Asian students. One Hispanic student expressed such concern vividly: "I think a lot about whether I am going to be able to finish the [CS] degree or not. I am always doubting myself. …And that discourages me. …All my classes have gone well so far. So, that is what keeps me going."

Caring for Students

Generally, a good teacher is primarily concerned with his/her students' learning and appreciation of the subject. The student must feel valued by the teacher for his or her potential and as a person. Building a relationship of respect between teacher and student should be the first order of business, but it is often taken for granted. New instructional approaches, no matter how ingenious, cannot succeed without a positive student-teacher relationship. Students tend to be influenced by what they believe the teacher thinks of them and their abilities [6]. If teachers treat minority students differently, they may convey the subtle message that minorities are not expected to participate fully in CS.

Students interviewed reported positive experiences with the CS faculty and did not raise strong complaints against them. Students liked those teachers who were not only knowledgeable, but also cared about teaching, and about the student learning experience. Generally, older teachers conveyed to students that they were interested in teaching, whereas younger teachers conveyed a stronger interest in research than in teaching. Teachers who showed respect for students were appreciated the most. They had friendly interactions with students both inside and outside the classroom.

Several students raised issues that are important in improving minority students' academic performance and learning experiences. Some minority students found a few teachers to be extra strict with them.

These students believed that some teachers perceive white and Asian students to be smart and hence more likely to excel in CS classes. Such perception of the faculty prevented a few minority students from asking questions in class or approaching the faculty for help. One African American student said: "I think professors are willing to help you, but I would not go to them. I feel they would say, 'How come you don't understand this stuff?'" Another Hispanic student indicated: "Some professors are narrow-minded. Perhaps they get so many excuses from minority students for late homework, especially in the lower-level classes."

Teaching Assistants Need Training

Since the mid-1980s, the number of foreign students enrolling and earning master's and doctoral degrees in CS fields in the U.S. has been increasing. This increase, coupled with a declining number of American students, has resulted in an approximately equal number of American and foreign students in CS graduate programs. Most of these foreign graduate students are supported by assistantships. Graduate teaching assistants play a major role in the education process; they participate in the instruction, advising, and evaluation of undergraduate students. They act as a liaison between the undergraduate students and the faculty. To fulfill their multiple roles successfully, the teaching assistants need to be experts in their subject and a facilitator in learning. Generally, foreign teaching assistants are admitted after passing the Test of English as a Foreign Language (TOEFL). They have to meet minimum proficiency requirements in spoken English before taking teaching responsibilities for undergraduate classes.

Most students interviewed found teaching assistants very thorough with the course content. Teaching assistants prepared materials for the discussion or laboratory sections, lectured, demonstrated how to complete lab work and exercises, and graded assignments. Although they were expected to devote an average of 20 hours per week, according to students interviewed, teaching assistants put in more time. But some students reported communication problems with foreign teaching assistants. One Hispanic student noted: "When TAs are from different countries, they have different accents, and they cannot explain everything so nicely like American TAs." Some minority students also felt that some of the foreign teaching assistants were old-fashioned in their thinking in dealing with minority and female students. This perception resulted mostly from comments and/or jokes made by foreign teaching assistants. However, none of the minority students indicated experiencing any overt racial/gender discrimination.

Advisors Must Recognize Diversity

Academic advisors work with students to develop their degree completion plan. They provide assistance during the initial stages of enrollment, monitor academic progress toward the degree, address academic concerns, and assist with the program of study. Academic advisors are, therefore, resource people who are supposed to be with the students every step of the way as they work to complete their degree. A good academic advisor needs to be aware of the particular nature of the field he or she is advising, and the diverse needs of students. In general, CS is a rigorous and demanding technical field. The pace of a CS program is fast and a large volume of course work is tightly coupled with the need for high speed to master it. Computer programming courses tend to take extra time to complete than other courses, and thus are all the more demanding for non-traditional students. Traditional students enter university immediately after finishing high school, while non-traditional students may have to work for a number of years after high school to save money for their college education. These students are likely to be married or have young children. If these students are not from well-off families or have families to support, then they are likely to have a part-time job. Ideally, academic advisors are aware of the diverse challenges facing students, but this is not always the case.

Many minority students interviewed indicated that they were married, had young children, or were single parents. Further, they worked part-time to support their studies and families. They found themselves struggling to keep up with rigorous curricula requirements, looking after children, maintaining a social and family life, and working part-time. They felt that the CS program was designed for those students who joined immediately after high school, and who were single, childless, and not working. As one Hispanic student put it: "It is hard to be a minority. You have to work harder. You have things that work against you. Certain projects, I could not do because I was a single mom and I worked part-time. …My advice to a minority high school student would be just work hard." This student advised postponing parenthood until one's studies were complete. A Native American student generalized: "I think some of it might have to do with the socioeconomic status of minorities. Because they are more likely to be poor, they are going to have to work part-time when they are in college. So, they are going to face other factors besides being

interested in education." Consequently, many minority students felt overwhelmed. It resulted in some minority students thinking about switching their major from CS to computer engineering or information systems.

Though most students interviewed found advisors helpful, sincere, and knowledgeable, they were not satisfied with the way they were guided. They believed advisors often did not know what was going on in the classes and the academic problems students face. The advisors generally planned the whole CS curricula to be completed in four years even though none of the students interviewed expected to finish their degree in that time frame. Many minority students were worried financial aid would not be available after four years, and they felt they were not provided counseling and guidance to deal with this financial aid crisis.

Connecting with Fellow Students

General anxiety in the classroom can be mitigated to some extent by feelings of interpersonal familiarity and acceptance by peers. Students feel more comfortable if they interact more with peers who are similar to them. The more students feel they can communicate openly with their peers, the better they are likely to do in learning outcomes. They will develop their social identity based on how they fit into relationships with other students [4]. The general picture of a successful CS student, however, depicts a white male, geek/nerd/hacker. He sits in front of the computer 24-hours-a-day, has close encounters with the super-smart computer, talks about computers endlessly, developed a computer fascination quite early in life, and has no other identity than being a geek [3]. The existence of a strong white male culture such as this one in CS may inhibit a positive climate for minority students, especially female minority students.

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Students interviewed perceived their fellow CS classmates as friendly, helpful, intelligent, hard-working, and motivated. Since most of them ended up taking the same classes, they developed a good level of camaraderie. Most students worked in small groups; it was important to participate in such groups to increase their knowledge base and also to bring about a feeling of oneness. Minority students felt that non-minority students did not look down on them. However, some minority students did feel a little air of competition with white students. They found some white students to be arrogant, with a tendency to show off. One Hispanic student said: "[They] talk more about computers than any other topic. Even the fun topic [they] make fun of is computers. So, usually

[they] just talk about computers all the time." Minority students also differed from white students on their reasons for majoring in CS. While white students cited intrinsic interest in computers as the main reason to major in CS, minority students pointed to pragmatic factors such as secure employment and high pay.

Bridging the Digital Divide

The first question is what should be done with those minority students who do not experience early exposure to computers and whose high school teachers do not put computers to good use by teaching simple programming and as an aid for solving mathematical problems. Even though the youth digital divide is outside the scope of universities, they still can get connected with high schools whose minority students they tend to inherit. CS departments can inform high school teachers about the difference between courses designed for users versus courses design for students pursuing CS degrees. The ACM K–12 CS Model addresses the CS educational needs of young people in high school as well as those in K–8 [1].

The second question is how to improve minority students' mathematical and problem-solving skills, since their high schools do not prepare them well for CS at the college level. Generally, CS departments require students to enroll in remedial math courses before entering the program. Those teaching remedial courses should be experienced in new teaching techniques as well as minority students' issues. These courses should be taught by experienced teachers, and not by graduate students or part-time faculty.

The third question is how to improve the faculty-student relationship and enhance learning experiences of minority students. Generally, most communication between faculty and minority students takes place in the classroom, which is large and rarely suitable for fostering close associations between faculty and students. It is important that students, especially minority students, interact with the faculty outside the classroom so they have a sense of belonging to the CS department, the school/college, and the university. To foster user-friendly classrooms for minority students, the CS department should train faculty to demonstrate appreciation for minority students' learning styles and social context. This requires identifying dynamic faculty who are willing to rethink educational approaches. Such faculty should consider different learning styles such as team-based and problem-based learning. They should take actions to integrate existing minority programs and student support services within CS department.

Most importantly, CS departments should organize workshops on curriculum development. Specific examples could include increasing instruction on debugging tools and techniques in CS courses to decrease student frustration with medium-sized code preparation, increasing feedback on programming assignments, increasing in-class problem solving in lower-level courses, and adding problems that demonstrate the relevance of CS requirements. CS departments should invite practitioners of CS from the nearby public and private sectors to bring real-world problem solving into the CS classroom. To develop appreciation for research, the faculty could involve senior students in their research projects.

Another issue is how to improve student-teaching assistant relationships. To improve teaching effectiveness, teaching assistants should be asked to undertake a course evaluation midway through the semester to get feedback from students. Teaching assistants should be asked to observe successful teachers. Occasionally, the faculty member should observe teaching assistants to provide teaching tips. To ensure effective communication and learning experience, foreign teaching assistants should be encouraged to take those courses that will improve oral proficiency such as communication or public speaking. Merely giving teaching assistants an orientation in their first semester and then leaving them alone is not productive. CS departments need to develop handbooks for their teaching assistants.

Positive student-student relationships are also important for maintaining a healthy environment. CS departments should recruit senior and/or graduate minority students to serve as mentors for freshmen and sophomore students. The mentors could participate in freshman-level introductory courses to introduce a peer-led learning component at an early phase in the CS curricula. They could discuss how they became involved in undergraduate education, their experiences, the courses they consider to have been most critical, and other aspects of being a CS major. The mentors can give minority students a chance to learn from someone who has been in the system a while. Another effective way for minority students to interact with each other is to establish an email discussion group. It could provide a forum for discussion

of both the problems and joys of being a minority student in CS and a medium for networking and mentoring.

The stereotypes regarding computers and good CS students must be addressed. It is important that minority students perceive that studying CS is consistent with their view of themselves as members of a group. It is also important they believe they have the ability to participate successfully in CS education. To make the general environment more minority student friendly, faculty must be educated about the types of attributes and behaviors that create the stereotypes about CS.

It is important to address what should be done with a high percentage of low-income financially needy minority students. Scholarships, which have been the backbone of any effort to increase graduation rates of minority students, need to be combined with other retention activities. CS departments can offer financial incentives such as tuition credit hours to students in their final years.

Since this study was completed, the author has conducted another study of 150 undergraduate students majoring in CS in six minority-serving institutions. The preliminary findings from the large study support the findings from the case study presented here. C

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