Retention of Minority Undergraduates in Information Technology

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Abstract

Undergraduate minority student retention is a major problem in core information technology fields namely computer science (CS) and computer engineering (CE) in American colleges and universities. Even though increasing numbers of minority students are declaring CS and CE as their major, departments are having a difficult time retaining and graduating them. The minority students are often less well prepared for CS or CE education and are preoccupied with outside jobs and family issues. They struggle with financial difficulties due to lost tuition revenues. It is complicated by the fact that CS and CE are demanding technical fields. The result has been low retention rates of minority students, namely Afro-Americans, Hispanics, and Native Americans. There is a need to improve their retention rates in CS and CE fields. This paper suggests administrative and educational policies that can be initiated to retain them.

Introduction

Afro-Americans, Hispanics, and Native Americans are referred to as under-represented minorities (hereafter minorities) in core information technology (IT), namely computer science (CS) and computer engineering (CE). Under-representation means that the members of a profession include a significantly smaller proportion of people from that population group than exists in the total working-age population. CS and CE are generally called core IT fields because jobs for computer scientists, computer engineers, systems analysts, and programmers have grown much faster than other jobs such as web-design and word processing, and traditionally students have picked up technical skills for such jobs in CS and CE fields. Many other fields such as information systems, multimedia design, system administration, web service design, graphics, and human computer interface are called IT-related fields.

Afro-Americans, Hispanics, and Native Americans together make up over 24% of the U.S. population, but less than 8% of the IT workforce. Even though more minorities are pursuing core IT fields than in the past, the number of them being educated in these fields is still low. For instance, in 1999-2000, Afro-Americans earned 324 (4%) of the CS and 72 (4%) of the CE bachelor degrees awarded. Similarly, Hispanics earned 292 (3%) of the CS and 74 (4%) of the CE bachelor degrees; the figures for Native Americans were 31 (0%) and 4 (0%), respectively. This is in contrast with Asians who earned 1988 (23%) of the CS and 319 (17%) of the CE...
bachelor degrees; and whites who earned 4,744 (55%) of the CS and 1,106 (59%) of the CE bachelor degrees awarded.

The racial/ethnic gap in IT education is critical for American society, which has been called the information society, the digital economy, and the Internet economy. IT has brought about fundamental changes in the way people work, learn, interact, do business, and govern themselves in the United States. Further, according to the U.S. Bureau of Labor, employment in IT related occupations is expected to increase by about 82% over the 2000-2010 decade, with more than 1.9 million new jobs being added. Jobs for computer scientists and computer engineers are expected to increase from 697,000 to 1.4 million, while employment for computer system analysts is expected to grow from 431,000 to 689,000 jobs.

American policy makers are trying to tap into underutilized minorities in IT education since the size of the minority school-age population has increased significantly. However, institutions of higher education are faced with low retention of minority students in CS and CE fields. Reasons for their departure are complex. CS and CE are hard technical fields requiring a solid background in mathematics and science. Often, minority students are less well prepared for CS or CE curricula. Further, they are preoccupied with outside jobs and family issues that take time away from study. They struggle with financial pressures to support family and study. In commuter institutions they have little connection with campus life whereas CS and CE demands students spend most of their time on campus namely in labs. Such factors are beyond the realm of influence of institutions of higher education. However, colleges and universities can initiate several policies that will improve retention of minority students in core IT fields.

This paper reports the findings from a case study conducted at the University of New Mexico (UNM), a Doctoral Extensive and a Minority/Hispanic-Serving Institution. UNM grants undergraduate degrees in both core IT fields—CS and CE. Due to its proximity to national laboratories (e.g. Sandia & Los Alamos laboratories), private industry (e.g. Intel), and state government, core IT education at UNM offers excellent job and career opportunities for New Mexico students, especially minorities. In Fall 2001, out of 313 undergraduates enrolled in CS, 31% were Hispanic, 4% were Asian, 3% were Afro-American, and 3% were Native American. For the same period, out of 114 undergraduates in CE, 36% were Hispanic, 12% were Native American, 4% were Asian, and 3% were Afro-American. Approximately 21% of undergraduate population in CS and 20% in CE were women. The CS and CE departments have been successful in recruitment of minorities; however, the same is not true for retention of minorities. Although data are not available, generally over 35% of minorities end up either dropping out of UNM or switching their major from CS and CE to another major.

Methodology

With the goal of understanding what makes minority students attach to or detach from core IT fields, the technique of ethnographic interviews was utilized. This method studies the topic from the subjects' point of view rather than from the experts'. In-depth interviews were conducted with 40 subjects at UNM. This sample size includes 34 undergraduate students majoring in CS or CE, and another six students who have switched to a different program of study, namely information systems offered by the School of Management. All students came from different ethnic
backgrounds: white (7 female and 4 male), Hispanic (7 female and 4 male), Native American (4 female and 3 male), Asian (4 female and 4 male), and Afro-Americans (3 male). This cross-gender and cross-cultural sample size was designed to provide a better understanding of the issues related to the lack of participation by minorities in CS and CE education.

The interviews were based on both structured and unstructured formats. They were structured in the sense that certain topics were covered; they were unstructured in the sense that they more closely resembled a private conversation with the subjects. Such a combination allowed subjects to express themselves in depth, while the interviewer maintained a certain control over the topics, and was able to probe further on interesting leads. These interviews, conducted in 2001, lasted anywhere from 45 minutes to almost two hours. Each interview was audio taped and transcribed verbatim. The Nvivo software program was used for qualitative analysis. The data were coded for all issues that had any bearing on students’ attachment to IT, preference for any other major, and detachment from IT. They were also sorted by ethnicity, gender, and IT-fields. Yet, the subjects' original story was preserved as much as possible.

Findings

1. Narrowing the Digital Divide

With the rise of information society, computers and other digital technologies have been widely diffused both at home and in the K-12 educational system. Schools are expected to expose all children to computer technology so American society does not become divided into information-haves and information-have-nots. However, there is an info-chasm among different groups of people. Minority students interviewed differed in their early access to computers, use of computers, local area networks, satellite dishes, Internet access, and high-speed connections. Many did not have a computer at home or in their classrooms in elementary and middle schools. Access was restricted, partially, because when these students went to school, computer technology was not diffused. Generally, their high schools had computers but rarely had high-speed Internet connections. It should be noted that the pace of change has been rapid with computer technology and any measure of access quickly becomes out of date.

With the digital divide the question is: How should government intervene? The U.S. government, among other things, has been closing the K-12 digital divide by buying computers and connecting schools and classrooms to the Internet for the most needy. For instance, the Universal Service Fund for Schools and Libraries or E-Rate provides schools and libraries access to telecommunications and advanced technologies. It gives discounts on the number of students eligible for the National School Lunch Program. Schools and libraries in low-income urban communities and rural areas qualify for the highest discounts. Still the digital gap is unrelenting. For instance, for high-poverty schools (those with 75% or more students eligible for free or reduced-price lunch), 60% of all instructional rooms had Internet access in 2000, up from 5% in 1996. Schools with less poverty tended to have a larger percentage of rooms with Internet access—77% or higher in 2000, up from 11-17% in 1996.

Making computer technology accessible is necessary, but only a part of the solution. In addition, K-12 teachers need to be trained on computers and there must be resources to support the technology. Many minority students interviewed reported that their high school teachers did not
put computers to good use. For instance, computer classes were offered as an elective. Further, computers were used for word processing, web design, networking, and graphics rather than to solve mathematical problems or to do simple programming. Computer learning was rarely integrated into the general curriculum. Most importantly, high schools seldom offered programming classes. Without teachers trained in computing, computers were used for classroom drill rather than for programming and other instructional activities. Further, there was a variation on minority students’ access and exposure to computers along gender lines. Minority female students had least tinkered with the machine. As a female Hispanic student said: “My experience with computers was none, zero in high school. The first time I ever saw a computer when I was 16 in a college.” A male Afro-American student noted: “In high school, I always used [computers] to do reports and used the Internet to find information for different things.” A male Native American student said: “My high school had a computer room... The only reason you could go into that computer room was if you were taking a computer class. So, I got enrolled in the course. They did not have any great big computer knowledge about programming itself. We mostly did typing.”

Since CS and CE departments at UNM will inherit minority students who may not be trained to design and invent computer applications, these departments need to get connected with local high schools. It should be noted that most students pursuing CS or CE degree at UNM tend to be New Mexico residents. CS and CE departments could educate high schools about the difference between courses designed for users versus courses design for computer scientists or computer engineers. It will not only produce well-trained future students in IT, but would also improve the public image of the UNM.

2. Building Academic Skill

Mathematics and science are at the core of producing successful students in CS and CE. However, many of today’s minority students are entering CS or CE programs at university without the necessary academic skills required to be successful in these programs. Average mathematics scores have increased for all racial/ethnic groups since 1990. But, unlike women, differences between the score of white students and minorities have not significantly narrowed. Differences by race/ethnicity also exist in the percentages performing at proficient levels in mathematics. For instance, while 34% of Asian and 20% of white 12th graders scored at or above the Proficient level in 2000, only 4% of Hispanic, 3% of Afro-American, and 10% of Native American 12th graders scored at that level. Similarly, the National Assessment of Educational Progress (NAEP) for science shows that in 1999, 75% of white 17-year olds scored 282 or above, while only 25% of Afro-American 17-year-olds and fewer than 50% of Hispanic 17-year-olds scored at that level

Students learn what they are taught and most of minority students are not being taught what would lead to strong performance in mathematics, sciences, and engineering. Lack of sufficient skills in science and mathematics is a critical filter that contributes to differences in retention of minority students in CS and CE. Many minority students interviewed were more enthusiastic than white students about science and mathematics yet did not view these as their strongest subjects in high school. Minority students felt their high school did an average job in preparing them in science, mathematics, logic, and reasoning. Consequently, they differed in on self-
confidence about their computing, problem-solving, and mathematical skills, as well as logical thinking from the white and Asian students at UNM. In one female Hispanic student’s words: “I think a lot whether I am going to be able to finish this degree or not. I am always doubting myself whether, if I can do it or not. And that discourages me. Sometimes, I just feel, I don't know if I can do this. All my classes have gone well so far. So, that is what keeps me going.”

To deal with students who scored lower in mathematics in high school and standard tests, the School of Engineering (SOE) at UNM requires students to enroll in remedial math courses before entering the engineering curricula. The basic purpose of these courses is to improve students’ mathematical and problem-solving skills. Those teaching these and other courses should be trained in new teaching techniques and minority students’ issues. Generally, the faculty is aware of improving instruction through new approaches like problem-based learning, but comparatively few follow through to implement changes. The faculty needs to devise and use a pedagogy that develops critical thinking, problem-solving abilities, and lifelong learning in students. To deal with students’ anxiety, self-confidence, and adjustment problems, faculty members need to take advantage of the diverse student population and their learning styles. The faculty should recognize that different students learn in different ways with differing levels of ability.

3. Creating a Faculty/Student Relationship

It is crucial that students especially minority students develop comfortable relationships with faculty members. Studies have shown that students expect friendly interaction with faculty\(^2\). Learning, academic performance, and retention are positively associated with student interaction with faculty\(^{13}\). Students who are isolated from faculty both inside and outside the classroom may not persist in the program as well as in the university\(^{10}\).

Most students including minorities interviewed reported positive experiences with the faculty, teaching assistants, administrative staff, and technical support group. They felt supported by the faculty and did not voice strong complaints against them. As one female Hispanic student said: “I have not had any bad teachers. I have had difficult teachers. But, actually those teachers have turned out to be good.” A male Afro-American student noted: “For the most part, [professors] seem to be really helpful, especially with some of us who are starting out.” None of the minority students narrated racial/gender stories from their own or from other students’ experiences about faculty though a few believed race/gender to be an issue in a subtle form. Yet, there were some issues with faculty and teaching assistants, which are likely to have adverse effects on minority students’ academic performance, learning experience, and retention.

First, some minority students believed that some teachers perceive science, mathematics, computer science, and computer engineering to be high-achiever disciplines whereas minority students are perceived as low-achievers. According to students, these teachers are mostly used to working with white and Asian students who are considered high-achievers. Consequently, some minority students, in order to prove to faculty that they are smart, did not always ask questions in class or go to teachers for help. As one male Afro-American student put it: “Professors are willing to help you. But, I would not go to them. I felt they would say, ‘How come you don’t understand this stuff?’ I don’t know why I thought they would look down on me if I ask..."
questions.” Teachers’ perception of minority and other students lead to differences in teachers’ interactions with them. In other words, some teachers may be sending subtle messages that CS and CE are white and Asian domains. As one female Hispanic student said: “Some professors are really narrow minded. Perhaps, they get so many excuses from minority students for late homework, especially in the lower level classes when you have a lot of students right out of high school, that you literally have to give them proofs. Once I was in the emergency room, followed by an operation. And that professor never said, no you can’t have two more days on your programming assignment, but he didn’t say yes either. He just hemmed and hawed, like, oh, another problem with Hispanic students. And so I just turned in my program two days late and lost 30%.”

Second, many students noted a tension between teaching and research. They felt that the older teachers were more interested in teaching than younger teachers who were preoccupied with research, grants, conferences, and workshops. In one female Hispanic student’s words: “I felt like a lot of my professors were more concerned with publishing. A lot of them are doing research and writing books. I felt like their focus was more on that than actually preparing lectures and working with students.”

Finally, many students felt that some of their teachers and teaching assistants were out-dated in their thinking on race/gender issue and thus showed some insensitivity. This perception resulted from unkind remarks and jokes made by teachers and teaching assistants. However, none of the minority students’ felt that there was any overt racial/gender discrimination against minority and female students. It should be noted that this study is solely based on interviews; generally negative experiences with faculty and teaching assistants are likely to surface in anonymous surveys or classroom observations rather than in face-to-face interviews. It is equally important to point out that UNM is a minority-serving institution and thus has a large ratios of Hispanic students in many classes.

Generally, students interviewed characterized good faculty members as those who are open, care for teaching, respect students, encourage discussion, and discover things together with students. To improve the faculty/student relationship, it is important that students especially minority students interact with the faculty outside classroom so they have a sense of belonging to UNM, the SOE, and the CS and CE departments along with building their academic skills. Minority students must feel that the faculty is interested in their learning and future and not only in Asian and white students. Currently, most communication between faculty and minority students takes place in the classroom. Further, most undergraduate classes are large and thus are rarely suitable for fostering close associations between faculty and students. There is no reason why faculty members should not foster user-friendly classroom environments to encourage minority students to learn and ask questions. The faculty needs to incorporate cooperative and collaborative learning by making minority students work together on assignments, spend time outside the classroom with faculty, and participate in class discussions with teaching assistants. This will increase frequent contact between the faculty and minority students. Under no circumstances should faculty convey the message to students that the faculty’s primary concern is research and not teaching and addressing students’ needs. One solution could be to involve students in faculty research. More than one faculty member should teach the more difficult courses in which the majority of minority students think about switching majors.
Generally, teachers of the same race/ethnicity as the students may serve as role models, provide culturally sensitive ways of teaching, as well as instruction. However, both CS and CE chairs have said that it has been difficult to hire minority faculty due to the supply barrier; currently, both departments only have one minority and four female instructors on their faculty. Similarly, teaching assistants are seldom minorities though most of them are foreign-born Asians. CS and CE departments can recruit minority students to mentor freshmen and sophomore students. The volunteer mentors include juniors, seniors, and graduate students. Such mentor programs can give minority students a chance to learn from someone who has been in the system a while.

4. Dealing with the Stereotypes

Stereotypes about computers dominate the educational and intellectual environment. The general picture is that the successful computer scientist or computer engineer is a White male, nerd/hacker. He sits in front of the computer 24 hours a day. He wishes to have a close encounter with a super smart computer. He is anti-social and talks about computer all the time. He developed his fascination with the machine quite early on in life. All students, both minority and non-minority, interviewed had similar stereotypes about computers. They believed that good CS and CE students are hooked to computers as soon as they are exposed to them. They handle difficult CS and CE curricula without much effort since they are super smart. Some female minority students indicated that computers ought to serve higher societal goals. As one female Hispanic student said: “Don’t have a life definitely…They are always in the lab. Don’t have a social life. It is pure study, dedication to the computer.” One male Afro-American student noted: “Typically knowledgeable. The kind of person you see sitting down at a computer with a bag of snacks and just doing stuff at the computer. They just tend to want to work by themselves.” Another male Native American student echoed: “They are not party animals. I mean a lot of them are real nerdy.” However, most minority students male and female indicated that they do not match/fit such image.

The stereotypes regarding computers and good CS or CE students need to be dealt with. It is important that minority students perceive that studying CS or CE is consistent with their view of themselves as members of a group. It is also important that they believe they have the ability to participate successfully in IT. To make the general environment more minority student friendly at UNM, faculty needs to be educated about the types of attributes and behaviors that create the stereotypes about CS and CE. Since significant stereotypes about computers come from students, it is important for minority students to interact closely with other students. Social engagement among students is a crucial factor in the equation for their success and retention. One of the effective ways for minority students to interact with each other is to establish an electronic mail discussion group. It could provide a forum for discussion of both the problems and joys of being a minority student in CS or CE and a medium for networking and mentoring. This is particularly important for minority women since they are so dispersed and might not otherwise be able to interact with many other minority female computer scientists and computer engineers. CS and CE departments need to approach the minority groups housed in the SOE for such an activity.
5. Removing Pressures

In general, CS and CE are rigorous, hard, and demanding technical fields. The pace of CS and CE courses is faster than absorption. The large volume of course work is combined with the high speed to master it. In addition, computer programming takes extra amounts of time. These fields become more demanding for those minority students at UNM who are non-traditional. They often do not enter UNM immediately after finishing high school; instead, they enter after working for a number of years to save money for their education. The average age of undergraduate students graduation is 26 years. Generally, CS and CE classes have 20 year-olds as well as 30 year-olds. Often, minority students are married, have young children, or are single parents. Further, many work part-time to support their studies and families. These minority students struggle to keep up with rigorous curricula requirements, look after children, maintain a social and family life, and work part-time. The CS and CE programs are designed for those students who join immediately after high school, and are young, single, without any children, and outside jobs. It is not surprising that minority students feel overwhelmed, fall behind, and end up repeating courses. Difficulty in maintaining their course work and balancing that with families and jobs is one of the main reasons minority students talk about switching their major from CS or CE or dropping out of the SOE. As one female Hispanic student put it: “It is hard to be a minority. You have to work harder. You have things that work against you. I define being a single parent as being a minority…. I really do not have the time to put the studying in. Certain projects, I could not do because I was single mom and I worked part-time…. My advise to a minority high school would be just work hard. Try not to have a baby or get pregnant. Just concentrate on school. Make that your priority. Because if you have other priorities, it is going to be tough.” Another student said: “I think some of it might have to do with the socio-economic 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 have other factors besides being interested in education.”

It is important that CS and CE departments develop and implement new methods of teaching which will accommodate the range of issues minority students face. CS and CE courses can keep the programs short, at least in the early stages. A parallel with mathematics courses can be useful. Mathematics relies on drill; students work on many similar problems in order to master them before moving to the next level. Similarly, instead of requiring long programming assignments that students must design, code, debug, and test, faculty can ask students to write many small programs. These programs should be difficult enough to make students think but not so difficult to take too much of their time. Further, instructions need to increase on debugging tools and techniques to decrease students’ frustration with code preparation.

One major problem for the CS and CE majors is the lengths of time it takes to complete an undergraduate degree. It is expected that the degrees will be earned in 4 years. However, approx. 10% of students finish their undergraduate degree in 4 years; 5 is a more realistic timeline. This leaves many minority students experiencing a financial aid crisis after 4 years. Advisors could play an important role in planning the whole curriculum. Effective counseling and guidance are important to all undergraduate students, but particularly to minority students. Advisors need to help students to have a realistic course load and better time management skills.
Most importantly, the issue of what should be done with a high percentage of low-income financially needy minority students should be addressed. Scholarships must be the backbone of any effort to increase the retention and graduation rates of minority students. Approximately 200 students receive scholarships and stipends from the Minority Engineering Math and Science or MEMS Project. However, scholarships alone are not enough; they need to be combined with other retention activities. For instance, minority students must maintain a specific course load and grade level to keep the scholarship. This does not go well with non-traditional minority students who have families to support. Further, CS and CE departments can take an unconventional approach to student retention by offering some financial incentives such as tuition credit for students who are in their final year.

Concluding Remarks

Minority students have been taking advantage of opportunities available in IT by pursuing education in CS and CE against all odds. A significant number of them, however, end up leaving CS or CE programs. While limited access to the computer in early years and subtle biases in early socialization are not under UNM’s control, many educational and administrative policies can be initiated to improve attrition in CS and CE at UNM. These departments need to provide a curriculum that engages and motivates the diverse students, enabling every student especially minority students to learn. There is a need to create and support learning communities for minority students and faculty such as interactions outside the classrooms. The faculty needs to recognize that different students learn in different ways and with differing levels of ability. Both departments need to take academic advising seriously. Students should be instructed on what constitutes a realistic workload based on their work and family situation.

Acknowledgment

This research was supported by a grant from the Alfred P. Sloan Foundation (B2000-72).


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