CAHSI Year 2 Annual Evaluation Report

Recruiting, Retaining, and Advancing Hispanics in Computing

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Executive Summary

CAHSI institutions have focused their efforts on the recruitment, retention, and advancement of Hispanic computer science students. In 2007, the seven CAHSI computer science departments graduated 149 Hispanic computer science majors. Excluding the University of Puerto, Rico, Mayaguez, which is 100% Hispanic, 45% of computer science majors at CAHSI institutions were Hispanic. In addition, two CAHSI institutions graduated an above-average proportion of women in computer science. Three institutions serve other underrepresented minorities as well, specifically African-American computer science students. When compared to other Hispanic serving institutions, the enrollment of Hispanic computer science students at CAHSI institutions is closer to parity with the overall enrollment of Hispanic students at their schools. However, most CAHSI schools have opportunities for growth in this area.

The Alliance has implemented multiple interventions to enhance the recruitment, retention, and advancement of Hispanic computer science students at participating institutions. The CS-0 course is intended to help CAHSI institutions recruit and retain more Hispanics into the computer science major. At every institution, the percentage of Hispanics enrolled in CS-O is higher than the percentage of Hispanics enrolled in the CS major, suggesting that CS-0 is an effective method for recruiting more Hispanics into the department. Although the recruitment, retention, and advancement of women into computing are not explicit goals of CAHSI, CS-0 has also been successful in enrolling women in CS-0. At every institution except one, the percentage of women undergraduates enrolled in CS-0 is higher than the percentage of women enrolled in the CS major. Though the CS-0 course has attracted more Hispanics and women than are presently enrolled in CAHSI computer science departments, it is too early to tell whether these students will continue in computer science. To determine the retention rate of CS-0 students, the evaluation team will track whether these students enroll in CS1 in subsequent semesters. In addition, the enrollment of Hispanics in many CAHSI computer science departments is lower than the enrollment of Hispanics in the institution, suggesting that there is room for growth in the recruitment of Hispanics into the computer science major.

The CS-0 course was successful in boosting students' confidence in their programming abilities. Students who had not programmed a computer made the greatest gains in confidence. Women gained greater confidence in computer programming than men. All racial/ethnic groups, including Hispanics, exhibited strong increases in confidence in computer programming. Indeed, the gains in computer programming confidence across all demographic variables, such as gender and ethnicity, suggest that the CS-O course served to boost the confidence of most students.

Peer-Led-Team-Learning in "gatekeeper" courses aims to increase student retention in the major by providing near-peer role models to boost their confidence and knowledge. Sessions were informal and involved group work to develop relationships among students in the course, said to influence student persistence in the major. Overall, students found the PLTL sessions to be fun, interesting, and helpful. Students, particularly Hispanic students, gained confidence in their computing abilities through PLTL sessions, and leaders reported confidence gains as well.

Being a peer leader increased students' communication, teaching, leadership, and interpersonal skills. Hispanics had slightly better gains in skills than other peer leaders. Students were generally confident in their skills as a peer leader, particularly in their ability to help

students understand concepts, to motivate students, and to effectively communicate. Students' experiences as peer leaders also increased their aspirations to have a computing career and, to a lesser extent, their aspirations to attend graduate school in computing. Peer leading had a more positive influence on the aspirations of women and Hispanics. Being a peer leader also enhanced students' disciplinary and conceptual knowledge. In part, this increase in knowledge and confidence contributed to some students' motivation to pursue graduate studies.

Undergraduate research is a proven method to increase retention and graduation rates for students. Affinity Research Groups (ARGS) are a model for undergraduate research development, which provides both undergraduate and graduate students with opportunities to learn, use, and integrate the knowledge and skills required for research with those required for cooperative work. As most students participate in ARGs throughout the academic year, a survey will be distributed to all research participants at the end of the spring semester. The survey will assess the impact of research on students' personal, professional, and intellectual development.

Professional development workshops are another means to increase the retention and advancement of Hispanic graduate students and junior faculty. Overall, the workshops gave undergraduate and graduate students as well as junior faculty a window into professional computing practice. Participants were able to learn the "inside story" from workshop providers, which was helpful in planning career paths. The majority of participants viewed workshops as relevant to their careers and educational programs, and could see ample applications for the knowledge they received at the CAHSI annual meeting.

The CAHSI Alliance has made a concerted effort to both align with other national programs with similar goals and to disseminate effective practices within the seven core institutions. CAHSI's Board of Advisors include administrators, industry professionals, and scholars representing the Hispanic Association of Colleges and Universities, IBM, the National Center for Women in Information Technology, and the Computing Research Association, to name a few. Evaluators are also well positioned to facilitate cooperation and collaboration among related organizations, as they are connected with a multitude of higher education institutions and faculty interested in broadening the participation of underrepresented individuals in the computing professions.

CAHSI Alliance members disseminate their best practices with other Broadening Participation in Computing (BPC) grantees. In May of 2007, each of the CAHSI principal investigators attended and presented at the National Center for Women & Information Technology (NCWIT) annual meetings. A CAHSI best practice, the use of Peer Led Team Learning, or PLTL, in computer science courses, became the subject of an NCWIT best practices sheet. In addition, associations with the STARS Alliance continue to grow. A faculty member of the STARS Alliance attended the second annual CAHSI meeting, and provided input during All Hands CAHSI meetings. A handful of CAHSI-supported students attended the October 2007 Tapia Celebration, which served as the Empowering Leadership Alliance kickoff meeting as well, and CAHSI plans to send a greater number of students in future years. Beyond BPC organizations, CAHSI also has presented their work at conferences such as the Frontiers in Education Conference (2006 & 2007) and the Special Interest Group in Computer Science Education (SIGCSE of the Association fro Computing Machinery (ACM) in 2008.

Within the Alliance, communication is facilitated by regular telephone conferences, distribution of meeting minutes and task lists, regular email communication, and strategic use of national conferences to schedule CAHSI meetings in conjunction with computer related events across the country. The annual meeting serves as a works session as well as a community event.

Student posters will be posted on the CAHSI website, so that those who were unable to attend the meeting might learn about computing research from their peers. When needed, CAHSI institutions hold workshops hosted by partner institutions to disseminate best practices. For example, faculty and students from the University of Texas at El Paso visited Texas A&M University Corpus Christi to train Peer Led Team Learning leaders for the fall 2007 semester. Also, California State University, Dominguez Hills hosted a workshop for professors beginning to teach Alice programming in a CS-0 course.

The Alliance has employed several strategies that have enhanced the communication and productivity of members. Upon the recommendation of the advisory board, the Alliance has created an executive council to streamline communication and work flow. The executive council consists of three institutional leads who work together on a regular basis to advance the mission of the group. The Alliance has also instituted formalized processes, similar to those advocated by the Affinity Research Group model, to enhance the communication and work flow among the group. For instance, meeting minutes containing action items and defined deliverables for Alliance members are disseminated after every meeting or teleconference. The inclusion of action items and defined deliverables into the group process increases individual accountability within the Alliance and creates clear, effective communication processes.

When asked about the "value-added" elements of the Alliance, as opposed to individual contributions, institutional leads had a variety of responses. All leads agreed that they could do more as an Alliance than they could individually. For example, a few institutional leads mentioned that they had adopted CS-0, PLTL, and ARG because of the Alliance. CAHSI members also believed that the formation of an Alliance allows them greater advantage so that they collectively have a more significant impact on the advancement of Hispanics in computing than as individuals. However, the primary contention among institutional leads about the value added by the Alliance was the opportunity to learn from each other and share ideas. CAHSI members noted that the group had a long history together and had established a strong rapport that facilitated the sharing of information, resources, and "lessons learned" among the group.

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1 Background

1.1 Program Overview

The Computing Alliance of Hispanic-Serving Institutions (CAHSI) is a partnership of seven higher education institutions and the Hispanic Association of Colleges and Universities, with the mission of increasing the number of Hispanics pursuing bachelors and advanced degrees in computing. The methods of goal attainment include the implementation of several interventions that address the key causes for under-representation of Hispanics in computing. These interventions support the recruitment, retention, and advancement of Hispanic undergraduate and graduate students and faculty in the computing, information sciences, and engineering (CISE) areas, and are integrated across three critical educational transitions: high school to college; undergraduate to graduate study; and graduate study to the professoriate. The seven CAHSI higher education institutions are:

- California State University at Domingo Hills (CSU-DH)
- Florida International University (FIU)
- New Mexico State University (NMSU)
- Texas A&M University at Corpus Christi (TAMU-CC)
- University of Puerto Rico at Mayaguez (UPR-M)
- University of Houston-Downtown (UHD)
- University of Texas at El Paso (UTEP)

1.2 Goals of the Alliance Interventions

The evaluation assesses the degree to which the Alliance's interventions are individually successful in their goals of recruiting, retaining, and advancing students in computer science.

Recruitment through CS-0: **Increasing student familiarity with and motivation to study computer science, provide confidence and encouragement for pursuing a CS major**. CS-0 is a three-unit course in introduction to computer programming and concepts designed to better prepare students for success in computer science. The CS-0 courses are realized differently at each institution implementing the course, which will permit comparative analysis of methods and produce ideas for customizing or adapting for other universities. Generally speaking, students with little to no prior background in computing enroll in the course. They are provided with the opportunity to learn the basics of programming concepts and develop problem solving and systematic reasoning skills while becoming familiar with a programming environment.

Retention through Peer-Led Team Learning: **Developing a sense of community and belonging among students while providing meaningful, timely academic support**. PLTL provides academic and social support to CS students in gatekeeper courses, or the courses that tend to deter students from remaining in the major. As a part of PLTL, peer leaders provide timely assistance to students for concepts that the students have identified as unclear or difficult. The process requires the instructor to adjust lectures accordingly and the peer leader to conduct a session to address the concerns. Peer tutoring consists of faculty-supervised, one-on-one tutoring by students who have successfully completed and excelled in the course. Peer tutors provide direct assistance with the course concepts, programming, and other assignments in a manner accessible to the student.

Affinity Research Groups: Engendering understanding of research and research careers as well as a sense of belonging in a research community. Affinity Research Groups (ARGS) are a model for undergraduate research development that provides both undergraduate and graduate students with opportunities to learn, use, and integrate the knowledge and skills required for research with those required for cooperative work.

Development Workshops: **Supporting completion of the Ph.D. and promotion and tenure for junior faculty.** Development workshops are designed to provide graduate students and faculty with effective skills to succeed in their careers and studies. Development workshops provide opportunities: (a) to disseminate information about "survival in graduate school and academe," (b) for discussion of critical issues to career success, (c) for creating mentoring communities, and (d) for establishing cohorts of students and faculty with common goals.

1.3 Purpose of Evaluation

The purpose of the evaluation is five-fold:

- To inform the ongoing work of the Alliance so that year-to-year improvements can be made and to support the development of model programs for adoption by other higher education institutions;
- To determine the extent to which the short and long-term goals of the Alliance's four main interventions have been achieved;
- To establish short- and long-term tracking of student outcomes (completion of CS undergraduate and graduate degrees, commitment to research careers);
- To provide an evaluation model which can be used by other institutions who adopt these interventions in the future; and
- To provide information that supports the success of the Alliance as a partnership.

This evaluation addresses the five distinct components of the Alliance described above:

- CS0 (Intervention 1)
- PLTL (Intervention 2)
- ARGs (Intervention 3)
- Development workshops (Intervention 4)
- The Alliance partnership

2 Evaluation Procedures: Data Gathered and Analytical Methods

2.1 Evaluation Methods

Evaluation methods include observation, interviews (individual and group), surveys, and participation in Alliance meetings. Qualitative data support more nuanced interpretation of survey results. Participation in Alliance meetings allows evaluators to better understand goals and processes and permits sharing of findings from social science and educational research and from other projects the evaluators have contact with. The specific data collections for CAHSI interventions are as follows:

- CS-0: Pre-post student survey and course observations at two institutions
- PLTL: End-of-semester survey for students in PLTL courses and peer leaders
- ARG: End-of-academic year survey to be administered to ARG students in April 2008
- Development workshop: Survey for all participants
- Alliance communication strategies: Interviews with institutional leads

A discussion of survey development and administration is provided in the appendix.

2.2 Data Analysis

The quantitative data were entered into the statistical package SPSS where descriptive statistics were computed. Means, standard deviations, and frequencies are reported. To test for statistically significant differences among various subgroups of the sample, t-tests, one-way analysis of variance (ANOVA), and repeated measures tests were used. Further explanation of quantitative measures and discussion of reliability and validity tests of survey instruments can be found in the appendix.

Write-in responses to open-ended survey questions were entered into a spreadsheet and coded as follows. Each new idea raised in a response was given a unique code name. As later respondents raised these same ideas, a tally was added to an existing code reflecting that idea. At times the write-in answers were brief and counted within one category, but more frequently, responses contained ideas that fit under multiple categories, and these were coded separately. For instance, students may have listed more than one favorite element about the CS-0 course (e.g., completing a course project and working in a group), and these were each counted.

3 CAHSI institutions: comparisons with similar "H-SI"s, & Computer science enrollment and graduation

3.1 Hispanics Enrolling, Graduating in Computing

At CAHSI institutions, Hispanic students are enrolling in and graduating from computing programs at the undergraduate and graduate levels. Currently, UTEP has the highest percent of Hispanic students graduating and enrolling in its computing programs except for Puerto Rico. The average percentage of Hispanic graduates from across all CAHSI undergraduate computing programs over the past eight academic years ranged from 12% to 58%, with Puerto Rico steadily at 100%. The graphs of percentage scores showed no systematic differences, meaning the fluctuations in percentages of Hispanic enrollees and graduates appeared to be random. See Table 1.

Differences between enrolled percentages and graduated percentages for undergraduate Hispanic students in computing indicate that Hispanic students may opt out of computing programs at higher rates than students of other ethnicities. These differences are relatively small among CAHSI institutions, ranging from 0-13% when comparing averaged scores, and 0 and 25% when comparing each year for each institution. Differences in graduation rates might also be due to time-to-graduation differences among Hispanic students and their non-Hispanic peers, particularly because Hispanic students are more likely to work and care for families than their non-Hispanic classmates.

Table 1. Average percent of undergraduate computing students enrolled and graduated who are Hispanic (2000-2007)

Institution	Average Percent Hispanic Undergraduate Students Enrolled (2000-2007)	Average Percent Hispanic Undergraduate Students Graduated (2000-2007)
UTEP	63%	59%
TAMU-CC	39%	28%
FIU	55%	52%
UPRM	100%	100%
NMSU	34%	27%
UHD	28%	15%
CSU-DH	13%	12%

The percent of Hispanic graduate students enrolled and graduating from CAHSI institutions' computing programs have been more dynamic; in the past eight years, two institutions (FIU and UTEP) have seen large increases in their Hispanic MA student graduation, from 4% and 15% in 2000 to rates of 42 and 43% in 2007[HT1].

Table 2 Average percent of graduate computing students enrolled and graduated who are Hispanic (2000-2007)

Institution	Average Percent Hispanic Graduate Students Enrolled (2000-2007)	Average Percent Hispanic Graduate Students Graduated (2000-2007)
UTEP	29%	28%
TAMU-CC	10%	9%
FIU	55%	21%
UPRM	100%	100%
NMSU	4%	1%
UHD	NA	NA
CSU-DH	NA	NA

3.2 Underrepresented Minorities Enrolling, Graduation in Computing

For most schools, the percentages of underrepresented minority students (African American, Hispanic, and Native American) were identical or nearly identical to their rates of Hispanic students. This was based on the racial and ethnic makeup of the communities the schools served, primarily Hispanic students. There were three notable exceptions: Florida International University, University of Houston Downtown, and California State University. These schools also served a significant number of African American students in their computing programs. See Table 3.

Table 3 Average percent underrepresented students enrolling in and graduating from computing programs at CAHSI institutions (2000-2007)

Institution	Average Percent Underrepresented Undergraduate Students Enrolled (2000-2007)	Average Percent Underrepresented Undergraduate Students Graduated (2000-2007)
FIU	69%	57%
UHD	43%	24%
CSU-DH	40%	21%

3.3 Women Enrolling, Graduating in Computing

CAHSI institutions graduate women at a slightly higher rate than the 2006 national average for computer science and computer engineering majors (11% and 15%, respectively) and slightly lower than the 2007 national average for computer science and computer information systems majors (19%, IPEDS). According to the United States Department of Education, women comprised 11% of the computer science graduates, and 15% of computer engineering graduates in 2005-2006. Among CAHSI institution graduates, averages of 15-35% of the total number of graduates were women in the past eight academic years. UPRM and NMSU have been graduating women at a higher rate than the other schools over the eight years of data examined. None of the schools is nearing parity in the percentage of women enrolling and graduating in computing programs. We see this as an opportunity—for example, a recruitment effort targeting women may bring in a greater number of Hispanic women, thereby furthering CAHSI's goals. It is important to document the retention of women in CAHSI computer science programs, because the interventions employed by CAHSI institutions are promising practices for broadening participation in computing, across gender and ethnic categories.

Table 4 Average percent undergraduate female students enrolling in and graduating from computing programs at CAHSI institutions (2000-2007)

Institution	Average Percent Female Undergraduate Students Enrolled (2000-2007)	Average Percent Female Undergraduate Students Graduated (2000-2007)
UTEP	19%	18%
TAMU-CC	20%	16%
FIU	14%	15%
UPRM	25%	28%
NMSU	19%	35%
UHD	19%	17%
CSU-DH	22%	17%

Surprisingly, despite their low rates of attending undergraduate computing programs, larger proportions of women enroll in MA degree programs at CAHSI institutions, and in most cases graduate from the MA program at higher rates than that at which they are enrolled. It is unclear why women were graduating at a higher rate than their male peers. This is an avenue for possible exploration in further CAHSI research. While[HT2] numbers still place female graduate students and degree earners at just over one quarter of total computer science MA students, these numbers are higher than the national average. The percentage of female students earning graduate computing degrees peaked in 2001, when three of the five CAHSI institutions preparing graduate students saw nearly 40% female enrollment.

Table 5 Average percent female graduate students enrolling in and graduating from CAHSI institutions (2000-2007)

Institution	Average Percent Female Graduate Students Enrolled (2000-2007)	Average Percent Female Graduate Students Graduated (2000-2007)
UTEP	24%	26%
TAMU-CC	24%	25%
FIU	14%	24%
UPRM	31%	31%
NMSU	22%	16%
UHD	NA	NA
CSU-DH	NA	NA

3.4 Hispanic Students Enrolling and Graduating from CAHSI Institutions

While CAHSI institutions' computer science departments enroll and graduate a relatively high number of Hispanic students, in most cases they enroll a smaller proportion of Hispanic students than are enrolled in their institutions as a whole. In other words, there are not a representative number of Hispanic students in computer science, though values are approaching parity for most institutions. The difference between Hispanics enrolled in an institution and Hispanics enrolled in computing varied from 0-15% in 2007. This indicates that CAHSI institutions are enrolling Hispanic computer science students at a much higher rate than the national average, and are close to parity in their departments. Given that only 17 Hispanic PhD students graduated from US computing departments last year, it is clear that more effort is needed nationally to significantly affect this trend[HT3].

Table 6 Percent undergraduate Hispanic students enrolled in computing compared to percent undergraduate Hispanic students enrolled in the institution

Institution	Percent Hispanic Undergraduate Students Enrolled IN COMPUTING (2007)	Average Percent Hispanic Undergraduate Students Enrolled IN INSTITUTION (2007)
UTEP	64%	73%
TAMU-CC	37%*	38%*
FIU	53%	53%
UPRM	100%	100%
NMSU	33%	47%
UHD	26%	37%
CSU-DH	14%	29%

3.5 Comparing CAHSI Institutions to public, 4 year computing at HSIs

It was unclear to the CAHSI team how the CAHSI partner institutions were faring compared to other Hispanic-Serving Institutions (HSIs), in terms of graduating Hispanic students in computing. In order to draw comparisons, CAHSI evaluators computed 2006 Hispanic graduation rates for CAHSI institutions and for all public four-year HSIs in California, Texas, and New Mexico, three states served by CAHSI institutions.

Of the 26 institutions, only seven schools graduate Hispanic students at the percentage of the least diverse CAHSI institution (19%). Additionally, two of these schools graduated two or fewer Hispanic students in computing, indicating high rates, but few total numbers of Hispanic graduates. Only three institutions graduated more than 50% Hispanic students from their computing programs in 2006, while this was the median percent Hispanic graduates for CAHSI institutions. None of the Hispanic serving Institutions (CAHSI or non-CAHSI) schools were enrolling or graduating the same proportion of Hispanic students as were enrolled in their institutions, and so each program still must work to achieve parity. It is too soon to tell if CAHSI interventions will advance this goal.

Contrasting total numbers of Hispanic computer science graduates from CAHSI institutions and from non-CAHSI HSIs in Texas, California, Florida, and New Mexico we find that CAHSI institutions graduated 52%, or 178 students out of 328 total Hispanic graduates from all public, Hispanic serving institutions in 2005-2006.[1] This confirms that CAHSI institutions are well-positioned to dramatically increase the number of Hispanic computer scientists in the United States, and have the capacity to increase the number of Hispanic computer science professors in the nation.

3.6 Conclusions and Recommendations

CAHSI institutions lead other Hispanic serving institutions in graduating Hispanic computer science students. In 2007 alone, the seven CAHSI computer science departments graduated 149 Hispanic computer science majors. In addition, two CAHSI institutions graduate an above-average proportion of women in computer science, though more work could be done to recruit and retain women in CAHSI computer science programs, as none reach parity in this area. Three institutions serve other underrepresented minorities as well, specifically African American computer science students. When compared to other Hispanic-serving Institutions, CAHSI institutions are closer to parity in the proportion of Hispanic students enrolled in computer science when compared with Hispanic student attendance at the Universities overall. All schools show room for growth in this area. Future reports will include student-level information regarding recruitment and retention of Hispanic students via CS-0, PLTL, and ARG, in which students who have enrolled in an intervention will be tracked in the semesters following the intervention.

Comparison data with other HSIs could be used to determine which schools would be possible candidates for CAHSI participation, as partners or as sites that might implement CAHSI curricular and programmatic initiatives. For example, by investigating HSIs with large

[1] IPEDS data includes all public 4 year bachelors and masters institutions designated “Hispanic serving” in the 2004 department of education report. Data were collected from each school using the following graduation CIP codes: computer and information sciences, general; computer engineering, and computer science

computing programs, evaluators identified two computing programs that may be of interest to CAHSI leaders. The schools (University of Texas at Brownsville and California State University Fullerton) have relatively large computing programs as well as very high percentages of Hispanic students. By reaching out to these schools, CAHSI could provide tools, curricular materials, workshops, or other resources to recruit, retain, and advance Hispanics at other institutions.

4 Computer Science Zero (CS-0)

4.1 What happens in a CS0 classroom?

We open our discussion of CS-0 with two scenes from our observations of CS-0 classrooms. These narratives highlight the day-to-day activities and interactions found at our observation sites, NMSU and UTEP.

4.1.1 Scene 1

"It's just like Happy Feet!" exclaims a young woman, as she operated her program on Alice. At the click of her mouse, 10 penguins pirouette simultaneously on her laptop screen. She nudges the older man sitting next to her with an elbow. "Did you see?" Her eyes are full of excitement, and her neighbor smiles.

"Yeah, this is cool. Can you make them go in order? Mine are spinning at the wrong times." He asks. The room is abuzz with 13 students' chatter. A soft spoken woman approaches the front of the room.

"Students," she says, "it does matter which order you place the penguins in. You are creating a data structure, and the program only knows to follow the order in which you create the patterns."

"Awww," whines a young man, "I have to start over."

"I'm going to make them dance. Can I add another action, Dr. Villaverde?"

"Yes, feel free to experiment. Think about what you will want your characters to do in your video game."

4.1.2 Scene 2

"Whoa. That one is like, satanic," says a young man, stooped at a computer, an ear bud attached to one ear. He plucks the earphone out and hands it to his classmate, who grins wide. "Where'd you get that sound file?" he asks. Twenty undergraduate students chatter as they manipulate sound and images, mixing Spanish and English seamlessly.

"I got it from an old cartoon. You can search for the sounds online," he turns to his screen. "Here's what it sounds like going forward." He opens a sound file and plays it, as his neighbor shoves the ear bud back in place. At the next computer screen a young woman adjusts the color on an image using python software.

"Miss, I can't make it purple," she says. A woman of middle age walks over to the students' computer.

"Have you tried changing this number here, dear? Purple would be in this range," she says, pointing to a series of numbers on the screen. The young woman makes a few adjustments, and then executes a program. The flower on screen flashes, turning from an ivory shade to a vibrant violet. The student smiles. “You did it!” the instructor exclaims.

The above scenes describe the daily activities found in CS-0 classes at two CAHSI institutions. Our observations suggest that students became highly engaged in the sound and image manipulation activities within the CS-0 course. This is corroborated by survey data as well. We will now discuss the findings from the pre-post survey administered at the five CAHSI institutions with CS-0 courses: UTEP, NMSU, TAMU-CC, UHD, and CSU-DH.

4.2 Who Are the CS-0 Students?

CS-0 pre-survey respondents represented a diverse group of students. One hundred and sixty students completed the pre-survey. Their profiles are as follows:

- 36% UHD, 28% UTEP, 16% CSU-DH, 11% NMSU, 9% TAMU-CC
- 56% Hispanic, 24% African-American, 13% Caucasian, 6% Asian, not from the Indian subcontinent, 1% Asian, from the Indian subcontinent, 1% Native American
- 63% male, 37% female
- 37% CS majors, 23% Social Science majors, 13% Engineering, 13% Fine Arts/Humanities, 11% physical/life science & mathematics, 3% unsure
- 41% freshman, 24% sophomore, 21% junior, 14% senior

The majority of CS-0 students were Hispanic, indicating that CAHSI institutions have effectively used the CS-0 course as a method to recruit Hispanics into an introductory computing course. It is too early to tell whether these students will persist in the major, though.

Most students had minimal background in computing, indicating that the Alliance is meeting their goal of recruiting students with a limited background in computing. The most common prior experience in computing was a high school course in technology (74% of CS-0 students). However, most of these technology courses did not involve computer programming. The most frequent high school technology courses were keyboarding (26%), Business Computing Information Systems (19%), MS Office (11%), Multimedia (10%), and Web Design (10%). A small portion of students (14%) had taken a high school computer-programming course. The most common high school computer-programming course was Introduction to Computer Science (6%). Likewise, many students had not completed advanced Mathematics courses in high school; only 16% had taken a high school Calculus course. However, 44% of students had taken pre-Calculus. In addition, 24% of students had taken high school Trigonometry and 79% had taken Geometry.

Twenty-two percent of students had taken a college computing course. Most of these students had taken Introduction to Computer Science, and a few other individuals had taken courses in Visual Basic, Java or C++. Overall, twenty percent of students reported that they had programmed a computer before.

More students had taken college mathematics than college computing courses. The largest portion of students (47%) had taken College Algebra. Nineteen percent of students had taken Business Math, 16% had taken Calculus I, 13% had taken Trigonometry. Few students had taken more advanced college mathematics courses: 9% had taken Calculus II, 5% had taken Linear Algebra, 3% had taken Calculus III, and 3% had taken Differential Equations.

Students also had minimal background in multimedia applications, with the exception of editing an image on a computer using software such as Paintshop Pro or Adobe Photoshop (67% of students had experience with this). On the other hand, only 28% of students had experience creating or editing music using software, and 25% had edited video with software. Even those with prior experience in multimedia applications were not entirely proficient. For example, only 7% of students reported that they could teach someone else how to edit an image using computer software, even though 67% of students had done this before. Similarly, 3% of students reported that they could teach others to edit video using software, and 3% of students reported that they could teach others to create or edit music using software. Computer science majors had significantly more experience than non-majors in editing images (p=.000, t=4.23, df=151), and editing video (p=.047, t=2.00, df=155). .

Women and men differed in their background experience in computing and mathematics. Surprisingly, women had a stronger background in high school computing and mathematics, although men were more likely to be CS majors and had a stronger background in college computing and mathematics. Though not statistically significant, women were slightly more likely to have taken a high school computer-programming course (18% of women, 13% of men). Women were also significantly more likely to have taken high school Calculus than men (p=.001, t=-1.66, df=145). On the other hand, men were more likely to have programmed a computer before (p=.005, t=1.36, df=145).

There was very little difference in the background experience of overrepresented (white and Asian) and underrepresented students (Hispanics, African-Americans, Native Americans). For instance, 74% of overrepresented students had taken a high school technology course, while 72% of underrepresented had done so (specifically, 71% of Hispanics). There were also few differences in the proportion of overrepresented and underrepresented students who had taken high school Calculus (22% and 23%, respectively; specifically, 17% of Hispanics) or who had programmed a computer before (19% and 20% respectively; specifically, 18% of Hispanics). While there were few differences in background experience for various racial/ethnic groups, Hispanics consistently had slightly less experience than their peers, even those from underrepresented groups.

CS-0 students were likely to work, primarily in off-campus employment. The majority of students at all institutions (66% of the entire sample) reported that they work: 50% of CS-0 students at UTEP and TAMU-CC worked, 65% of students at CSU-DH, 75% of students at NMSU, and 76% of students at UHD. Almost all of these students work off-campus. Only 9% of the pre-survey sample reported that they held on-campus jobs.

Students were also likely to work long hours. The majority of CS-0 students work more than 20 hours a week: twenty-six percent of students work 21-30 hours per week, 18% of students work 31-40 hours, 12% of students work more than 40 hours, 12% work 11-20 hours, and only 4% of students work 1-10 hours per week. Women were also significantly more likely to work than men (p=.027, F=-2.48, df=132), and to work longer hours than men (p=.000, F=13.88, df=98). There were no statistically significant differences in employment for ethnicity.

CAHSI institutions reported that they adapted the CS-0 model to accommodate students' work schedules. One student wrote on the end-of-semester survey:

"I was able to take this course because the labs are incorporated into the class rather than being held at an entirely different time. Please do not change this aspect of the course so other people with strict schedule requirements like myself may take advantage of what is offered here."

Students also listed other interests and activities they were involved in outside of school. Thirty-eight percent of students in CS-0 listed family obligations as an important aspect of their lives (n=51), while 34% described hobbies and sports in which they were involved (n=45). Students also mentioned church responsibilities (11%, n=14) and spending time with friends (9%, n=12) as significant interests. Students' extensive responsibilities and long work hours indicate that the adaptation of the CS-0 course to incorporate labs into the class itself is a necessary adaptation to accommodate students' busy schedules.

4.3 Recruitment of Women and Hispanics into CS-0

The CS-0 course is intended to help CAHSI institutions recruit and retain more Hispanics into the computer science major. At every institution, the percentage of Hispanics enrolled in CS-0 was higher than the percentage of Hispanics enrolled in the CS major. The higher proportion of Hispanic students in CS-0 suggests that the course has been successful in attracting Hispanics into an introductory computing course. It is too early to tell, however, whether these Hispanics will advance to further computing courses.

Table 7 Percent Hispanic undergraduates enrolled in a computing major compared to percent Hispanic undergraduates enrolled in CS-0

Institution	Percent Hispanic Undergraduate Students Enrolled in computing (2007)	Percent Hispanic Undergraduate Students Enrolled in CS-0 (2007)
UTEP	64%	84%
TAMU-CC	40%	50%
NMSU	33%	44%
UHD	26%	27%
CSU-DH	14%	46%

Although the recruitment, retention, and advancement of women into computing are not explicit goals of the Alliance, CS-0 has also been successful in recruiting women into computing. At every institution except one, the percentage of women undergraduates enrolled in CS-0 was higher than the percentage of women enrolled in the CS major. At one school, TAMU-CC, the proportion was relatively even. However, it is also too early to tell whether this will translate into increased numbers of female CS majors.

Table 8 Percent female undergraduates enrolled in computing major compared to percent female undergraduates enrolled in CS-0

Institution	Percent Female Undergraduate Students Enrolled in computing (2007)	Percent Female Undergraduate Students Enrolled in CS-0
UTEP	16%	39%
TAMU-CC	17%	15%
NMSU	14%	40%
UHD	16%	48%

CSU-DH	20%	23%

Therefore, the data indicate that CS-0 is a successful method to recruit both Hispanics and women into an introductory computer course, though we will be unable to tell for several years whether these students have been retained in the major.

We will now discuss specific findings from the pre-survey so that CAHSI members may better understand the attitudes, beliefs, and aspirations that CS-0 students hold when they enter the course. Advisory board members suggested at the annual meeting that the CS-0 survey data be used to "target" students who may need more support in the course due to their lack of experience and/or confidence. Following our discussion of the pre-survey, we will discuss changes in students' attitudes and aspirations over the course of the semester.

4.4 Students Attitudes and Beliefs About Computing at the Beginning of the CS-0 Course

Students held a generally positive orientation toward computing at the beginning of the semester. The following items in Table 9 assessed students' attitudes towards computing and yielded relatively high means.

Table 9 Means for attitude items on pre-survey

Item (on a 4-point likert scale, 1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree)	Mean	S.D
Programming languages can be learned through practice.	3.37	.515
Programming is a creative activity.	3.26	.563
I enjoy problem-solving.	3.13	.657
Computing is boring.	1.56	.631

Most students strongly disagreed that "computing is boring." Students were also in agreement that programming is creative and can be learned through practice. There was slightly less consensus that, "I enjoy problem solving," however, the mean for this item was still quite high. The variance for all of these items as measured by the standard deviation is somewhat low, indicating that most students agreed or strongly agreed with the items.

There were few group differences in attitudes at the beginning of the course. There were no statistically significant differences for ethnicity or gender. The most striking differences were between CS majors and non-majors, and students who had taken high school computing courses and those who had not. Interestingly, students who had taken a high school computer programming course were less likely to believe that programming is a creative activity (p=.001, t=1.05, df=124), or that programming languages can be learned through practice (p=.000, t=1.66, df=134). These students were more likely to feel that computing is tedious and difficult, indicating that their high school preparation in computing programming was poor.

As might be expected, computer science majors held more positive beliefs about computing than non-majors. Computer science majors were more likely to agree that programming is a creative activity (p=.001, t=-2.5, df=124), and that programming languages can be learned through practice (p=.003, t=-2.28, df=134).

Therefore, several groups of students held less positive beliefs about computing at the beginning of the semester. The following groups were less likely to view computer programming as a creative activity that can be learned:

- Non CS-majors
- Students who took a high school technology or computer-programming course (though not students who had taken college computing courses)

4.4.1 Students' Computing Confidence at the Beginning of the Semester

While student beliefs and attitudes toward computing were generally quite positive, students expressed limited confidence in their abilities at the beginning of the semester. Table 10 highlights students' mixed responses about their math and computer programming abilities.

Table 10 Means for confidence items on pre-survey

Item (on a 4-point likert scale, 1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree)	Mean	S.D
I am confident in my math ability.	3.01	.691
I am confident in my computer programming ability.	2.49	.783

The variance of student responses as measured by the standard deviation was also higher for the confidence items than for the beliefs/attitudes, indicating that there was less agreement about these items and a wider range of student responses.

4.4.2 Women and Hispanics: Computing Confidence at the Beginning of the Semester

There were few differences in confidence among groups. Though not statistically significant, women expressed less confidence in their math ability (female mean=2.7, male mean=2.97) and computer programming ability (female mean=2.4, male mean= 2.51) at the start of the semester. The difference in means for confidence in math is particularly striking given that women had taken more advanced math courses in high school than men. However, men had a stronger background in college math.

There were few differences in the computer programming confidence of overrepresented and underrepresented groups (overrepresented mean= 2.53, underrepresented mean=2.52). The mean for Hispanic students, in particular, was 2.47. However, underrepresented students had more variance in their answers and were more likely to either strongly agree or strongly disagree with their confidence levels. Though the groups overall were relatively equal, Hispanics had slightly less confidence in their programming ability than their peers.

Similarly, there was little difference among overrepresented and underrepresented groups in confidence in their math abilities (mean=2.88, mean=2.9, respectively). Hispanics, specifically, had the greatest overall confidence in math (mean=2.97). Interestingly, Hispanics had the highest confidence in their math ability, yet the lowest confidence levels in their computer programming ability.

4.4.3 Background Experience Affects Computing Confidence

Though not statistically significant, students who had taken high school Calculus had greater confidence in their computer programming (HS Calculus mean=2.59, non-HS Calculus mean=2.46), and math abilities (HS Calculus mean= 3.28, non-HS Calculus mean=2.77).

Likewise, computer science majors were significantly more confident in their computer programming abilities (p=.047, t=-2.00, df=147).

Though students with a high school technology background had more negative beliefs about computing, they also had greater confidence in their computing and math abilities. For example, students who had taken a high school computer programming course were more confident in their programming ability (p=.036, t=-.88, df=107). Though not statistically significant, students who had taken a high school technology course were also more confident in their computer programming ability (HS technology course mean=3.0, no-HS tech mean=2.5).

Therefore, pre-survey results suggest that the following groups of students may demonstrate less confidence in their computer programming and/or math abilities at the beginning of the CS-0 course:

- Women, for math and computer programming confidence
- Students with a weaker high school math background, for math and computer programming confidence
- Students without high school technology courses, for math and computer programming confidence
- Underrepresented groups (particularly Hispanics and Native Americans), for computer programming confidence only
- Non-CS majors, for computer programming confidence only
- Students without high school or college computer programming courses, for computer programming confidence only

4.5 Students' Aspirations at the Beginning of the Semester

At the beginning of the semester, students were asked to rate their aspirations to major in computing or go to graduate school in computing. Table 11 demonstrates that students had stronger intentions of taking more computing courses than majoring in computing or pursuing graduate school in computing.

Table 11 Means for aspiration items on pre-survey

Item (on a 4-point likert scale, 1=very unlikely, 2=somewhat unlikely, 3=somewhat likely, 4=very likely)	Mean	S.D
How likely are you to take more computing courses?	3.24	1.01
How likely are you to major in computing?	2.98	1.26
How likely are you to pursue a graduate degree in computing?	2.74	1.25

The standard deviation reflects that there was a greater range in student responses than for some other survey items; this is not surprising given that there was a mix of majors and non-majors in the overall sample.

4.5.1 Aspirations of Women and Hispanics

Though not statistically significant, Hispanics had higher aspirations in computing than other racial/ethnic groups at the beginning of the semester. For example, the proportion of students who were very likely or somewhat likely to major in computing is as follows:

- 66% of Hispanic students were very likely or somewhat likely to major in computing
- 61% of Caucasian students
- 55% of Asian students
- 50% of African-American students

Given that more men in CS-0 were computer science majors, there were also gender differences in aspirations. For example, 73% of men, yet only 36% of women were somewhat likely or very likely to major in computing at the beginning of the course. Likewise, 64% of men, but only 37% of women were somewhat likely or very likely to pursue a graduate degree in computing. There was less difference in aspirations to take more computing courses; 81% of men and 65% of women were somewhat likely or very likely to take more computing course.

Overall, the pre-survey demonstrates that the CS-0 courses at CAHSI institutions attracted a diverse group of students, including strong proportions of Hispanics and women. Students had minimal background experience in computing at the beginning of the semester, suggesting that the CS-0 course is effectively targeting and recruiting students with little experience in computing. Students generally had favorable attitudes and beliefs about computing, though their confidence levels in math and computer programming were mixed. Students were also somewhat likely to continue with computing either through taking more courses or through majoring in computing.

4.6 CS-0 Outcomes

4.6.1 The pre-post sample of students

The post CS-0 survey also reflected the diversity of students in the CS-0 course, although there was a much lower response rate than for the pre-survey. Eighty-one students completed the post survey, half the response rate of the pre-survey. Other demographic information such as gender, ethnicity, major, and year in college, was collected in the pre-survey; therefore, we only have demographic information for students who completed both pre and post surveys. The means reported in this section may differ from the means reported in the "pre-survey" section because that section addressed the entire pre-survey sample of 161 students, while this section addresses the smaller sample of students who completed both pre and post surveys (n=74). Due to the smaller pre-post sample, we were unable to run statistical tests of significance for some sub-groups such as institution and ethnicity, because the variation among sample sizes across institutions was too large to conduct meaningful statistical analyses. The student demographic information for the pre-post matched sample is as follows:

- UTEP 45%, CSU-DH 18%, NMSU 16%, TAMU-CC 12%, UHD 9%
- 62% men, 38% women
- 43% CS majors, 21% Engineering majors, 11% Fine Arts & Humanities majors, 13% Social Science majors, 11% Math and Science majors, and 1% unsure

- 4% Asian, not from Indian subcontinent,;1% Asian, from Indian subcontinent; 12% Caucasian; 12% African-American; 68% Hispanic; 3% Native American
- 55% of Hispanics were CS majors, 35% of African-Americans, 100% of Native Americans, 25% of Caucasians, 66% of Asians, not from Indian subcontinent, and 0% of Asians, from Indian subcontinent
- 61% freshmen, 20% sophomore, 10% junior, 9% senior

Due to the decreased response for the post-survey, there were some differences between the pre-survey sample and the pre-post matched sample. The demographics of the pre-survey sample are more representative of CS-0 students overall. The ratio of men and women was comparable for both samples. There were more Computer Science (43%) and Engineering (21%) majors in the pre-post matched sample than in the pre-survey sample (37% and 13%, respectively). There were also more freshmen in the pre-post sample (61%) than in the pre-survey sample (40%). Finally, there was a higher proportion of Hispanics (68%) in the pre-post sample than in the pre-survey (56%). Overall, the differences between the samples may indicate that the pre-post sample was not as representative of the overall enrollment in CS-0 at CAHSI institutions as it could be, and may reflect a greater proportion of Hispanics, computer science majors, and engineers.

4.6.2 Students View the Work of a Computer Scientist More Positively at the End of the Semester

Students were asked to rate their level of satisfaction if they spent their day engaged in computer science-oriented tasks, such as constructing and completing a project, analyzing the principles required to solve a problem, and focusing on the details necessary to perfect a solution. Students' responses on this scale rose significantly from the beginning to the end of the semester (p=.015, F=7.322, df=70). Students were more amenable to engaging in computer science-related tasks after experiencing those types of activities themselves through the CS-0 course. Thus, students' interest in computer science-type work increased over the course of the semester,

The table below demonstrates the means, standard deviations and the percentage of students who were satisfied or very satisfied with the activity in the post-survey. Students took the greatest satisfaction in "having constructed and completed a project," and "having the flexibility to design your own solutions" in the CS-0 course. Students took slightly less satisfaction in "analyzing the principles required to solve a problem" and "directing others in completing a project." Overall, the means for the entire scale rose from the beginning to the end of the semester.

Table 12 Means for "computer science work tasks" scale on pre-survey

Indicate your enjoyment of each of the following as related to course activities. (on a 4-point scale, 1=very dissatisfied, 2-dissatisfied, 3=satisfied, and 4=very satisfied	Mean	S.D.	% satisfied or very satisfied
Having constructed and completed a project.	3.57	.63	96%
Having the flexibility to design your own solutions.	3.57	.57	96%
Recognizing the solutions you developed could be helpful to others.	3.53	.57	96%
Focusing on the details necessary to perfect your solution.	3.43	.59	95%
Analyzing the principles required to solve a problem.	3.42	.59	95%

Directing others in completing a project.	3.42	.68	94%

4.6.3 Women and Hispanics Make Gains in their Views of the Work of Computer Scientists

There were significant differences for gender on the "work tasks" scale. There were also differences among racial/ethnic groups. There were no differences by institution or amount of background experience in computing. Women's responses on the "work tasks" scale rose significantly more than men from the beginning to the end of the semester (p=.031, F=5.55, df= 72). The standard deviation for women also fell quite significantly, indicating that there was less variability in women's responses at the end of the semester. While both groups rated work tasks higher at the end of the semester than the beginning, women made greater gains on the scale.

Table 13 Pre-post change in gender means for "work tasks" scale

	Pre-survey mean for "work tasks" scale	S.D.	Post-survey mean for "work tasks scale"	S.D.	Change
Women	3.13	1.50	3.44	.552	+.31
Men	3.34	.405	3.53	.434	+.19

Though not statistically significant, Hispanics and other underrepresented students (African-Americans and Native Americans) also made greater gains on the "work tasks" scale than their overrepresented peers (Caucasians and Asians), as demonstrated in the table below.

Table 14 Pre-post change in race/ethnicity means on "work tasks" scale

	Pre-survey mean for "work tasks" scale	S.D.	Post-survey mean for "work tasks" scale	S.D.	Change
Hispanic students	3.08	1.55	3.44	.491	+.36
Other underrepresented students	3.26	.501	3.76	.337	+.50
Overrepresented students	3.38	.477	3.67	.350	+.29

At the beginning of the semester, women and underrepresented students expressed less interest in computer science-oriented work tasks than their white and male peers. However, the CS-0 course closed this gap as the scores of women and underrepresented students rose more than the scores of whites and males. Through hands-on projects that allowed students to be flexible and creative, CS-0 increased the interest of underrepresented students in the type of work activities that they would encounter as computer scientists.

4.7 Attitudes and Beliefs about computing

4.7.1 CS-0 Builds Confidence

Students' confidence in using computers and in their computing programming abilities rose significantly during the semester (p=000,t=4.575, df=52). On the other hand, students' confidence in their mathematics ability decreased slightly.

Table 15 Pre-post change in means for confidence items for all students

Item (on a 4-point scale, 1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree)	Pre-survey mean for all students	S.D.	Post-survey mean for all students	S.D.	Change
I am confident in my computer programming ability.	2.49	.869.	3.13	.682	+.64
I am confident in my math ability.	3.01	.691	2.91	.793	-.10

Students also directly attributed their increased confidence in computing to the CS-0 course.

- "Has this class affected your confidence in using computers?
76% of students responded yes, n=60

Therefore, the CS-0 course was highly successful in increasing students' confidence in their programming abilities, though it did not appear to impact students' confidence in math.

There were some differences in confidence according to the background experience of students. For example, students who had not programmed a computer before made greater gains in confidence than students with programming experience. Though students without programming experience exhibited less confidence in their programming abilities at both the beginning and end of the semester, their scores increased more than those of students with prior programming experience. CS-0 may have helped to lessen the gap in confidence between students with and without prior programming experience.

Table 16 Pre-post change in means for confidence in computer programming based on prior programming experience

Means for confidence in computer programming (Items are on a 4-point scale, 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree)	Pre-survey mean	S.D.	Post-survey mean	S.D.	Change
With programming experience	3.00	1.00	3.30	.675	+.30
Without programming experience	2.39	.814	2.97	.677	+.58

Though the differences were not statistically significant, there were also slight differences in confidence according to gender and race/ethnicity. Women gained greater confidence in computer programming than men during the semester, although women exhibited greater confidence than men in their programming abilities both at the beginning and end of the semester. In this respect, the smaller pre-post sample differed from the overall CS-0 student sample from the pre-survey. In the larger pre-survey sample, women expressed less confidence in their programming ability than men. Nevertheless, women in the pre-post sample demonstrated slightly stronger gains in confidence in their programming abilities than men.

Table 17 Pre-post change in means for confidence in computer programming based on gender

Means for confidence in computer programming (Items are on a 4-point scale, 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree)	Pre-survey mean	S.D.	Post-survey mean	S.D.	Change
Women	2.55	.738	3.12	.800	+.57
Men	2.46	.960	2.96	.608	+.50

All racial/ethnic groups exhibited strong increases in confidence in computer programming. In fact, overrepresented students, Hispanics, and other underrepresented students (African-Americans and Native Americans) all gained at least a half point on a 4-point scale. The differences among the groups were negligible, although overrepresented students gained slightly more confidence in programming than underrepresented students did.

Table 18 Pre-post change in means for confidence in computer programming based on race/ethnicity

Means for confidence in computer programming (Items are on a 4-point scale, 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree)	Pre-survey means	S.D.	Post-survey means	S.D.	Change
Overrepresented	2.63	.894	3.25	.707	+.62
Hispanic	2.42	.948	2.97	.638	+.55
Other underrepresented	2.71	.753	3.30	.518	+.59

Indeed, the gains in computer programming across all demographic variables, such as gender and ethnicity, suggest that the CS-0 course served to boost the computer programming confidence of almost all students.

4.7.2 Influence of CS-0 on Students' Attitudes towards Computing

Students were asked to answer a series of items about their attitudes toward computing. This scale assessed changes in students' attitudes, confidence, and beliefs about computing. Overall, students' responses on this scale rose slightly over the course of the semester, though the results were not statistically significant. However, the results indicate that students began the semester with positive attitudes towards computing and moderate confidence levels in computing and math, and students' positive attitudes and confidence increased during the semester. There was also less variability among students' responses at the end of the semester, as seen in the decrease in standard deviation. Therefore, students' responses clustered more closely around "agree" at the end of the semester than they did at the beginning of the semester.

Table 19 Pre-post change in means for attitudes and beliefs scale for all students

Mean for Attitudes and Beliefs Scale (Items are on a 4-point scale, 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree)	Pre-survey mean	S.D.	Post-survey mean	S.D.	Change
All students	3.12	.824	3.24	.386	+.12

There were no statistically significant differences on the attitude scale for different groups, such as gender. The lack of statistically significant differences is most likely because students' overall movement on the scale was quite small due to students' largely positive responses at the beginning of the semester. There was almost no discernable difference between men and women on the attitude scale (women moved +.01 and men moved +.04 on the scale). However, there was a larger difference among ethnic groups.

Table 20 Pre-post change in means for attitudes and beliefs scale based on race/ethnicity

Mean for Attitudes and Beliefs	Pre-	S.D.	Post-survey	S.D.	Change

Scale (Items are on a 4-point scale, 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree)	survey mean		mean		
Hispanic students	3.07	1.11	3.19	.334	+.12
Other underrepresented students	3.14	.661	3.4	.417	+.26
Overrepresented students	3.23	.369	3.35	.334	+.12

African-American and Native American students' scores increased the most on the attitude scale, while Hispanics' and overrepresented students' scores increased slightly less.

4.7.3 Students' Beliefs about Computer Science Changed

Students were also asked to write a definition of computer science at the beginning and end of the semester. In the pre-survey, 153 CS-0 students answered this question. The most common responses were "computer science is programming" (37%, n=57), and "computer science is learning about computers" (24%, n=37). Other responses to this item included: "computer science is the study of how the computer functions or works" (14%, n=21), "computer science is problem solving" (10%, n=16), and "the application of programming" (10%, n=15). Thirteen students admitted they did not know what computer science was, and another thirteen respondents made a positive comment about computing (e.g. computing is fun, computing helps people).

Following their experience with CS-0, students defined computer science differently. Eighty-one students answered this item in the post survey, coming up with 127 distinct ideas regarding the definition of computer science. Nearly one quarter of the students mentioned the process of problem solving in their definitions (n=19), while nearly a third described computer science in terms of programming (n=24, 30%). In the post survey responses, however, students described programming differently than they did in the pre-survey. In the post-survey, students described a process of programming with a purpose, and as a means to develop real world applications. CS-0 students were also more likely to describe computing as a way to serve people, rather than as an isolated, esoteric practice. CS-0 students offered their definition of computer science at the end of the course:

"Computer science is the study of how computers work and how they may be manipulated to produce beneficial outcomes (that) make life easier/better."

"Computer science is the study of programming and the application of programs to solve everyday problems."

CS-0 students viewed the study of computer science as a process, intended to create new things, innovate, and solve problems. They also saw computer science as a study of computer functioning—a way to "look under the hood" and figure out how computers work (25%, n=20). Students believed that computer science skills develop through practice in programming (n=9, 11%). Sixteen percent of students relayed positive attitudes towards computers in this item, while only two percent mentioned negative attributes.

Overall, students made strong gains in confidence in their computer programming abilities and slight gains in attitudes toward computer science. The differential impacts among gender and race/ethnic groups were negligible. In general, students began the semester with positive attitudes toward computing and programming and those attitudes increased slightly during the semester. On the other hand, many students lacked confidence in programming at the beginning of the semester and their confidence increased dramatically by the end of the semester. Students' confidence in their math ability decreased slightly. Finally, students broadened their view of computer science and began to see it in a more applied manner, as programming with a purpose and a means to serve people.

4.8 Influence of CS-0 on Students' ASPIRATIONS in Computing

Unlike the dramatic increases in confidence in computer programming, students' aspirations remained relatively flat from the beginning to the end of the semester. While the likelihood that students would take more computing courses or pursue graduate school in computing remained almost even, there was a slight decrease in the likelihood that students would major in computing. However, the decrease was not statistically significant.

Table 21 illustrates the pre-survey and post-survey means for the "aspirations" items for the entire pre-post sample of students.

Table 21 Pre-post change in means for aspiration items for all students

Item (on a 4-point scale, 1=very unlikely, 2=somewhat unlikely, 3=somewhat likely, and 4=very likely)	Pre-survey mean	S.D.	Post-survey mean	S.D.	Change
How likely are you to major in computing?	2.98	1.25	2.89	1.17	-.11
How likely are you to take more computing courses?	3.24	1.01	3.23	.935	-.01
How likely are you to pursue a graduate degree in computing?	2.74	1.25	2.73	1.18	-.01

4.8.1 Women's and Hispanics' Aspirations in Computing

Though not statistically significant, women fared better in their aspirations to major in computing and go to graduate school in computing. In fact, women stayed relatively even on these items, while men's aspirations fell during the semester. While women began the semester less likely to take more computing courses than men, they ended the semester with equal aspirations.

Table 22 Pre-post change in means for likeliness of taking more computing courses based on gender

Means for "How likely are you to take more computing courses?" (Items are on a 4-point scale, 1=very unlikely, 2=somewhat unlikely, 3=somewhat likely, and 4=very likely)	Pre-survey mean	S.D.	Post-survey mean	S.D.	Change
Women	3.18	.834	3.19	.939	+.01
Men	3.27	1.11	3.18	.995	-.09

Women were also less likely to aspire to major in computing than men; however, women's aspirations remained relatively even during the semester, while men became slightly less likely to want to major in computing. Nevertheless, a large gap between men and women in aspirations to major in computing remained.

Table 23 Pre-post change in means for likeliness of majoring in computing based on gender

Means for "How likely are you to major in computing?" (Items are on a 4-point scale, 1=very unlikely, 2=somewhat unlikely, 3=somewhat likely, and 4=very likely)	Pre-survey mean	S.D.	Post-survey mean	S.D.	Change
Women	2.51	1.28	2.52	1.26	+.01
Men	3.22	1.17	3.05	1.07	-.17

Women's aspirations to pursue graduate school in computing increased slightly over the semester, while men's aspirations fell slightly. However, women were still less likely to aspire to graduate school in computing than men at the end of the semester, indicative of the lower number of female computer science majors.

Table 24 Pre-post change in means for likeliness to pursue a graduate degree in computing based on gender

Means for "How likely are you to pursue a graduate degree in computing?" (Items are on a 4-point scale, 1=very unlikely, 2=somewhat unlikely, 3=somewhat likely, and 4=very likely)	Pre-survey mean	S.D.	Post-survey means	S.D.	Change
Women	2.42	1.24	2.44	1.22	+.02
Men	2.93	1.23	2.85	1.18	-.08

Differences among racial and ethnic groups for aspirations in computing varied. Overrepresented students' (whites and Asians) scores increased more than Hispanics or other underrepresented groups (African-Americans and Native Americans) in their likelihood of taking more computing courses. The scores of Hispanics stayed flat (with a slight decrease) and the scores of other underrepresented students decreased a bit.

Table 25 Pre-post change in means for likeliness of taking more computing courses based on race/ethnicity

Means for "How likely are you to take more computing courses?" (Items are on a 4-point likert scale, 1=very unlikely, 2=somewhat unlikely, 3=somewhat likely, 4=very likely)	Pre-survey mean	S.D.	Post-survey mean	S.D.	Change
Hispanics	3.2	1.04	3.18	1.00	-.02
Other underrepresented students	3.5	.534	3.38	.517	-.12
Overrepresented students	3.42	1.16	3.58	.755	+.16

Though other underrepresented groups declined in the likelihood that they would take more computing courses, their scores increased for their likelihood of majoring in computing. Therefore, while a few underrepresented students decided not to continue with computing, others were more likely to want to major in computing. However, scores of Hispanics and overrepresented groups declined. Hispanic students' scores declined less than those of overrepresented students.

Table 26 Pre-post change in means for likeliness of majoring in computing based on race/ethnicity

Means for "How likely are you to	Pre-survey	S.D.	Post-	S.D.	Change

major in computing?" (Items are on a 4-point likert scale, 1=very unlikely, 2=somewhat unlikely, 3=somewhat likely, 4=very likely)	mean		survey mean		
Hispanics	3.02	1.24	2.91	1.17	-.11
Other underrepresented students	2.50	1.20	2.67	1.36	+.16
Overrepresented students	3.08	1.36	2.91	1.31	-.17

All ethnic groups declined in their likelihood of pursuing a graduate degree in computing. Although other underrepresented students declined the most, Hispanics showed the least decline on this item. In fact, Hispanics expressed the greatest likelihood that they would attend graduate school in computing.

Table 27 Pre-post change in means for likeliness of pursuing a graduate degree in computing based on race/ethnicity

Means for "How likely are you to pursue a graduate degree in computing?" (Items are on a 4-point likert scale, 1=very unlikely, 2=somewhat unlikely, 3=somewhat likely, 4=very likely)	Pre-survey mean	S.D.	Post-survey mean	S.D.	Change
Hispanics	2.83	1.24	2.79	1.18	-.04
Other underrepresented students	2.75	1.04	2.40	1.14	-.35
Overrepresented groups	2.82	1.38	2.67	1.30	-.15

4.8.2 Students with Less Computing Experience Make Gains in Aspirations

There were also differences in students' aspirations according to their prior experience in math and computing. Students with a stronger math background were more likely to make gains in aspirations, particularly in their likelihood of majoring in computing (p=.038, t=-.67, df=65). On the other hand, students with little prior computing experience made the greatest gains in aspirations. Though not statistically significant, students without a high school technology course made greater gains in their likelihood of taking more computing courses (those without a HS tech course increased by +.35, those with a HS tech course decreased by -.16), and in the likelihood that they would major in computing (those without a HS tech course increased by +.27, those with a HS tech course decreased by -.18). Students without a high school technology course also made stronger gains in their likelihood of going to graduate school in computing (those without a HS tech course increased by +.15, those with a HS tech course decreased by -.06). However, the differences did not hold true for other background experience variables such as having programmed a computer before, or having taken a computer-programming course in high school or college.

Non-computer science majors also made stronger gains in aspirations than majors, who decreased slightly on all of the aspiration items. For instance, non-majors gained in the likelihood that they would major in computing (non-majors increased by +.12, majors decreased by -.24), and take more computing courses (non-majors increased by +.09, majors decreased by -.15). Therefore, the CS-0 course has engaged non-majors and slightly increased the likelihood that they may major in computing or take more computing courses.

4.9 Interest in a Computing Career

In an open-ended question, students stated whether they were interested in computing careers in the beginning and at the end of the CS-0 course. In the beginning of the course, 138 students responded to this item, with 71% (n=99) indicating interest in a computing career. They listed passion for computing (n=49), the ubiquity of computers and computer programs (e.g. computers are everywhere, everyone uses computers, n=17), interest in computer programming and video game development (n=22), skills and confidence in computing (n=9), and love of problem solving as reasons they were interested in computing careers. Nine of these students stated that computer science was something they "had always wanted to do."

In the pre-survey, 39 students said they would not be interested in a computing career; eleven of whom said this was because they were more interested in other topics. Eight of the uninterested students stated that they disliked computing, while four preferred an "active" profession, three were interested primarily in software applications only, and two said they lacked the knowledge to pursue a career in computing.

The post-survey had significantly fewer respondents to this open-ended item (n=67). Of the 67 students who replied, 66% (n=44) were interested in computing careers, 20 were not interested, and three stated they might be interested in a computing career. The decline in percent of interested students may be related to the student groups who participated in the post survey compared to the larger population. For example, in one CAHSI school, CS-0 is offered as a general requirement course, meaning students from a multitude of majors enroll in the course. Survey respondents from this school made up nearly half of all post-survey respondents (45%, n=37).

In the post-survey, students stated similar reasons as they did in the pre-survey for their interests and lack of interest in a computing career. Students were interested in using computing as a tool to help people.

"Yes, it (a career in computing) would (interest me) because i would like to be able to tell the computer to do something and do things with it that other people can look up to or use to help them."

Other students had always been interested in or passionate about computing.

"*Yes, a career in computing does interest me because I've always been fascinated with the new era of technology and all it's gadgetry."*

The CS-0 course also helped to increase students' confidence in computing and interest in a computing career.

"Yes, (a career in computing would interest me), because in the beginning, this class was a challenge for me. But with hard work and dedication, I achieved greatness."

In conclusion, students' aspirations in computing remained relatively even from the beginning to the end of the semester. Given the high attrition rate in many introductory computer courses, it may be promising that student intentions to continue in computing did not significantly decline. Women experienced better outcomes than men as far as aspirations in computing, and Hispanics experienced better outcomes in their intentions to go to graduate school, though not in other areas. However, students with little background in computing and non-majors had the most positive outcomes as far as their aspirations in computing. Some non-majors expressed that they were more likely to major in computing after having taken the C-0 course. Given that students' interest in the types of work activities that they would perform as computer scientists increased, yet their interest in computing careers decreased slightly, the CS-0 course may benefit from an increased emphasis on educating students about computing careers.

Students' Self-assessment of learning

At the end of the semester, students were asked to provide feedback about the course itself and course tasks, including homework, quizzes, and exams. These items allow students to rate their learning gains from the course and the impact of different course elements, such as the instructor and class environment, on their learning and motivation. These survey items comprise the "self-assessment of learning" scale. The overall mean on the scale was relatively high.

Table 28 Mean for Self-assessment of learning scale for all students

Mean for Self-Assessment of Learning scale (Items are on a 4-point scale, 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree)	Mean	S.D.
All students	3.25	.525

The means, standard deviations, and frequencies of the individual scale items are as follows:

Table 29 Means for all items on students' self-assessment of learning scale

Item (Items are on a 4-point likert scale, 1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree)	Mean	S.D.	% agree or strongly agree
The class environment was conducive to asking questions.	3.44	.592	95%
Attending lectures helped me learn in this course.	3.34	.673	89%
Doing homework helped me learn in this course.	3.32	.676	89%
I learned skills from this course that will be useful in other areas of my life.	3.31	.748	86%
Working with others on assignments helped me learn in this course.	3.31	.673	91%
I learned technical skills from this course.	3.28	.628	91%
The professor increased my interest in this course.	3.26	.719	85%
I developed my problem-solving abilities in this course.	3.09	.745	80%

The means for all items were between the "agree" and "strongly agree" rating, indicating that students were very satisfied with the CS-0 course and believed that they learned valuable skills from the course. Overall, students rated the class environment the most positively. This is important given the lack of confidence displayed by some students at the beginning of the semester. Students felt comfortable asking questions in the class which may have increased their confidence and strengthened their understanding of important concepts. Students also believed that homework, lectures, and working with others contributed to their learning. Students felt that the skills that they learned in the course would translate to other areas of their lives. Students also responded that they gained problem-solving skills from the course, though to a lesser extent than technical skills.

4.9.1 CS Majors Made Stronger Learning Gains

There were no significant differences on the "self-assessment of learning" scale for year in college, whether students worked, gender, and for many background experience variables such as having taken high school Calculus, a high school technology course, or having programmed a computer before. As mentioned previously, we were unable to conduct statistical analyses by institution or ethnicity because of the variability of the sample size among institutions. The only statistically significant variables were:

- Computer science majors made greater learning gains than non-majors ($p=.043$, $t=-2.058$, $df=72$).
- Students who had taken a computing course in college made greater learning gains than those without a college computing course ($p=.022$, $t=-2.47$, $df=72$).

4.9.2 Women and Hispanics Rated their Learning Gains Slightly Lower

Though not statistically significant, there were some minor group differences in students' self-assessments of their learning. For example, women rated their learning slightly lower than men (women mean=3.18, men mean= 3.3). However, both groups still rated their learning highly. Likewise, overrepresented students rated their learning higher than Hispanics and other underrepresented groups (overrepresented mean=3.48, Hispanic mean=3.17, other underrepresented mean=3.38). Hispanics had less background experience in computing and this may have contributed to their lower self-ratings, as students with more computing experience rated themselves higher on the self-assessment of learning scale.

Though we could not test for statistical significance by institution, there were some differences across institutions in students' self-assessment of learning. Nonetheless, students at all schools assessed their learning highly as all means were above 3.0 on a 4-point scale. As mentioned previously, computer science majors rated their learning gains higher than non-majors. Therefore, the institutions with the greatest number of majors in their CS-0 course reported the strongest gains on the student self-assessment scale. The University of Houston, Downtown and the University of Texas, El Paso had the least amount of CS majors in their CS-0 course and students reported slightly lower learning gains at these schools.

Table 30 Means for student self-assessment of learning scale by institution

Mean scores on student self-assessment scale (Items are on a 4-point scale, 1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree)	Mean	S.D.
NMSU	3.52	.542
CSU-DH	3.50	.405
TAMU-CC	3.38	.359
UHD	3.25	.577
UTEP	3.03	.513

Overall, CS-0 students rated their courses highly. They found the class environment to be positive and comfortable. CS-0 instructors increased students' interest in the course. CS-0 students gained valuable skills from the course that they believed would transfer to other aspects of their lives. Computer science majors had the strongest responses, while women and Hispanics had slightly lower responses. Nonetheless, all groups of students rated the course and their learning highly.

4.10 Course Projects

In open-ended comments, students indicated that their CS-0 projects contributed immensely to their learning and to their satisfaction in the course. Course projects also increased students' confidence as they took pride in having mastered a challenging task.

4.10.1 CS-0 Projects that Made Students Proud

In the post-survey, students said they were most proud of their CS-0 projects, including video game development (20%, n=17). Students wrote:

"One project that I was particularly proud of was creating a gaming program. I incorporated all of the skills I learned in the course into the program."

"My tutorial game that I had created from scratch [made me proud].... It was great seeing something start from completely nothing and work its way up to a masterpiece..."

One-third of students indicated that sound and image manipulation labs gave them the most pride (33%, n=27).

"The project that I was particularly proud of was changing the color of the person's hair, clothes, or eyes. It was amazing to see what you could do with a computer and a few programming functions. The best part is just knowing that you have achieved something amazing and you could pretty much do anything with a computer."

Five students stated that all of their lab work made them proud, while two were most satisfied with their test performance, two with their greeting cards, and another pair most enjoyed making penguins dance in Alice. Two additional students enjoyed the robot project best.

In sum, CS-0 students took pride in their work. They were particularly satisfied with projects in which they created something, such as video game programs or image and sound manipulation.

4.10.2 CS-0 Projects Built Confidence, Highlighted Programming Process

Labs and assignments in the CS-0 course challenged (n=15) and interested students (n=11). Students noted the hard work and effort required to complete assignments; however, the difficulty of the tasks contributed to the sense of pride and satisfaction that students felt upon completion of course projects. Students wrote:

"The most important part that made the project meaningful to me is that it was the most difficult one. This encouraged me to push through and think of different ideas in order to finally solve and create a function that changes the color completely. I grew more and more encouraged with the project as I came closer to the final result. It gives you a real sense of accomplishment when you see your final product in action."

"The project was very hard for me and my partner and required allot of work. However, the ending result was very satisfying!"

In particular, student became motivated through their engagement with the programming process (n=25). The opportunity to create new games, animations, and images made students proud of their course work (n=14). Twelve students enjoyed the freedom to follow their own project ideas with limited guidance and few restrictions. Eighteen students said that working on CS-0 projects boosted their confidence in programming, and encouraged them to continue learning about computers. The following quotes indicate the benefits students received from their course projects:

"(This project) allowed me to think outside my normal realm. I had to figure out ways to move in the game and think about smaller movements, and how they were affected."

CS-0 students described the confidence gained from course projects:

"(The project) was a real taste of what computers can do, and something that I once imagined would be very difficult and out of my realm of possibility was taught to me, and now I am able to do it."

"The ability to be capable of programming sound in a very easy and understandable way. I am no longer afraid of getting into a program and start writing down recipes."

A CS-0 student described her experience with computer programming:

"I will never forget my first assignment. My first assignment increased my love for computer science. When I receive my Master's degree in this field, I will look back at my first computer science assignment and think, 'this is what started me on the road to where I am now.'

In sum, CS-0 students demonstrated increased confidence, motivation, and commitment to computing from their project work in the course. CS-0 projects motivated students to work hard, learn new concepts, and think in new ways. Students felt a sense of pride and ownership in their accomplishments.

4.10.3 Course tasks provided an appropriate level of challenge

Students were asked to rate the difficulty of course tasks, such as homework, exams, and labs. The table below demonstrates the mean and standard deviation for all CS-0 students on the "difficulty of course tasks" scale.

Table 31 Mean for difficulty of course tasks scale for all students

Mean for Difficulty of course tasks scale (Items are on a 4-point scale, 1=very easy, 2=easy, 3=difficult, 4=very difficult)	Mean	S.D.
All students	2.45	.902

The overall mean for students on the "course tasks" scale was directly in between "easy" and "difficult." The means and standard deviations for student ratings of course tasks are as follows:

Table 32 Means for individual items on difficulty of course tasks scale

Rating of difficulty of course tasks (Items are on a 4-point likert scale,1=very easy, 2=easy, 3=difficult, 4=very difficult)	Mean	S.D.

Labs	2.29	1.18
Homework	2.37	1.17
Quizzes	2.45	.60
Midterm	2.75	.62
Final (n=53)	2.91	.74

Students rated all of the items in between "easy" and "difficult." Students rated labs as the easiest course task and the midterm and final as the most difficult. Not all of the students had completed the final upon the survey administration, so the analysis of that item was run with students who had already completed the final. The standard deviations for homework and labs were larger than for the other items, indicating that there was greater variance in student responses and less agreement as to the difficulty of those tasks. Overall, student ratings of course tasks indicate that they provided an appropriate amount of challenge for students and were neither too easy to foster learning nor so difficult as to undermine student confidence.

There were very few group differences in students' ratings of the difficulty of course tasks. There were no meaningful differences among institutions. There were also no real differences according to the computing or math background of students. Indeed, it is surprising that there was not a greater differential in student scores according to background experience. Interestingly, CS majors rated the course as more difficult than non-majors (majors had a scale mean of 2.64 and non-majors had a scale mean of 2.45).

There were virtually no gender differences in ratings of course tasks, but there were some differences by ethnicity. Women and men rated the difficulty of course tasks almost equally (scale means of 2.53 and 2.56, respectively). However, overrepresented groups rated course tasks as slightly easier than Hispanics or other underrepresented students.

Table 33 Differences in means on difficulty of course tasks scale by race/ethnicity

Rating of difficulty of course tasks (Items are on a 4-point likert scale, 1=very easy, 2=easy, 3=difficult, 4=very difficult)	Mean	S.D.
Overrepresented students	2.44	.608
Hispanic students	2.54	.479
Other underrepresented students	2.73	.452

In conclusion, students' ratings of the difficulty of course tasks demonstrate that course activities, assignments, and projects provided an appropriate level of challenge for students. Underrepresented students also found course tasks to be more difficult than overrepresented students. This may be because underrepresented students had less prior experience in computing and math than overrepresented students. However, underrepresented students still rated course tasks as between "easy" and "difficult," demonstrating that course activities were not too difficult.

4.11 CS-0 Course Interests Students Through Focus on Creation, Process

In an open-ended question, sixty-five students described their favorite elements of the CS-0 course. One-fifth of CS-0 students stated that the opportunity to create projects was the most intriguing aspect of the course (n=14), while twelve students mentioned they enjoyed the process involved with troubleshooting and designing different technological artifacts. Students enjoyed programming (n=14), and some particularly enjoyed working in groups with peers (n=7). Eight students said they enjoyed all aspects of the course, and five appreciated the real world applications employed in CS-0.

Students listed few improvements for the introductory computing course; in fact, out of 63 item responses, the most frequent reply was "none" (n=17). Students suggested technology improvements (n=5), such as faster computers, the addition of more laboratory assignments (n=5), more assistance or easier work (n=3), and a change in textbook (n=2). A couple of students requested more group work, while another pair asked for more variety in assignments. Four students were concerned with syllabus and schedule clarifications, stating they needed more details in order to plan their semesters. Six students suggested changing the programming language to something more complex, and three students suggested more course offerings in animation topics. Ten students mentioned other concerns that were not relevant to the course. Overall, the lack of consensus suggests that the course was appealing and effective for most students.

4.12 Conclusion

Students entered the CS-0 course with limited prior experience in computing and low confidence in their programming abilities. CS-0 significantly increased students' confidence in their programming abilities and their comfort with computing. Students took great pride in their course projects and their accomplishments helped to boost their confidence. The proportion of Hispanics and women in CS-0 courses was higher than the proportion of Hispanics and women in the CS major, indicating that CS-0 may be an effective method of recruiting underrepresented students into introductory computing. However, it is too early to tell whether these students will continue in computing. CS-0 did not appear to influence students' aspirations in computing, though non-majors were more likely to express interest in a CS major at the end of the semester. Hispanics were also more likely to express an interest in graduate studies in computing than their peers. Given that CS-0 increased students interest in computer science-oriented work activities yet students' aspirations to major in computing and pursue a computing career remained flat, the course may benefit from greater discussion of computer science careers.

4.12.1 CS-0 Recommendations

- Add discussions of computer science careers and the computer science major into the course.

5 Peer Led Team Learning (PLTL): Retaining Hispanics in Computing

5.1 Who are the PLTL Students?

Forty-eight students responded to the fall 2007 PLTL course survey, representing three CAHSI institutions: UTEP, TAMU-CC, and NMSU. Half of the students are Hispanic (22 of 44 respondents, or 50%), while a slightly smaller percentage indicated they are Caucasian (19 of 44 respondents indicating ethnicity, or 43%). Three students are Asian, according to student survey results.

One fifth of the participating students are female (10 of 47 indicating gender, or 21%). This percentage reflects the gender imbalance in computer science programs nationally, where approximately 15% of computer science graduates are female.[2] Two-thirds of the responding students reported a cumulative GPA of 3.0 or above, 45% stating their GPAs are above 3.5 on a 4.0 scale. Seventy seven percent of PLTL students are computer science majors.

Nearly two thirds (66%, 31 of 46) of the students responding to this survey reported taking 0 or 1 computing course so far in their college careers. This is not surprising, as PLTL was designed to retain students early in the computer science sequence of coursework. However, seven students reported they had taken 5 or more computing courses. This data suggests that some students may be taking courses out of sequence, or repeating a course for credit.

Math experience among PLTL students was varied. More than half of the students had taken fewer than 3 math courses in their post-secondary schooling, while 10 students completed 5 or more math courses.

Almost 80% of the students attended 91-100% of the PLTL sessions. For the two courses with the most respondents (UTEP's CS 1305 and TAMUCCs CS 1401) the PLTL sessions were required, while at NMSU, the peer led tutoring was voluntary.

5.2 PLTL Benefits for Learning

Students enrolled in computer science courses implementing PLTL were asked to answer items regarding the effectiveness of the peer leading process for relaying computing concepts, explaining course material, and modeling/describing problem solving strategies. The following paragraphs describe survey results related to these themes.

According to 70% (34 of 47 pupils) of survey respondents, PLTL leaders described computing concepts well, helping students understand difficult ideas that were the building blocks necessary for understanding more advanced coursework. Twelve students disagreed with this statement, and 1 replied that he or she "did not know" if the PLTL sessions helped his or her understanding of computing concepts.

Fourteen students stated in an open-ended item that leaders' explaining computing concepts was the most influential aspect of PLTL. One student replied:

"PLTL helped me understand concepts that were foggy when I first learned them. It helped me use what I learned in class in an actual problem solving program."

Nearly three-fourths of students said that PLTL helped them learn course material (74%, 35 of 47), and one additional student said that PLTL assisted in developing problem solving skills (77%, 36 of 47).

5.2.1 PLTL builds confidence in computing

Seventy percent of students (33 of 47) said that their experience in a PLTL course increased their confidence in their computing ability, and 71% (34 of 47) agreed that their

[2] US Department of Education IPEDS database

participation in PLTL "showed (them) they could succeed in computing". In open-ended survey items, students described this idea in more detail. For example, PLTL students stated:

"PLTL has shown me the gateway into the world of computer science, and I like it."
"PLTL has shown me that I can do the stuff in class, and that I am good at what I do."
"PLTL has given me more confidence in my work, because it provides guidance on how to approach problems."
"After participating in a PLTL course, I have more confidence in myself in completing computer assignments, and I feel that I can complete the other computing courses in the future."

Peer-Led-Team-Learning was developed to increase student confidence in computing by providing near-peer role models (undergraduate students who had recently completed the course) and comfortable learning environments that encourage dialogue and peer support. Open-ended survey data supports the notion that this curriculum model works to increase student confidence.

5.2.2 PLTL leader comfort, confidence

Most of the PLTL students were comfortable asking their leaders questions about computing (73%, 35 out of 47), while nine were uncomfortable asking PLTL leaders for assistance. Similarly, 35 out of 47 students were confident that their peer leaders could help them (73%), though two students were unsure of their confidence in their peer leaders and 10 were not confident that their peer leader could assist them in their computing coursework.

In open-ended items, students described positive relationships with their leaders. They felt the leaders were especially effective because they provided an alternative perspective from the professor, and often explained concepts in different ways. For example, PLTL student participants said the following about their leaders:

"If you had a question about anything, the Peer Leaders would help you out, and then explain it so that you could understand the concept."
"PLTL helped me understand certain concepts because the leaders would explain from a different perspective."
"My peer leader showed me how to solve common errors so that I wouldn't make the same mistakes twice."
"My peer leader gave me extra help when I had trouble understanding certain concepts."

According to PLTL students, the majority felt comfortable asking their peer leaders questions about computing, and was confident in their leaders' responses. Encouraging student comfort is an effective pedagogical practice in undergraduate computing education (Eisenhart & Finkel, 1998; Waite, Jackson, & Diwan, 2003).

5.2.3 PLTL and Test preparation

The majority of students stated that their PLTL participation prepared them for tests (36 of 47, or 75% or al respondents). In addition to providing test preparation activities, PLTL may have provided an opportunity for students to get to know one another in a more relaxed course setting. Students reported meeting with other PLTL participants on their own time to study (36%, 17 out of 47). PLTL pupils described test preparation in more detail, and suggested more of these review sessions to improve the PLTL:

"PLTL sessions helped me review for tests. The leaders helped to clarify difficult and confusing topics."

"The few times we did review instead of some activity I feel that it helped."

The second quote expressed the opinions of a few PLTL students, who preferred the more structured format of a test review session, as opposed to group work and hands-on activities. More information is provided about these students in following sections of this report.

5.2.4 Influence of PLTL in pursuing additional computing courses

Twenty two students enrolled in PLTL courses said that their participation in PLTL sessions influenced their decision to take more computing courses, while 25 pupils disagreed with this statement. One possible confounding factor in this item is student major: over three quarters of students were already computer science majors, and so their PLTL course may have had little effect on their intentions to take CS courses.

Twenty of the students described how the course influenced their decisions to pursue computing. For six students, PLTL sessions helped them define computer science, understand complicated computing concepts, and discover new problem solving strategies. Eight students said that PLTL increased their confidence in their computing ability. Seven survey respondents said that the course influenced their decision to take computing courses because the PLTL sessions developed a greater interest in computing and computer programming. For example, one student stated:

"PLTL sessions promote the computer science courses because they make us feel more interested in them."

Two students found that PLTL sessions made computer science course sequences more transparent. This might be due to the fact that more advanced undergraduate students run the sessions, and in fact are only a few steps ahead of PLTL students in the sequence. This recent exposure to CS coursework might enhance PLTL leaders' abilities to make connections among courses.

5.2.5 Benefits for Hispanic students

Survey responses were compared by gender and by ethnicity, meaning that the mean values for women were compared to the mean values for men on survey items, and the mean values for Hispanic students were compared to the mean values for non-Hispanic students. Only one item showed a statistically significant difference between the groups—"My participation in the PLTL sessions increased my confidence in computing." For this item, Hispanic students had a higher mean score, indicating that Hispanic students were more likely to say that PLTL sessions increased their confidence in computing than non-Hispanic students. This is significant, as CAHSI's aim is to increase the number of Hispanics in the computing professorate. Confidence is often cited as a major factor in continuing in academic computing programs (Eisenhart & Finkel, 1998; Cohoon, 2002).

5.2.6 Dissenting Opinions: a few students prefer traditional curriculum

A review of the data showed that most items had a consistently favorable response from three quarters of the PLTL survey respondents. A closer look at the individuals completing the survey revealed that 12 individuals consistently responded negatively to survey responses. Student resistance to educational reform efforts is to be expected (Benvenuto, 2002; Dannels, Anson, Bullard, & Perretti, 2003; Henderson, Stelzer, Hsu, & Meredith, 2005; Hogg, Schau, Whittinghill, 2002; Lindham & Tahamont, 2006) By closely examining these individuals' responses, the evaluators hoped to understand why these students held negative attitudes towards PLTL.

Students were filtered from the database if they responded "strongly disagree" or "disagree" to the item "The PLTL sessions helped me understand difficult computing concepts". This item was chosen because it had the greatest number of negative responses. Twelve students responded accordingly, and their answers to all survey items analyzed separately.

Five of the dissenting students attend UTEP, six are enrolled in TAMU-CC, and one student was from NMSU. Ten of the twelve students are male, and 60% indicated they are Hispanic. When taken together, these 12 students were responsible for over 80% of all negative responses regarding PLTL sessions. This information makes it clear that PLTL was highly successful for most students, and very unsatisfactory for a small minority of students.

Survey responses indicate that this group of students had varied computing experience, as well as a large spread of GPAs. One variable that stood out was the math experience of this group of students; ten of them had taken 2 or more math courses in college. The strong math background of this group of students might suggest that these students did not need as much support as their peers. Open[HT4]-ended responses show that this group of students was more comfortable in the traditional curriculum, in which a TA might be available during lab time to answer questions, the session facilitated independent work on assignments, and which no one was encouraged to engage in hands-on activities. Students were also uncomfortable with class participation. Some quotes from this group of unsatisfied participants include:

"I believe our instructor facilitated the learning we needed during lecture by providing examples and diagrams. I felt the PLTL was simply repetitious and was not much help."

"I felt like I was back in kindergarten. The lessons were not prepared well and did not increase my knowledge, most of the time I ended up more confused. It took away time in the lab to work on actual lab assignments, which in turn put me behind in the class. They did not help me with any lab assignments, and were actually distracting. It would have been more helpful to actually get the entire lab period to work on the lab assignment and ask questions about those."

"I felt that public humiliation on the white board is not a positive way of helping a person who is clueless."

"The PLTL sessions were a waste of time, the TA is enough, peer led does not help at all, and it is uncomfortable."

The students who responded unfavorably to PLTL seem to prefer the traditional computer science curriculum, in which students complete work individually and attend lab sessions with TAs when they need assistance. They were uncomfortable with the group work and hands-on activities facilitated by peer leaders, and at least in one case saw group work as intimidating.

These perspectives are important to consider when designing PLTL activities and deciding the format of PLTL.

Best part of PLTL

"I think that the best part of the PLTL sessions was that they were always fun and exciting. I never knew what to expect each class, but I always liked the activity we did and it helped me out a lot."

Overall, students found the PLTL sessions to be fun, interesting, and helpful. PLTL leaders were able to explain and illustrate difficult computing concepts in a relaxed environment that facilitated one-on-one communication, peer interaction, and viewing computer science from an alternative perspective. PLTL participants enjoyed getting to know one another in small group activities, and appreciated learning from a student who was successful in the computing course previously. A small group of PLTL pupils were not satisfied with the PLTL sessions, perhaps because they were more comfortable with the traditional computer science curriculum.

Student Recommendations for PLTL

Only 21 students responded to this item, and five had no suggestions, as they found PLTL to be effective as it was presented. Three students suggested returning to a less structured, TA run question and answer lab period. Three requested more explicit ties between activities and laboratory assignments. While one student wanted fewer activities, another requested more activities during PLTL sessions. One student recommended a PLTL syllabus, so that students would know what to expect during their lab time. The remaining suggestions were specific to courses or individual activities (e.g. dislike of duck, duck, goose), such as faulty computers, poor scheduling of lab time, etc. Two students mentioned lack of pedagogical skill of PLTL leaders, though one respondent suggested that the PLTL leaders simply needed more teaching experience to improve their effectiveness.

5.3 PEER LEADER outcomes

5.3.1 Who are the PLTL Leaders?

Sixteen peer leaders completed the peer leader survey at the end of the fall semester in 2007. The demographic characteristics of the survey sample are as follows:

- 44% from UTEP, 44% from TAMU-CC, and 13% from CSU-DH
- 71% were male, 29% female
- 50% were seniors, 22% juniors, and 29% sophomores
- 50% were Hispanic, 29% white, and 21% Asian, not from the Indian subcontinent
- 79% had been a peer leader for 1 semester, 7% for 2 semesters, and 14% for 3 semesters

Skills

Peer leaders reported a strong increase in skills from their experience. Peer leading helped students to increase their communication, teaching, leadership, and interpersonal skills. To a lesser extent, students also increased their decision-making, and study skills. Students' reported that their peer leading experience developed their communication skills: 100% of students agreed or strongly agreed that their oral communication, teaching, and interpersonal skills increased, while 94% agreed or strongly agreed that peer leading increased their leadership skills. On the other hand, 50% agreed or strongly agreed that peer leading increased their study skills, while 56% agreed or strongly agreed that peer leading increased their decision-making skills. The highest means were also for teaching skills, interpersonal skills, oral communication, and leadership skills (3.56, 3.56, and 3.5 and 3.37 on a 4-point scale, respectively).

There were very few differences in skills gains across different groups, such as gender, institution, or race/ethnicity. However, women reported stronger gains in oral communication skills than men. Seventy-five percent of women strongly agreed that peer leading had improved their oral communication skills, while 40% of men strongly agreed with this statement. Likewise, 75% of women and 50% of men strongly agreed that peer leading increased their teaching skills. Hispanics also had slightly better gains in skills than their non-Hispanic peers, with higher percentages strongly agreeing that peer leading had improved their teaching skills (71% vs. 43%), and study skills (29% vs. 0%). Moreover, UTEP peer leaders also displayed stronger increases in gains. We will discuss this finding in detail in the section about long-term and new implementers. Peer leaders at UTEP reported stronger increases in oral communication skills (57% strongly agreed vs. 44% at other schools), and leadership skills (57% strongly agree vs. 33% at other schools.

Confidence as a peer leader

Students were generally very confident in their skills as a peer leader, particularly in their ability to help students understand concepts, to motivate students, and to effectively communicate (87%, 100%, and 100% agreed or strongly agreed with these statements, respectively). Students also reported that they generally facilitate PLTL sessions effectively (94% agreed or strongly agreed). Similarly, students also disagreed that they were uncomfortable addressing students' questions (75% disagreed or strongly disagreed). Peer leaders also felt that their hard work and effort with students paid off: 75% disagreed or strongly disagreed that "When I put more effort into my PLTL sessions, I see little change in students' achievement." Therefore, peer leaders were highly confident that they could help students and that they were effective in their role as peer leaders.

On the other hand, there was less agreement among peer leaders that they "often think of better ways to facilitate PLTL sessions" (69% agreed or strongly agreed). The only area in which peer leaders expressed uncertainty was the item, "I question whether I have the skills necessary to effectively facilitate PLTL (44% agreed or strongly agreed). Students' relative uncertainty over their skills stands in contrast to their strong agreement that they are confident in their ability to motivate students and to help students understand computing concepts.

There were some group differences among the peer leaders. As might be expected, students who had been peer leaders for more than one semester had better outcomes than first-time peer leaders. For instance, 100% of the students who disagreed that "I often think of better ways to facilitate PLTL sessions" were new peer leaders. All veteran peer leaders agreed or strongly agreed with this statement, indicating that experience helps peer leaders to feel more effective in their role. Institutions that had implemented PLTL for several years, such as UTEP, also had better outcomes than new adopters, such as TAMU-CC and CSU-DH. For example, 14% of UTEP students disagreed that they "often think of better ways to facilitate PLTL," while 44% of students from institutions that had recently adopted PLTL disagreed with this statement. Again, long-term implementation may lead to more experienced and effective peer leaders.

While there were not many gender or ethnic differences, there are some indications that women and Hispanics had higher confidence in their abilities as a peer leader. For example, 100% of women agreed or strongly agreed that they often think of better ways to facilitate PLTL, while 60% of men agreed or strongly agreed with this statement. Likewise, 100% of Hispanics agreed or strongly agreed with that statement, while 57% of Whites and Asians agreed or strongly agreed. Moreover, 57% of Hispanics strongly agreed that "I generally facilitate PLTL sessions effectively" while 0% of white and Asians strongly agreed with this statement. These results indicate that women and Hispanics have higher confidence in their abilities and effectiveness as a peer leader, suggesting that the experience of being a peer leader is highly positive for members of underrepresented groups in computing.

5.3.2 Aspirations

Students' experiences as peer leaders also increased their aspirations to have a computing career and, to a lesser extent, their aspirations to attend graduate school in computing. Most peer leaders (87%) agreed or strongly agreed that their "role as a PLTL leader has increased my interest in a computing career." The mean on this item was 3.44 on a 4-point scale, with 1=strongly disagree and 4=strongly agree. Therefore, peer leading helped to increase students' interest in a career involving technology and computing.

To a lesser extent, students' (29%) reported that their experience as a peer leader influenced their aspirations to go to graduate school. In an open-ended question, students were asked to explain the influence of their experience as a peer leader on their intentions to go to graduate school. The primary reason (75% of positive responses) that peer leading had influenced students to go to graduate school was the boost in confidence and knowledge that they received from being a peer leader. A smaller portion of responses (25%) stated that peer leading had made students consider the professoriate for a career. Peer leaders wrote:

"My experience as a peer leader has some influence on me to go to graduate school by that being a PLTL Leader has helped me reaffirm my knowledge and confidence in the subject."

"The program shows that I can excel at computer science, because when I first started out I knew nothing about programming, now I am helping others!"

Although the majority of students disagreed that peer leading had influenced their decision to attend graduate school, many of those who disagreed with this statement (57%) reported that they were already planning to go to graduate school. A student wrote:

"I was thinking to attend graduate school before being a peer leader, so I can't say that being a peer leader influenced me."

The remainder of students who stated that peer leading had not influenced them to go to graduate school (43%) reported that they planned to get a job in computing directly after graduation. However, it is notable that all of these students expressed an intention to go to graduate school after several years of work.

"I had never really planned on attending graduate school right away. I had always planned to go to graduate school after getting a good job after graduating with an undergraduate degree."

"The reason this has not had an influence on my choice to go to graduate school is because I would like to obtain my Bachelor's degree and start working before I decide to return to school."

There was not a single peer leader who had completely ruled out the possibility of graduate school. Moreover, peer leading clearly influenced some students to consider graduate school as an option because of the increase in confidence they received from their experience. The opportunity to teach and help other students strengthened their conceptual knowledge and increased their confidence that they could succeed in graduate school.

A greater number of students (43%) reported that peer leading had influenced their thoughts and impressions about being a computer science professor. Half of students who reported that they are more interested in becoming a professor stated that peer leading had increased their interest in teaching. The other half of students simply stated that peer leading had helped them to realize that there are some similar aspects between peer leading and being a professor. However, several of the students who became more interested in teaching were still somewhat uncertain about graduate school. A student who became more interested in teaching from peer leading wrote:

"I discovered I would like to teach actually, but I'm not sure if I would go all the way to PhD."

Other students expressed increased interest in being a computer science professor, yet were still uncertain whether this was the right career path for them.

"It has had an influence because at first becoming a computer science professor did not appeal to me as much as it does now. Teaching others can be a rewarding job, but I don't think that becoming a computer science professor is right for me."

While close to half of students reported that peer leading had increased their interest in the professoriate, students' statements generally expressed uncertainty over the career path.

A slim majority of students (57%) expressed that peer leading had not influenced their thoughts of becoming a computer science professor. These students often reported that they had never considered the professoriate as a career option. Many of these students also stated that it was rewarding to work with students, though they did not aspire to become a professor.

"I really don't have any intention of becoming a professor, however it is a good feeling to know that you are helping students succeed."

Peer leading had the strongest influence on students' general interest in a computing career and a lesser degree of influence on students' aspirations to attend graduate school or enter the professoriate.

There were also several group differences in peer leaders' responses about career and graduate school aspirations. Sophomores and juniors experienced a greater influence in their interest in a computing career than seniors. For instance, 75% of sophomores, 100% of juniors, yet only 29% of seniors strongly agreed that peer leading had increased their interest in a computing career. Sophomores and juniors may be more open to influences on their career path as they may be less likely than seniors to have a definite career choice. Sophomores also experienced a greater influence on their graduate school aspirations. Half of sophomores asserted that peer leading had positively influenced their decision to attend graduate school, while 33% of juniors agreed and 14% of seniors. These findings indicate that it may be more beneficial for students to start peer leading as sophomores, if possible, or juniors. The experience may be more likely to influence their graduate school aspirations and career ambitions as seniors may be more set in their plans than sophomores or juniors.

Peer leading also appears to have a more positive influence on the aspirations of women and Hispanics. For instance, 75% of women and 50% of men strongly agreed that being a peer leader increased their interest in a computer career. Moreover, all of the women peer leaders agreed or strongly agreed with this statement, indicating that peer leading may be a successful way to advance women into computing careers. However, there were no gender differences in the influence of peer leading on aspirations to go graduate school. Peer leading has also had a positive impact on the aspirations of Hispanic students, particularly on their graduate school ambitions. For example, 43% of Hispanic students reported that peer leading had positively influenced their decision to go to graduate school in computing, while only 14% of whites and Asians reported the same. Again, Whites and Asians were more likely to already have plans to attend graduate school, while peer leading helped to increase the confidence of Hispanic students that they could be successful graduate students. These findings indicate that peer leading may be an effective recruiting and retention tool to increase the interest of underrepresented students in graduate school and careers in computing.

5.3.3 Beliefs about PLTL and its effectiveness

Peer leaders overwhelmingly believed that PLTL is an "effective way to teach students with little background in computing" (100% agreed or strongly agreed with this statement). In an open-ended question, students were also asked to describe their role as a peer leader. The majority of students' (66%) described their role as a facilitator or guide, rather than a teacher.

"As a peer leader, I specifically design a lesson plan using cooperative learning and try to focus on the topics that the students are having trouble with. My job is not to teach, but to get the students to teach each other and work together smoothly."

"I would describe my role as a peer leader as someone who does not necessarily teach students, but rather helps a group of people learn through a different method than lecturing."

The remainder of the responses emphasized the types of activities that peer leaders facilitate, such as active or cooperative learning.

"The role of a Peer leader is to emphasize and reinforce the topics of a class or lecture. This should be done using non-traditional ways of teaching such as active group activities."

Therefore, peer leaders strongly believed in their roles as facilitators, rather than teachers. Peer leaders were also strong advocates of non-traditional teaching methods, such as active and cooperative learning.

In keeping with students' beliefs about their roles as peer leaders, students emphasized that the most effective pedagogical strategies were active learning methods (43% of responses), encouraging collaboration and teamwork among students (36%), and maintaining strong communication with students and other peer leaders (21%). Peer leaders asserted that students become more engaged through active learning methods, particularly games or competitions.

"To motivate them I got creative. I did a small video game, in which while you played, you were challenged by the CS review concepts, also it was a parody of CS life, and it turned out to be a great hit. Also, my class this semester was the first CS class, so it was very useful to show them how what they were learning applied later on to harder examples. And last but not least, I encouraged competition and teamwork by doing small contests."

Peer leaders also found that encouraging collaboration among students helped students to help each other, allowing the peer leader more time to attend to students who need the most assistance.

"The most important thing I have encountered in peer leading is to maintain a good rapport with the students. This encourages the students to work together and to ask me questions when they need help."

Peer leaders also stressed the importance of communication among students, and also among peer leaders and the course instructor. Peer leaders found planning and problem-solving sessions to be very helpful.

"Communication with students, professor, and other peer leaders have been very useful. After each week getting feedback about what we did and what we are going to do helps."

Peer leaders noted that collaboration with the course instructor was essential for success. Peer leaders were asked how they would improve their collaboration with the course instructor. A little more than one-third of students (36%) reported that they would like more meetings with the PLTL professor.

"Keep meeting with them. One meeting a week is not enough."

Overall, peer leaders emphasized that techniques that encourage active learning and collaboration were most helpful to them in their role as peer leader. They also reported that building a good rapport with students and working closely with other peer leaders and faculty were strategies that contributed to their success.

5.3.4 Knowledge of computing concepts

While peer leading increased students' skills and confidence, there was the greatest consensus among students that being a peer leader enhanced their disciplinary and conceptual knowledge. As mentioned previously, in part, peer leaders' augmented knowledge contributed to the confidence that increased their motivation to attend graduate school. There was strong consensus that "leading PLTL has increased my computing knowledge" and that "I understand computing concepts well enough to be an effective peer leader" (100% of peer leaders agreed or strongly agreed with these statements). Moreover, peer leaders also reported "I am typically able to answer students' computing questions" (94% agreed or strongly agreed).

Just as peer leading had a greater impact on the career and graduate school aspirations of sophomores and juniors, these students also gained greater conceptual knowledge. For instance, 100% of sophomores strongly agreed that "Leading PLTL has increased my computing knowledge," while 66% of juniors and 43% of seniors strongly agreed. Sophomores are newer to the discipline and have more to learn and, therefore, may gain greater knowledge from their experience as a peer leader. Likewise, gains in knowledge were greater at UTEP, an early adopter or PLTL, than at TAMU-CC or CSU-DH, which had recently adopted PLTL. For example, 86% of peer leaders at UTEP strongly agreed that "leading PLTL has increased my computing knowledge," while 44% of peer leaders at TAMU-CC and CSU-DH strongly agreed with this statement. Again, this indicates that peer leaders at early adopting institutions make greater gains than peer leaders at new adopters. Students with more peer leading experience, overall, were more likely to agree that PLTL had increased their disciplinary knowledge than students with only one semester of experience.

Women and Hispanics also benefited from the strengthening and reinforcing of knowledge that comes from peer leading. Women demonstrated greater increases in computing knowledge from peer leading, but also demonstrated less confidence than men in the depth of their understanding. For instance, 100% of women strongly agreed that "leading PLTL has increased my computing knowledge," while only 50% of men strongly agreed with this statement. On the other hand, 70% of men strongly agreed that "I understand computing concepts well enough to be an effective leader" but 50% of women strongly agreed. Finally, half as many women as men (50% of men and 25% of women) strongly agreed "I am confident in my ability to help students understand computing concepts." Therefore, women report that being a peer leader increased their knowledge to a greater extent than men; however, they also display less confidence than men in the extent of their knowledge and abilities.

Hispanics also had strong increases in computing knowledge. However, unlike women, they also demonstrated greater confidence than Whites and Asians. For instance, 71% of Hispanics strongly agreed that "I am typically able to answer students' computing questions," while 14% of Whites and Asians strongly agreed with this statement. Further, 100% of Hispanics strongly agreed that "I am confident in my ability to help students understand computing concepts," while 71% of Whites and Asians strongly agreed with this statement. Therefore, being a peer leader appears to increase Hispanics students' knowledge and confidence in the discipline.

5.3.5 PLTL Training

In an open-ended question, students were asked what their peer leader training lacked. The most common answer (42% of responses) was training on how create activities and come up with ideas for PLTL sessions. In line with this response, peer leaders (25% of responses) also indicated that they would like greater access to resources, such as books, that might help them in their role as peer leader.

"The training lacked the ability to teach the peer leaders how to come up with effective peer sessions. I think the training needed more emphasis on how to approach a topic rather

than give random samples. This way the peer leaders would be able to come up with activities in a more structured manner.”

“I didn't feel like I learned much about the process of creating an activity for the students. I felt that I was kind of just thrown in the midst of things and expected what to do without much practicing.”

Students also requested resources or examples of techniques and activities from existing programs.

“The actual training on activities, we were taught what they were suppose to do but not how to come up with good ideas, maybe examples from an existing program would have helped.”

However, it should be noted that almost all of the peer leaders were confident in their skills by the end of the semester. In fact, 94% of peer leaders agreed or strongly agreed that they “generally facilitate PLTL sessions effectively.”

To a lesser extent, peer leaders (17% of responses) also requested more training on techniques to motivate students.

“Probably more [training on ways to] motivate students for the last sessions.”

“One thing my PLTL training lacked was some sort of instruction on how to motivate students.”

However, peer leaders did learn how to motivate students over the course of the semester through their actual, hands-on work with students. At the end of the semester, 100% of peer leaders agreed or strongly agreed that they were confident in their ability to motivate students.

A few responses also referenced ways to assess student learning and time management strategies for PLTL sessions (8% each).

“The training did not provide adequate ways to determine how to gauge the students' understanding of concepts being taught.”

“Time management.... there are so many topics to cover in the workshops that I don't have time to address all the questions and material.”

Overall, peer leaders reported that their training should provide more instruction on how to create activities for students and more real-life examples of PLTL activities and motivational strategies.

5.3.6 Challenges of being a peer leader

Students were also asked about the greatest challenge of being a peer leader. In keeping with peer leaders’ statements about their training, peer leaders reported that their greatest challenges were creating activities for PLTL sessions and motivating students (40% of responses each).

“The main challenge is trying to come up with effective sessions. Every student has a different type of learning style and also learn on different levels. So trying to keep the sessions so everyone is learning is sometimes hard.”

"Coming up with activities that will keep the students active and want to attend their peer leading sessions (was challenging)."

Peer leaders also stated that motivating students was a challenge.

"Keeping the class interested. Some of the guys in the class have already programming skills... It is difficult to maintain a class interested when some of them already know everything, and some are struggling."

"My greatest challenge as a peer leader is to get students who don't want to participate to participate."

Peer leaders also reported that evaluating their effectiveness a peer leader was challenging (10% of responses).

"My greatest challenge is gauging my performance as a peer leader. It is difficult to read the students' faces to determine how well they are understanding me."

Some peer leaders also asserted that it was difficult to help students to "think like a programmer" (10% of responses). In other words, peer leaders had difficulty in helping students to correctly apply the concepts they had learned in class.

"My greatest challenge as a Peer Leader has been trying to get my fellow peers thinking like a computer programmer. My fellow peers seem to get the topics of the class, but I am unsure that they understand how to use them correctly."

5.4 Conclusion and Recommendations

Peer-Led-Team-Learning was developed to increase student confidence in computing by providing near-peer role models. Sessions were informal and involved group work to develop relationships among students in the course, said to influence student persistence in the major. Overall, students found the PLTL sessions to be fun, interesting, and helpful. Students, particularly Hispanic students, gained confidence in their computing abilities through PLTL sessions, and leaders reported confidence gains as well.

5.4.1 PLTL Recommendations

- Describe the purposes of PLTL to students- traditional students view them as ineffectual and may miss the point of the sessions
- Add training elements that introduce pedagogical decision-making and planning, so that lessons are geared to students' reaching academic benchmarks
- Planning sessions to closely tie with lab assignments, and creating a syllabus for PLTL will ensure that students see the relevance of PLTL activities to the computing subject matter

6 Affinity Research Groups (ARG): Retaining and Advancing Hispanics in Computing

The Affinity Research Group (ARG) model allows faculty to manage or mentor a large group of students, rather than the traditional one-on-one apprenticeship model of undergraduate research. The ARG model encourages the development of the knowledge and skills necessary for computer science research and for effective collaboration among the research group. The ARG model is based on fundamental group collaboration components:

1) An annual orientation to integrate new students into the research group;
2) A research project framework to link project goals to student tasks;
3) Defined deliverables to ensure individual accountability and progress toward project goals;
4) Skill-oriented monthly meetings that focus on collaboration, group skills, and critical thinking skills;
5) Weekly meetings to report progress, problem-solve, and discuss research, and
6) Outreach activities to encourage personal development and contributions to the community (Teller & Gates, 2001).

Affinity research groups are designed to improve the retention and advancement of both undergraduate and graduate students. Given that the doctoral graduation rate of Hispanic students in computer science in 2007 for the entire country was seventeen students, the involvement of graduate students as research participants themselves and as mentors to undergraduate students is particularly important.

The research literature, however, has not documented the benefits to graduate students of engagement in research groups such as ARGs. On the other hand, the literature on undergraduate research has demonstrated numerous benefits to students. Among the educational and career gains identified in the literature are increased interest in science careers (Bauer & Bennett, 2003; Russell, 2005; Zydney, Bennett, Shahid, & Bauer, 2002), particularly for underrepresented groups (Nagda, Gregerman, Jonides, von Hippel & Lerner, 1998); greater awareness of career options (Ward, Bennett & Bauer, 2002); and enhanced preparation for graduate school (Alexander, Foertsch & Daffinrud, 1998; Merkel, 2001; Russell, 2005). Although our previous research on UR has demonstrated that UR participation serves to confirm or clarify pre-existing career and educational goals (Hunter et al., 2007; Seymour et al., 2007), other studies have reported that participation in UR increases the likelihood that students will pursue graduate school (Bauer & Bennett, 2003; Kremer & Bringle, 1990; Russell, 2005). A large-scale study of undergraduate research at multiple institutions (Hathaway, Nagda, & Gregerman, 2002) demonstrated that undergraduate research is particularly effective in increasing minority students' aspirations to attend graduate school. Undergraduate research has also been argued to increase graduation rates (Kim, Rhoades, & Woodard, 2003, Nagda et al, 1998), and retention in the major (Nagda et al., 1998).

Recent research on UR has also begun to demonstrate the cognitive, personal and professional benefits of participation. Our research on UR has been the only empirical study to document increases in students' understanding of the nature of scientific knowledge (Hunter et al, 2007; Seymour et al, 2004). Also documented in our previous research and corroborated by other studies are increases in students' communication skills (Bauer & Bennett, 2003; Kardash, 2000; Ward, Bennett & Bauer, 2002), technical and laboratory skills (Ward, Bennett & Bauer, 2002; Lapatto, 2004), teamwork skills (Ward, Bennett & Bauer,2002), critical thinking and scientific analysis skills (Bauer & Bennett, 2003; Ishiyama, 2002; Merkel, 2001) and scientific research skills (Kardash, 2000; Lapatto, 2004). Through UR, students begin to take greater initiative and responsibility for their own learning (Bauer & Bennett, 2003; Ishiyama, 2002; Lapatto, 2004; Rauckhorst,2001; Ward, Bennett & Bauer, 2002) and boost their confidence in themselves as learners (Merkel, 2001; Rauckhorst, 2001; Russell, 2005, Ward, Bennett & Bauer, 2002).

The CAHSI evaluation team will collect data on Affinity Research Groups in the spring of 2008 to capture ARG students' experience after a complete school year of ARG participation. The student survey will assess the impact of the research experience on participants' educational and career aspirations, scientific thinking and problem-solving skills, research skills, confidence, and communication and teamwork skills.

7 Professional Development: Advancing Hispanics in Computing

7.1.1 Overview

Three workshops were held at the second annual CAHSI meeting. Professor Nayda Santiago from the University of Puerto Rico—Mayaguez led the first Saturday workshop, in which participants learned about the computer science research process, including the importance of publishing results, conceptualizing research topics, and developing strategies for collaboration. On Saturday afternoon, Elsa Villa and Ann Gates from the University of Texas at El Paso led 25 participants in a research workshop designed to articulate and illustrate the ARG model of research participation. The Sunday workshop led by Florida International University's Professor Irma Becerra engaged graduate students and professors in a lecture about young faculty success strategies.

7.1.2 Workshop participants from various computer science career stages

The largest workshop served 25 undergraduate students, graduate students, professors, and researchers. Participants were predominantly Latino/a. Many of the participants attended multiple workshop sessions. Those attending workshops were motivated to learn about research, develop a system for managing research, and meet peers in computing. Many were attending because they were recommended to attend, or because they were involved in CAHSI-related programs or interventions.

7.1.3 Similar Workshop Experiences

A small portion of attendees had received similar training at other venues, though most said the training was less complete. Those receiving formal training in similar topics did so through CAHSI, their home institutions, National Science Foundation-sponsored events, Computing Research Alliance-Women, and the National GEM Consortium.

7.1.4 Participants found workshops engaging & relevant to profession

Nearly all participants found the workshop to be clearly presented (69%, 96%, & 94%)[3], of good length (76%, 88%, & 88%), set at a reasonable pace (76%, 80%, & 75%), and well organized (76%, 84%, & 94%). A great share of participants would recommend the workshops to colleagues (76%, 96%, & 88%). Overall, most participants rated the workshops as better than

[3] Percentages listed represent responses from workshops 1,2, and 3, respectively. There were 17, 25, and 16 survey respondents for the CAHSI workshops

average (53%, 84%, & 75%). Overall, participants reported that the workshops met their expectations (88%, 92%, & 88%).

Students believed the workshops were relevant to their graduate studies (88%, 95%, & 56%), and nearly all participants said the topics were relevant to his or her career (94%, 92%, & 88%), and that they would use the ideas from these workshops in their professional lives (94%, 96%, & 100%). The amount of workshop resources was satisfying to CAHSI participants as well (76%, 92%, & 88%).

7.1.5 Developing research knowledge: Pre and Post Survey Responses

The first presenter requested a pre-post survey design for her workshop, in order to evaluate the participants' developing understanding regarding research process, publishing, and collaboration. The following questions were asked of participants immediately before the workshop and again immediately after the workshop concluded:

- What is systematic research in computer science? What does it "look like"?
- Please describe the research process in computer science. What stages does a researcher complete? What is an appropriate timeframe for research?
- Why is academic publishing so important in CS?
- How might computer scientists collaborate in research?

The following sections describe the results of these pre and post survey parallel items, employed to determine if participants changed their perceptions about computer science research.

7.1.6 What is the computer science systematic research process?

Fourteen participants responded to the pre survey, and seventeen filled out the post survey. On the pre survey, four students restated the question about research (e.g. "a step by step process"), three replied that they did not know the research process, and three more left the item blank. Those who completed the item described the research process as a way to advance the field of computing, a continuous effort, in which researchers evaluate a topic or question and determine an approach that would address the problem. Four respondents gave very complete answers to this item, mentioning the evaluation of a topic, determining a research approach, practicing the approach and analyzing results, and disseminating results. Three of them described the timeframe as fluid, or subject to change based on research iteration. Those with the most complete answers were: a male Hispanic lecturer, a female Hispanic graduate student, a male Hispanic graduate student, and a male Hispanic undergraduate research fellow. For example, one participant wrote:

"The research process consists of idea identification, review of related literature, development of algorithms/ experiments/ simulation strategies etc. analysis of results, conclusions, paper writing, and publication timeframe depends on research goals."

Following the workshop, there were many detailed responses to this portion of the survey, though five did not respond at all. Those who did respond wrote "the scientific method" (4), or wrote out specific steps (e.g. "idea, method, collect data, analyze data, prove belief from data analysis") (7). Three individuals referenced visual elements of the workshop, such as the concept map activity, a figure with arrows depicting direction, and the "waterfall" diagram. One participant wrote:

"(The computer science research process consists of) identifying the problem, reading to find out how other approaches have been made in order to compare, establish an hypothesis, design experiment, collect data, validate and analyzing results."

7.1.7 Publishing in computer science

Sharing knowledge (4), advancing the computer science field (5), avoiding repetition (3), and garnering prestige or credit for work (3) were reasons participants listed for publishing research in computer science before the workshop commenced.

Following the workshop, six participants listed both sharing knowledge and avoiding repetition as reasons for publishing in computer science, showing a developing consensus around the topic. In all, eight of the seventeen participants listed avoiding repetition of efforts as a reason to publish, and nine responded that publishing is a method for sharing knowledge. Other responses included collaboration possibilities, funding requirements, and prestige as incentives to publish research results. Three did not respond to this item in the post survey.

7.1.8 Collaboration in research

Before the workshop, participants found sharing knowledge (5) and forming interdisciplinary teams (4) the most promising ways to collaborate in computer science research. Participants also said that publishing together and sharing code, analyzing one another's written work, and using collaborative technologies such as wikis and email were ways they could collaborate with colleagues.

Following the workshop, respondents knew a variety ways by which they could collaborate with colleagues. The most remarkable change in responses involved the transformation for many from post-hoc collaboration (at the level of publishing) to a collaborative research effort, in which colleagues gathered data together (8) as well as published in teams (3). Participants maintained the notion of sharing knowledge as a means to collaborate (5), particularly in multidisciplinary teams (3) and using collaborative technologies (2). Three workshop audience members mentioned the need to network at conferences to develop collaborative relationships with peers.

7.1.9 Recommendations= more interaction, personal stories, multimedia

CAHSI workshop attendees recommend that workshop facilitators include more time for interaction among colleagues so that students and faculty have an opportunity to learn from each other and to establish relationships across campuses. Providing multimedia presentations that engage different kinds of learners in the subject matter would increase workshop effectiveness, according to workshop participants. Continuing to offer personal examples of careers and of research projects, as well as supplying information about professional experiences will enhance the relevance and usefulness of future workshops.

7.1.10 Workshops help CAHSI members reach professional goals

Workshop contributors planned to incorporate their newfound knowledge about research and academic career success into their daily practice. This finding was evident for undergraduate, graduate, and faculty. Participants said:

"(My involvement in this workshop) will help me establish my goals, plan each stage of my research carefully, and help me to be organized throughout each stage of the research (process)."

"The concept map exercise was very good. It helped me put my ideas on paper. I will continue refining my concept map as I advance in my research."

7.1.11 Online audiences- leveraging the workshop virtually

CAHSI workshop participants thought that the workshop could be featured online in several ways. They envisioned short video clips of presentations and interactions, podcasts, print materials, power point slides, blogs and wikis associated with ARG concepts available on the CAHSI website. One participant suggested "an animation explaining the flow of ideas behind the ARG model", and another suggested a Frequently Asked Questions document that would be accessible online.

One workshop participant expressed concern regarding online materials. He wrote:

"These types of workshops are usually best when there is personal interaction. I'm not sure if an online version of this would help."

CAHSI leaders and evaluators may need to clarify during workshops and in the survey questions that other presenters as well as potential online viewer/participants could use these electronically posted materials.

7.1.12 Conclusions

Overall, professional development workshops gave undergraduate and graduate students as well as junior faculty a window into professional computing practice. Participants were able to learn the "inside story" from workshop providers, which was helpful in planning career paths. The majority of participants viewed workshops as relevant to their careers and educational programs, and could see ample applications for the knowledge they received at the CAHSI annual meeting.

8 Appendix 1

8.1.1 EVALUATION METHODS

Evaluation methods include observation, interviews (individual and group), surveys, and participation in Alliance meetings. Qualitative data support more nuanced interpretation of survey results. Participation in Alliance meetings allows evaluators to better understand goals and processes and permits sharing of findings from social science and educational research and from other projects the evaluators have contact with.

8.1.1.1 CS-0

The primary source of evaluation data for CS-0 was a pre-post student survey. In consultation with project P.I's, the instrument was adapted from a survey originally designed by Mark Guzdial at Georgia Tech University. The revised CAHSI survey explores student attitudes and beliefs about computing upon entry into the course and after completion. The survey also assesses students' prior experience with computing and mathematics to determine whether students' background influences their comfort level or confidence in computing. The survey was administered at the beginning and end of the semester in Fall, 2007 at the five CAHSI institutions with a CS-0 course: University of Texas, El Paso; Texas A&M, Corpus Christi; New Mexico State University; California State University-Dominguez Hills; and University of Houston, Downtown.

All CS-0 students were invited to complete the survey at the beginning and end of the semester. The survey was distributed online and a link was sent to institution P.I.'s to send to CS-0 instructors. The response rate was larger for the pre-survey than the post-survey: 161 students completed the pre-survey, yet only 81 students completed the post-survey. Survey items were quantified on a 4-point likert scale. Negatively worded items (e.g. "computing is boring") were reversed so that all items were coded in the same direction. Demographic characteristics of survey participants are discussed later in the report.

The CS-0 survey consisted of several scales, or groups of items that represent specific domains. There were four scales on the CS-0 survey: the "computer science work" scale, the "attitudes and beliefs" scale, the "self-assessment of learning" scale, and the "difficulty of course tasks" scale. The "work" scale assessed students' attitudes toward computer science-oriented work tasks, such as analyzing the principles underlying a problem, and constructing and completing a project. The "attitudes and beliefs" scale was composed of items that assessed students' confidence in math and computing, attitudes toward computer science, and beliefs about computing. The "self-assessment of learning" scale asked students' to rate the aspects of the course that helped their learning, and the "difficulty of course tasks" scale asked students' to rate the difficulty of course tasks, such as homework, labs, and midterm and final exams.

A second source of data about CS-0 is a database that tracks student outcomes from CS-0 courses. We have worked with the institutional research office at each school to get student data from the CSO courses. We are tracking CS-0 students by their student number and will be able to determine which students went on to take CS1 or other CS/CE courses. These data will be available at a later date as it is still too early to determine the impact of CS-0 on student retention and advancement in the major.

We have conducted individual interviews with institutional leads of the CAHSI project to determine how CS-0 is being implemented at each school. We also conducted course observations and student focus group interviews during our site visits to University of Texas, El Paso and New Mexico State University during Fall, 2007.

8.1.1.2 PLTL

The primary mode of data collection for PLTL courses was surveys of students in PLTL courses and PLTL leaders. The peer leader survey was adapted from the Science Teaching Efficacy Belief Instrument (STEBI) developed by Riggs and Knochs (1990). Because the instrument was originally designed for pre-service elementary teachers, the items had to be revised to better fit the undergraduate classroom and the role of peer leaders as guides and tutors, not teachers. The peer leader survey assessed peer leaders' beliefs about their role, and the influence of their peer leader experience on their aspirations and skill development. The survey for students in PLTL courses was adapted by UTEP, and later revised by the evaluation team, from a survey developed by the City University of New York. The instrument assessed the quality of the peer leading sessions and its impact on student confidence. All students in PLTL courses and peer leaders were asked to complete the evaluation surveys. Links to the online surveys were sent to CAHSI P.I.s at the end of the semester to distribute to peer leaders and PLTL instructors. We received 47 responses from students in PLTL courses and 17 survey responses from peer leaders. Survey items were quantified on a 4-point likert scale. Negatively worded items were reversed so that all items were coded in the same direction. Demographic characteristics of participants will be discussed later in the report.

8.1.1.3 Affinity Research Groups

As many Affinity Research Group participants conduct research throughout the academic year, we will distribute a survey at the end of the spring semester to undergraduate research (UR) participants. The survey will assess the impact of the research experience on students' educational and career aspirations, scientific thinking and problem-solving abilities, research skills, confidence, and communication and teamwork skills. The survey is based on the benefits to students demonstrated from the research literature on UR. Most of the recent research on UR has focused on educational and career outcomes and has demonstrated particularly positive outcomes for underrepresented students.

8.1.1.4 Development workshops

Workshop surveys were distributed to all workshop attendees at the 2007 CAHSI annual meeting, leading to analysis of between 15 and 25 surveys per workshop. The surveys assessed the overall quality and effectiveness of the workshops and their impact on participants' personal and professional development. Professor Nayda Santiago from the University of Puerto Rico—Mayaguez led the first Saturday workshop, in which participants learned about the computer science research process, including the importance of publishing results, conceptualizing research topics, and developing strategies for collaboration. On Saturday afternoon, Elsa Villa and Ann Gates from the University of Texas at El Paso led 25 participants in a research workshop designed to articulate and illustrate the ARG model of research participation. The Sunday workshop led by Florida International University's Professor Irma Becerra engaged graduate students and professors in a lecture about young faculty success strategies.

8.1.1.5 Alliance Partnership

The Alliance Partnership was investigated through interviews with CAHSI PIs in the summer and fall of 2007. We conducted five interviews with institutional leads. The interviews explored the communication strategies utilized by the alliance, as well as CAHSI accomplishments and challenges.

8.1.2 Analysis methods

The quantitative data were entered into the statistical package SPSS where descriptive statistics were computed. Means, standard deviations, and frequencies are reported. To test for statistically significant differences among various subgroups of the sample, t-tests, one-way analysis of variance (ANOVA), and repeated measures tests were used. One-way ANOVA is used to test for statistical differences among three or more groups. Repeated measures ANOVA and paired samples t-tests are used for pre-post samples.

Because we rely on t-tests and ANOVA statistics in our discussion of group differences, we discuss here the meaning of these tests. We conducted paired sample t-tests and ANOVA tests of repeated measures, comparing means to determine differences between sample means (e.g. women) against the overall population mean on pre-post tests. T-tests are appropriate for cases when there are two independent variables (e.g. male and female, white and non-white). ANOVA tests are used to compare means among three or more groups, such as institutions or ethnicity. The t-test and ANOVA test calculate the probability that the difference between the group means is caused by chance or random variation within a population.

These tests are simple ratios. For example, in a t-test, the numerator of the ratio is the difference between the two sample means (e.g. female mean-male mean) and the denominator is the standard error. A "t-value" is determined from the ratio, or "F" value in the case of ANOVA. The sample size is also needed to determine significance. "Degrees of freedom" represents the total number of sample participants minus one (N-1). Finally, we must determine an alpha level, or a level of significance. In social science, a probability of less than 0.05 ($p<0.05$) is generally accepted as indicating a statistically significant difference. In other words, we have only a 5% chance that there is not a real difference between the groups.

Write-in responses to open-ended survey questions were entered into a spreadsheet and coded as follows. Each new idea raised in a response was given a unique code name. As these same ideas were raised by later respondents, a tally was added to an existing code reflecting that idea. At times the write-in answers were brief and counted within one category, but more frequently, responses contained ideas that fit under multiple categories, and these were coded separately. For instance, students may have listed more than one favorite element about the CS-0 course (e.g., completing a course project and working in a group), and these were each counted.

8.1.3 Reliability and Validity of surveys

We also conducted reliability tests for the CS-0 survey scales, though we did not conduct validity analyses due to the limited sample size. We also did not conduct reliability analyses for the PLTL surveys or development workshop surveys, because those surveys did not contain scale items upon which to conduct analyses.

We utilized the statistical test, Cronbach's alpha, to conduct reliability analysis. Cronbach's alpha is a coefficient of consistency that reflects whether answers to the separate items within the scale are the same—and thus measure some common construct consistently. Values near 1 mean the scale is internally consistent; values near zero mean the scale is not. Generally, in social science research, a measurement of 0.7 for Cronbach's alpha is acceptable. Cronbach's alpha for the "computer science work" scale was .892, the "attitudes and beliefs scale" was .726, [4]the "self-assessment of learning" scale was .875, and the "difficulty of course tasks scale" was .776. As the high values of Cronbach's alpha show for all scales, the internal consistency of the scales on the CS-0 survey was very high. However, while a highly valid survey item will also be reliable, the converse is not true. A survey can be reliable without being valid—and its results are not necessarily meaningful if that is the case.

However, the samples in this study were not large enough to conduct other types of statistical validity studies (such as factor analysis). Another type of validity measure is "construct validity." Construct validity is the type of validity that ensures that what you think you are asking about is really what you are asking about—that the respondent understands the construct being probed in the same way as does the surveyor. Some degree of construct validity was achieved for the CS-0 and PLTL surveys by grounding them in previously developed instruments and adapting them in consultation with institutional leads. Nevertheless, better

[4] The item, "computing is boring," did not "fit" well with the scale and was removed from the analysis of scale items on the "attitudes and beliefs".

degrees of construct validity would be achieved through studies such as a think-aloud interview with the survey respondent to understand what the student thought the question was about, why the student answered the question the way (s)he did, and whether it was the type of answer the survey designer intended.

9 Appendix B

9.1 References

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