*Journal of Women and Minorities in Science and Engineering, vol. 15, pp. 39–52, 2009*

# BRIDGING THE DIGITAL DIVIDE: COMPUTING IN TRIBAL COLLEGES AND UNIVERSITIES

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*Because of their relatively small number (1% as the single race and 1.5% in combination with other races of U.S. population), American Indians and Alaska Natives (AIAN) are seldom represented in the assessment of ethnic/racial disparities in computer science education. If they are included, focus is rarely on tribal colleges and universities (TCUs), which are perceived to be community colleges. This paper studies inclusion of AIAN in computer science education in TCUs. It is based on interviews with computer science faculty and students majoring in the computer science field at a TCU in 2005. The paper shows challenges that computer science faculty and students face in TCUs and how they differ drastically from main stream institutions.*

## INTRODUCTION

Computer science (CS) has become one of the most important academic fields in the era of information technology (IT). According to the U.S. Bureau of Labor Statistics (2008-09), the vast majority of IT jobs are as computer system analysts, computer scientists, computer engineers, and programmers. Traditionally, students pick up technical skills in CS programs. The number of American Indians and Alaska Natives (AIAN) pursuing education in CS has fluctuated. The number of bachelor's degrees earned in CS by AIAN grew to 139 in 1985, dropped to 80 in 1991, then increased to 249 in 2005 (National Science Board, 2008). Despite an increase, the percentage of CS degrees earned by AIAN has changed little from 0.4% in 1985 to 0.5% in 2005. Freshmen intention to major in CS has been an approximate prediction of trends in the number of bachelor's degrees awarded 5 to 6 years later. The proportion of AIAN students who thought they might major in CS fell from 5.1% in 1985 to 3.0% in 1995, then to 1.6% in 2006 (National Science Board, 2008).

In comparison to the growing scholarly work on women, African Americans, and Hispanics in CS education (e.g., Aspray & Bernat, 2000; Camp, 2002; Margolis & Fisher, 2002; Varma, 2003; Cohoon & Aspray, 2006; Trauth, 2006), the literature on AIAN is virtually nonexistent. There is some literature on AIAN in higher education, but it seldom centers on the science and engineering (S&E) fields (e.g., Goulding, 1995; Soroosh, 1997; Carney, 1999; Nee-Benham & Stein, 2003). When scholars have included AIAN on the assessment of ethnic/racial disparity in higher education in S&E fields, focus has rarely been on tribal colleges and universities (TCUs; e.g., Gandara & Maxwell-Jolly, 1999; Huang, Taddese, & Walter, 2000; Johnson, 2007). Also, scholars hardly make a distinction among S&E fields when studying AIAN.

This paper focuses on the challenges TCUs face in the inclusion of AIAN in CS education. TCUs, with few exceptions, are tribally controlled, and located on reserva-

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ISSN 1072-8325/09/$35.00 

tions. They are members of the American Indian Higher Education Consortium (AIHEC) and accredited by regional accreditation agencies. There are about 35 TCUs (the AIAN students' enrollment must be 50% of the total student enrollment) in 14 states. They are similar to 2-year colleges that provide access to postsecondary education; very few TCUs offer 4-year bachelor's degrees and master's degrees. Most TCUs offer associate degrees or certification in several fields, including S&E. Yet, TCUs are critical because they can reduce the high attrition rate of AIAN students who attend mainstream colleges and universities by providing a program that is culturally appropriate to their students (Marjane, 2002). Furthermore, AIAN students' enrollment in TCUs has been increasing faster than in mainstream colleges and universities (32% vs. 16%; Freeman & Fox, 2005).

## METHOD

An empirical study was undertaken to understand American Indian students' enrollment and retention in the CS field. In-depth interviews were conducted by the author with a CS chair, a CS teacher, and 24 American Indian students enrolled in a 4-year CS bachelor program at a TCU in 2005. The technique of in-depth interviews was selected because there is little detail information on the challenges American Indian students face in pursuing education in CS in TCUs. Further, in-depth interviews allow interactive probing to get unconscious and inaccessible aspects that have a bearing on CS education in TCUs. Questionnaires and surveys do not provide in-depth information about contextual factors. Permission to conduct interviews was acquired from the Institutional Review Board (IRB) of the University of New Mexico.

A TCU was selected after a web search of TCUs that offered bachelor's degrees in IT-related fields. The author then contacted the CS faculty who asked students to voluntarily participate in the study. The author had no prior relationship with the subjects. The interviews were structured in the sense that certain issues were covered. They were also unstructured in the sense that they resembled a private conversation with subjects. Such a combination allowed subjects to express themselves in depth, while the author could maintain a control over the topics and be able to explore interesting leads. Each interview lasted anywhere from 1 hour to over 2 hours. All interviews were recorded, subsequently transcribed, and inserted in the Nvivo software for data analysis. Two independent coders coded the data for consistency in data analysis. Once all interviews were coded, the author analyzed the data for possible relationships between concepts and variations in the patterns observed. Attention was paid to the number and types of properties, making a note not only of how many subjects exhibited a concept but also how often it emerged and what it looked like. Concepts were supported with interview excerpts.

The CS chair had worked for the TCU where the study was conducted for over 15 years, and the CS teacher, for over 1 year. The student sample in this study includes an equal number of males and females. A large majority of them were first-generation college students. The average age of students interviewed was 31 years. Almost 40% of them were attending TCU on a part-time basis. About 30% of students viewed their economic status as lower class and 70% as middle class. No students identified themselves as being in the upper middle or upper class. Nearly 70% of subjects held a job; only 27%

of them had a job that was related to their CS studies. About 40% of them were single parents, while more female than male students were single parents.

## FINDINGS

Before presenting results from the case study, a brief profile of AIAN is outlined to appreciate their special economic, educational, geographic, and social circumstances. According to the U.S. Census Bureau (2000), AIAN are those people who have origin in any of the original peoples of North and South America and who maintain tribal affiliation or community attachment. Approximately 4.3 million AIAN reside in the United States. This number includes 2.4 million who are only AIAN and 1.8 million who are AIAN as well as one or more other races. Almost 34% of AIAN live on more than 300 reservations and trust lands—areas with boundaries established by treaty, statute, and/or executive or court order. Though counted as one group, they are made up of approximately 500 tribes, which vary greatly in size. Only 6 tribes (Cherokee, Navajo, Latin American Indian, Choctaw, Sioux, and Chippewa) have over 100,000 persons each, and 4 tribes (Apache, Black feet, Iroquois, and Pueblo) have populations of at least 50,000 each; most tribes have populations less than 10,000 (Ogunwole, 2006). Unlike other people, AIAN are isolated by the remoteness of reservations and the size of communities.

Economically, AIAN confront hard challenges. In 1999, 25.7% of AIAN compared to 12.4% of total U.S. population lived below the official poverty line. For the same year, the median earnings of AIAN men ($28,900) and women ($22,800) who worked full time, year-round were substantially below those of all men ($37,100) and women ($27,200). In 2000, lower proportions of AIAN than all workers were employed in management, professional and related jobs (24.3% vs. 33.6%), and sales and office jobs (24% vs. 26.7%). However, higher proportions of AIAN than all workers were employed in service (20.6% vs. 14.9%); construction, extraction, and maintenance (12.9% vs. 9.4%); production, transportation, and material moving (16.8% vs. 14.6%); and farming, forestry, and fishing (1.3% vs. 0.7%) jobs. In addition, AIAN had more families maintained by a female household (20.7%) than the total population (11.8%) in 2000 (Ogunwole, 2006). Such economic inequalities give rise to less access to and, thus, success for AIAN in higher education than other people.

The educational attainment levels of AIAN have improved significantly over the last 2 decades. Still, AIAN remain considerably below the levels of the total population. They are less likely than the total population to graduate from high school, to enroll in college, and to graduate from college. In 2000, 71% of AIAN 25 years and older had at least a high school education compared with 80% of the total population. Only 11% of the AIAN population had a bachelor's degree compared with 24% of all people (Ogunwole, 2006). Among AIAN who do enroll in or graduate from college, they are less likely to be in S&E fields. In 2005, AIAN earned 1.5% of associate, 0.7% of bachelor's degrees, 0.4% of master's degrees, and 0.25% of doctorate degrees in S&E (National Science Board, 2008). Compared with other people, AIAN remain at a disadvantage with regard to higher education in S&E fields.

Finally, AIAN maintain tribal traditions, customs, values, and languages, which set them apart from the rest of people. The AIAN ethos is derived from a common un-

derstanding that sharing, generosity, and thinking as a group rather than as an individual contribute significantly to tribal survival (Huff, 1997). They tend to have humanistic and group-oriented approaches of learning and consider competitiveness, boasting about oneself, direct eye contact, and individual success taboos (Deloria, 1991). Such cultural factors present a challenge in the learning process of AIAN in mainstream institutions of higher education (Varma, in press). TCUs, on the other hand, are based on the belief that AIAN should design their own education systems that have a strong cultural foundation.

Despite geographic isolation, economic hardship, and educational challenges, TCUs have been trying to bridge the digital divide by providing programs in IT-related fields for AIAN students. Most TCUs offer associate degrees and/or certifications in IT-related fields, such as business data processing, business computer equipment operator, CS, computer office skills, computer support technology, e-commerce, information systems, information technologies, integrated office technology, internetworking specialist, graphic arts technology, microcomputer applications in business, microcomputer operations, and microcomputer management. Some have moved from certification and associate's degrees to a bachelor's program in CS.

### Starting a Computer Science Program

CS as a distinct academic discipline emerged from mathematics and/or electrical engineering in mainstream colleges and universities in the early 1960s (Denning, 2000). In the 1960s, courses and degree programs for CS were defined. By 1970s, CS had matured and grown into a typical university department in many mainstream colleges and universities. For instance, 6,426 bachelor's degrees, 2,299 master's degrees, and 210 doctoral degrees were awarded in 1977, 1975, and 1979, respectively (National Science Board, 2004).

Unlike many mainstream colleges and universities, which are older than the United States, most TCUs are about 35 years old. TCUs were established in the late 1960s to increase access to higher education for AIAN growing up on reservations and had no other means of accessing education beyond the high school level. TCUs have a dual mission: (a) to provide excellence in education and to prepare their students for employment in the 21st century and (b) to provide a place where Native language, culture, and the traditional wisdom of the elders are infused into the curricula and extracurricular activities (American Indian Higher Education Consortium [AIHEC], 1999). They seek to provide higher education for AIAN students without forcing them to assimilate into mainstream culture (Marjane, 2002). Key components of TCUs curricula are cultural studies, community service, tribal languages, and business management training, rather than S&E.

Most CS programs in TCUs began to emerge in the 1990s with the recognition that computer technology can help tribes overcome economic stagnation, geographic isolation, inadequate health services, and lack of higher education opportunities. Unlike CS programs in mainstream colleges and universities, which were established with institutional and state support, establishment of CS programs in TCUs meant overcoming significant financial challenges. TCUs are located on reservations that have high unemployment rates and low per capita income rates. Similarly, they are located on

federal trust lands and, thus, states do not have any responsibility to fund them. Also, congressional funding for TCUs is provided on a yearly basis, which rarely allows long-term planning (Nee-Benham & Stein, 2003).

Because TCUs are somewhat high-risk developing educational institutions, few individuals took the initiative and sought the financial support from the federal funding agencies. As the CS chair interviewed explained:

> I began by offering a course called Introduction to Computers, which basically used some version of the Apple computer to teach word processing. From there, I worked my way into Microsoft Platform, DOS, and Windows. I created a 1-year certification program in data processing and a 2-year associate degree program in the late 1980s. ... Another faculty member wrote a grant proposal to the National Science Foundation, and the university received funds to start a 4-year computer science program in the early 2000s. Unfortunately, this faculty member received an offer from [X] and left soon after starting the computer science program.

The 4-year CS program at this TCU seems to have grown from a number of initiatives taken by its faculty. They individually sought to produce American Indians as computer experts who would serve their people. The question of importance is what challenges this TCU has been experiencing with its 4-year CS program.

### Acquiring Facilities and Resources

CS programs need facilities with classrooms and laboratories for students and office space for teachers and staff. Mainstream colleges and universities were somewhat prepared to house a CS program when one was initiated (Denning, 2000). They had space for offices, classrooms, and laboratories as well as resources to buy necessary equipment. TCUs, on the other hand, are financially vulnerable and vary in terms of size, quality of buildings, and technology available to house a 4-year CS program. They have to do long-term planning and fundraising to provide students state-of-the-art facilities and equipment necessary for a CS program. In 2001, the National Science Foundation through its Tribal Colleges and Universities Program began to provide awards to enhance the quality of S&E instructional and outreach programs with an emphasis on the leveraged use of IT in TCUs. Still, many TCUs continue to experience crises stemming from the facility crunch and the lack of resources (Nee-Benham & Stein, 2003). They need to overcome physical resources to have successful CS programs.

A large majority of students interviewed (75%) believed that their TCU lacked necessary educational and computer resources, which created distinct obstacles for them to be prepared for CS. As one student stated, "For our computer and electronic classes, we do not have any labs, we do not have tools to do testing. I think it is better to learn in the lab along with the lectures." Another student said, "I wish we had more funds to update our labs, our facility." The CS chair explained, "We are somewhat alienated from the rest of the university. We are off in this secluded location and [main administration is] over there. ... Also, computer science is still new to them so they do not understand. The end result is that we do not get the support that we need."

The CS department has been making efficient use of existing spaces. For instance, the CS chair and teachers share offices; all faculty have their individual desks in one big office. Several spots in the hallway are used to support informal learning spaces. The main lobby is utilized to encourage interactions between faculty and students and to maintain a sense of community. The CS teacher showed his enthusiasm, "We do not believe that problems with office space or limited resources should hinder our teaching and professional activities." Most importantly, the CS department is constantly engaged in fundraising to make improvements to the existing facility and to acquire computer resources.

**Recruiting Faculty**

CS departments in mainstream colleges and universities follow the best practices established for faculty recruitment. They conduct a vigorous search by composing a search committee that represents a diverse cross section of the faculty. They develop position announcements that reflect the needs of the department as well as attract the largest available pool of potential applicants. Then, they publicize positions in national publications, professional conferences, mailing lists, and listservs. Once the deadline for applications has passed, they analyze the pool of applicants. Finally, they invite 4 or 5 candidates for interviews to select the best.

Recruiting and retaining qualified CS faculty in TCUs, however, have been one of the most serious challenges. Faculty who are AIAN can be a role model for students. Also, AIAN faculty are more likely to be sensitive and receptive to the particular needs of AIAN students (Wright, Hirlinger, & England, 1998). Though TCUs are grounded in their cultures and traditions, few qualified AIAN are available to teach CS at the undergraduate level. The number of doctoral degrees in S&E earned by AIAN increased from 43 in 1985 to 70 in 2005. Out of 70, only one doctorate was awarded in CS in 2005 (National Science Board, 2008). Generally, TCU teachers have either a bachelor's degree or master's degree (Phillips, 2005). Non-AIAN do not seem to be interested in teaching CS at TCUs because they are geographically isolated, predominantly engaged in teaching rather than research, and provided low salaries and benefits (AIHEC, 1999).

The CS chair interviewed shared his frustration:

> Our main problem has been to hire qualified people to teach numerous computer science courses. So far, only two to three people have taught everything. Teachers do not come here because there is no place close by for them to live. Without qualified teachers, it has been crazy.

Similarly, the CS teacher said, "only two instructors seem to be maintaining the degree... Luckily, we will have another teacher probably for a year. One graduate student from [X] is going to do an internship here by teaching some courses for us." Students echoed the same sentiment. In one student's words, "We had one instructor, and we just got another one. ... Our instructors do everything, they teach all classes. They do the labs. They advise students. It has been hard for both teachers and for us." Another student said, "Right now, we only have one person who is constantly trying to get more instructors from the outside. Generally, instructors do not stay longer than a

year. So, they are in and out every year." Without faculty, it is difficult to have a decent course rotation.

There is a demand for CS faculty to meet current and future needs of the CS program at this TCU; however, lack of supply has created a shortage of CS faculty. Without enough CS faculty, the quality of the program is affected, and it makes graduating students rather difficult.

### Preparing Students

It is generally believed that if students are proficient (solid academic performance) in mathematics, they will succeed in CS even if they were not exposed to computers in their early years. A strong high school curriculum in mathematics and sciences can make students ready for CS at the undergraduate level. Both the number and type of courses taken are positively related to students' achievement (Oakes, 1990).

Studies show that students who graduate from rural high schools are significantly less likely than others to study precalculus, statistics, or advanced placement calculus. Similarly, students from small high schools are about half as likely as those from medium or large high schools to complete an advanced placement calculus course (National Science Board, 2008). The National Assessment of Educational Progress (NAEP) shows that a lower percentage of AIAN students take advance mathematics courses such as precalculus, calculus and trigonometry compared to White, African American, Hispanic, and Asian American students in high school (Freeman & Fox, 2005). In 2005, among 12th grade students, 36% of Asian American students and 29% of White students were *proficient* in mathematics compared with 8% of Hispanic students and 6% each of African American and AIAN students (National Science Board, 2008). Mainstream colleges and universities tend to have admission policies on the basis of merit and ability to achieve, while ensuring equal opportunity to all applicants. TCUs do not have any entrance requirements; instead, they have open admission policies. Often, students entering TCUs are academically unprepared for a rigorous CS program.

Both the CS chair and teacher interviewed acknowledged academic challenges that students face in the program. The CS chair said:

> We do not have a close relationship with the high schools here. I think high schools do not prepare their students well. At the last assessment, almost 75% of high school graduates were not reading well, not to mention the problems with their math background.

The CS teacher was a "little bit disappointed with the level of knowledge students have when they join the program." None of the students said they felt fully prepared when they came to study CS at this TCU. They believed that their high school did not prepare them for a major in CS. Students found "mathematical aspect of computer science very hard." Even when they had a strong background in mathematics, they believed their high school should have done more to prepare them for CS. As one student said:

> Well, nobody ever talked about computers in high school. We had computers in our library, and they were mostly for printing. We used computers to

> print banners. It was like a print shop to us. So, we did not learn the basics of computers. But, I learned some of the basics in math. It does not really prepare you for computer science, but it gives you a base to build off.

Traditionally, the TCU being studied in this paper has focused on training students in biology and environmental sciences rather than engineering. Advance mathematics may not be needed for the sciences, but it is needed to succeed in engineering. To prepare incoming students in mathematics, the CS department has been working to establish a preparatory school for students and to offer classes in the summer to enhance their studying skills without using their financial aid until they are ready to start their freshmen classes. Most of the students, if not all, at this TCU receive some form of financial aid, which is often contingent upon the student's academic performance. If grades go down, students lose scholarships. The CS chair believes that

> many of our students end up in academic or financial aid suspension or probation. When they come back, they are under a lot of financial pressure. By going through this preparatory school, they can be prepared for computer science and avoid suspension or probation.

The CS teacher has "been trying to work with students by incorporating a lot of mathematics in computer science classes."

### Retaining Students

Retention in institutions of higher education generally refers to the numbers and percentages of students who stay in colleges or universities to graduate with 2-year, 4-year, or graduate degrees. Generally, institutions measure retention rates using 4-, 5- and 6-year cohort figures. Recent national statistics on students' retention rates from S&E fields are not available. One longitudinal study of 1st-year S&E students in 1990 found that fewer than 50% had completed a S&E degree within 5 years. A more recent longitudinal study of 119 colleges and universities from 1992 to 1998 found 38% had completed a S&E degree (National Science Board, 2008). Some studies have calculated persistence and dropout rates in S&E on the basis of enrollment profile and graduation rates (e.g., Seymour & Hewitt, 1997; Huang et al., 2000). These studies show that many S&E programs in mainstream colleges and universities have been struggling with the high attrition rate of students. These studies show that dropout rate for women (approximately 35%) and minorities (approximately 24%) in S&E programs is higher than men and White students. The attrition rate of AIAN students is even higher. Pedagogical approaches in mainstream colleges and universities do not go well with AIAN students, because they are not culturally relevant to them (Pewewardy, 2002). The phenomenon of stepping into and out of an S&E program has been a common mode of college attendance for many American Indian students (Varma, 2005).

Interviews with students on their reasons for majoring in CS show they had a personal interest in or curiosity about working with computers; they were encouraged by teachers and others to pursue the degree; they had early access to computers; or they saw gaining computer skills as enhancing their future job prospects. As one stu-

dent said, "I just started playing solitaire on a computer one day and then I wanted to know how it worked. So, I decided to take computer classes." Another student said, "Everything is computer based now. For every job, you have to learn how to use computers." This student thanked his father for the "encouragement" he received to pursue CS degree; his father "was a computer technician for the Bureau of Indian Affairs in the 1980s." The CS chair explained, "When students first join the program, they hope to learn how to fix computers, and actually have tools to take the cover off the computer and take the components apart."

Though students join the CS program with enthusiasm, they stop coming to classes or drop out of the program. The CS chair felt, "A lot of students do not think beyond being a computer technician. Soon, they learn that being in a computer science program means they have to become a programmer, which unfortunately they do not like that much." Most importantly, students experience difficulty in adjusting to the CS curriculum due to an insufficient background in mathematics and programming, economic hardship that pushes them to take a job, and/or family obligations that force them to stay at home to look after children and elders. The CS teacher noted, "The CS program has a lot of requirements for which students are not prepared. So, even though they do well for one semester, they do not do well the next semester." This student confirmed the CS teacher's assessment: "I have been thinking about changing my major because my computer classes are getting harder." The CS chair also believed that students lose interest once they find out that a degree in CS means leaving the reservation. He gave an example: "They do not like to move out of this place. I have set up internships where students can go for 6 weeks to various places. But, they do not want to do that because a lot of them are responsible for the family." This student substantiated the CS chair judgment: "I do not see a computer technician store around here. I think nursing has better opportunities here on the reservation."

The graduation rate has been rather low. As the CS chair acknowledged with regret: "We have 50 to 60 students who are somewhere in the system. But, we have graduated only two people with a computer science degree. I do not feel comfortable with this accomplishment. We could have done a little bit more." It seems some students meet their objectives but stop coming to classes for personal reasons, such as job conflict or family obligations. Once such issues have been resolved, they again start the program. Then, there are those students who are unprepared for CS courses to begin with or are not sufficiently motivated to complete the degree. Because of the drop-in and drop-out patterns, the CS chair and teacher have been trying to determine how TCU can be more helpful to students as they pursue their educational goals.

To promote retention and graduation, the CS department has been pushing parents and the Indian community to support students in their efforts. The CS chair and teachers personally interact with students and serve as mentors to them. They are aware of students' family problems, financial assistance, and college demands. In addition, the CS department has been motivating students by telling them the importance of higher education. While family seems very important for American Indians, strong family support for higher education in S&E is often limited. As one student said, "A lot of American [Indian] students do not have that kind of support from home growing up. They do not put a value of doing well in school." Another noted, "I was not discouraged at home, but I was not encouraged either to study computer." One explained, "There is a

resistance to adapt. Because of our history, we lost our identity, and we do not want this identity to get caught up into the White man's world. ... So, we do not know where to go. We do not even finish school."

Because it is important for students to have their own business on the reservations after attaining a degree in CS, the CS department has been working with the business department to offer information management. With this, students can incorporate software and some of the information management tools. The CS chair feels that

> for this area or the neighboring counties, the main industry is information management. Everything we do here is demographics, voting registration, and hospital management. We have to have land databases, tribal databases, certainly the fiscal accounting system, and all that is information management.

The CS teacher also believes that most "students are prepared to do well in a 4-year degree program in information management as opposed to straight computer science."

### Addressing Gender Issues

Women make up 51% of the U.S. population and 47% of the civilian labor force but comprise only 27% of computer/mathematical scientists. The number of women earning a bachelor's degree in CS grew sharply in early 1980, peaked in the mid-1980s, dropped precipitously before leveling off in early 1990, increased slightly in the late 1990, and has come down since early 2000. Most importantly, the number of females gaining CS bachelor's degrees in 2005 (11,235) has not surpassed its 1985 peak (14,431; National Science Board, 2008).

In recent years, scholars have turned their attention to the specific discipline of CS to explain this phenomenon. They discuss a range of factors that contribute to the relative paucity of women in CS education, such as limited access to computers in schools and at home (e.g., National Telecommunications and Information Administration, 2000); the differential use of the computer technology (e.g., Coley, Cradler, & Engel, 1997); subtle gender bias in early school years (e.g., Cassell & Jenkins, 1998); the performance gap in mathematics and physical sciences in high schools (e.g., Sax, 1995); the small proportion of women among CS faculty and student populations (e.g., Spertus, 1991); gendered recruitment techniques and pedagogy (e.g., Cohoon & Aspray, 2006); the harassment of female students by their male peers (e.g., Varma, Prasad, & Kapur, 2006); women's subjective evaluations of their self-efficacy (e.g., Margolis & Fisher, 2002); and the masculine environment (e.g., Varma, 2007).

In the last two decades, unlike women in other ethnic/racial categories, the percentage increase in the number of AIAN females has been slightly higher than the percentage increase in the number of their male counterparts. For instance, AIAN females increased their representation in CS from 37 in 1995 to 78 in 2005 (National Science Foundation, 2007). In other words, AIAN women have been embracing CS rather than rejecting it. Yet, there are significant gender issues among AIAN students in the CS programs.

The CS teacher interviewed found that "males are more technical. They want the more hands-on, taking-computer-apart training, whereas the females seem to be more analytical. They take a little bit more time with the programming problems or the algorithms." The CS chair showed his appreciation for female students:

> I think women are more voluntary and responsible compared with the men. The role of the female here for the most part is one who provides. So, the female is the one who is going to be more responsible to come to school, register, do the assigned work, ask questions in the class, etc. It is the males that I have to go after, and ask why they are not taking any classes or working. It is just hard to keep them in class. It just seems that you have to put a little bit more work into counseling the males than the females. Plus, you cannot say the wrong things to guys, because they will be put off, and they might not come back to class. This is not the case with females.

Yet, several female students pointed out how gender expectations associated with being an American Indian woman in CS hinders their success. One female student generalized, "We still hold on to a lot of our traditional values, where men do all the hard work and women do house work." The CS chair felt that "the more you get a female to come to class on a daily basis or go for an internship for 6 weeks, the husband or boyfriend gets suspicious. It is not just an academic problem, but also a social problem." Similar sentiment was noted by this male student, "there is a little envy between men and women. Men do not want women to be better than them in programming or in graphics." This female student was disappointed that "men look down at us. Just because we are women and they are men, they have the power to look down at us."

Most students acknowledged that CS is a "male-dominated field." As this female student said, "We do not see female teachers. We only see male teachers. This kind of discourages us." Also, lack of early exposure to computer technology makes women unfamiliar with the CS discipline. "Many women are scared of computers. They think that one wrong button could shut the whole system down," believed this male student. Then, there is a general feeling that you "have to be good in mathematics to do CS." One female student who tried to persuade her female friend to join the CS program found that her "friend thinks that she is not smart enough in mathematics to do computer science." This makes the CS learning environment rather "intimidating" for female students. In addition, female students experience family obligations such as, "motherhood [which] comes early for a lot of American [Indian] females." Cultural and technical expectations are different for men and women.

The CS department has been working to build the confidence level of female students, which will empower them to succeed in the CS world. The CS chair noted:

> The first student I graduated had enough confidence to start her own business in [X], where she was from. She received the very same learning materials that are given to the other students, but she worked hard to learn and not just get a passing grade. This is the kind of confidence we are trying to generate in other students, male or female.

## CONCLUSIONS

American Indians are seen as maintaining their distinct ways of life, despite federal efforts to assimilate them. American Indian students tend to experience limited success in S&E fields, including CS, in mainstream institutions of higher education that are organized, administered, and controlled by members of a predominately White society. They face problems as they try to maintain their cultural traditions in the educational system that does not recognize such traditions (Wenzlaff & Biewer, 1996). Also, the number of American Indians majoring in CS has been low compared to their population. Because the major elements of modern CS education are reductionism and compartmentalization, which are in antithesis to the holistic world view of traditional American Indian culture, scholars see a general disconnection of spirit from technology (Deloria, 1991; Mandel, 1991). CS programs in TCUs seem to be a solution as they are tuned with American Indian students' way of life. Computer technology is penetrated into American Indian communities living on reservations while they maintain their cultures, traditions, and values.

However, as this case study shows, TCUs continue to be at a disadvantage in terms of computer and educational resources and qualified faculty. Further, they have students who often enter the CS program with inadequate academic skills. There is a need to increase federal funding for CS in TCUs and to identify CS education best practices that are consistent with the mission of TCUs and values of American Indians. Also, K through grade 12 students and their elders need to be educated on how CS training and skills could help tribes. In the long run, American Indian students cannot sustain training in CS with the initiative of few dedicated individuals.

## ACKNOWLEDGEMENTS

This research was supported by a grant from the Alfred Sloan Foundation (B2002-68). I would like to thank all students and faculty who gave their valuable time.

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