Comparisons of More Applied Information Technology and Computer Science Undergraduates

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ABSTRACT

This paper presents a comparison study between undergraduates in the areas of applied information technology and those in computer science. A large, nationwide survey involving undergraduates from 42 institutions of higher education was conducted in Fall 2004. Basic demographical data and responses to survey questions dealing with behaviors, beliefs, and perceptions were collected. Underpinning the investigation was the question of the influence of gender, ethnicity, and university type (Historically Black Colleges and Universities or Predominantly White Institutions). Responses to survey items were statistically analyzed and results are presented in this paper. A great deal of similarity was found between the two groups of undergraduates.

Keywords: gender, ethnicity, university type, role models, mentors

1. INTRODUCTION

For the computing pipeline at U. S. colleges and universities, two watershed moments were the dot-com bust and the tragic events of 9/11. These events aggravated the already existing decline in Computer Science (CS) enrollments and started the spread of a lack of interest in other computing disciplines among incoming undergraduates.

In 2003, the National Science Foundation awarded a research grant to researchers at Xavier University of Louisiana to conduct a study of gender-based differences, ethnic and cultural models in the computing disciplines. The research team was a multidisciplinary group of computer scientists and psychologists. A multidisciplinary advisory board (with individuals credentialed in computer engineering, information systems, sociology, and education) guided the research team in this work. In addition, cooperation and support was obtained from faculty members at various institutions of higher education across the U. S. in different computing discipline departments.

A Web survey instrument was developed and pilot tested in Spring 2004. After an advisory board review of the results of the pilot, the finalized Web survey was launched on a secure server in Fall 2004.

2. LITERATURE REVIEW

Working together professional organizations, such as the Association of Information Technology Professional (AITP), the Association for Computing Machinery (ACM), the Computer Society of the Institute for Electrical and Electronic Engineers (IEEE-CS) and others, have labored to define the computing disciplines (Shackelford et al., 2006). Over the last few years, curriculum guides have become available (http://www1.acm.org /education/curricula.html) – CS in 2001, Information Systems (IS) in 2002, and Information Technology (IT) in 2005.

Although a large number of people entering the Information Technology Workforce (ITWF) have Bachelor's degrees in CS, a growing number are entering the ITWF with degrees in IS, IT or some other applied IS-or IT-like degrees. Historically, there has been an under-representation of women and minorities with CS degrees entering the ITWF (Camp, 1997). This situation has only worsened with the number of U. S. undergraduates enrolled in CS degree programs dropping 39% from 2001/2002 to 2005/2006 (Vegso, 2007).

As early as 2001, Canadian researchers suggested that the gender imbalance was being aggravated by narrow definitions of information technology (as CS and Computer Engineering) in contrast to those that focus on the application of technology (Cukier et al., 2001). Some US research has suggested that there is a reasonable supply of well-qualified women and minorities entering the ITWF from IS and IT programs (Randall et al., 2003). At the same time, Berghel and Sallach's (2004) research shows a paradigm shift at universities toward a more applied IT (AIT) where IS, IT, Information Science and other IS- and IT-like degree programs are being merged into departments or schools. Hence a research question that this paper seeks to address is: What are the differences, if any, in the demographics, behaviors, beliefs, and perceptions between CS and AIT undergraduates?

3. METHOD

The study used "purposeful sampling" to obtain computing discipline diversity as well as statistically significant numbers of women and minorities. This approach was in response to the many previous studies that consisted only of CS undergraduates conducted at Predominantly White Institutions (PWIs), which had statistically insignificant numbers of African American participants (Margolis & Fisher, 2002; Beyer et al., 2003). Hence a concerted effort was made to involve Historically Black Colleges and Universities (HBCUs). Faculty members at 42 colleges and universities across the U. S. invited undergraduates to take a Web survey. Of the 42 participating institutions, 21 were HBCUs and 21 were PWIs. Some institutions offered an undergraduate major in a single computing discipline (e.g., CS) while others offered undergraduate majors in two or more computing disciplines (e.g., CS, IS, and IT). Table 1 shows the location of the institutions where undergraduates were solicited and the counts of HBCUs and PWIs university types at that location.

Table 1. Sampling locations
and university types

Location	HBCU	PWI
Alabama	3	1
Arizona		1
Arkansas	1	1
Colorado		1
Connecticut		1
District of Columbia	1	1
Florida		1
Georgia	2	1
Illinois		1
Kentucky	1	1
Louisiana	2	1
Maryland	1	1
Minnesota		1
Mississippi	2	
Montana		1
North Carolina	2	1
Ohio	1	1
Rhode Island		1
South Carolina	2	1
Tennessee		1
Texas	2	1
Virginia	1	1

Survey participants were paid $10. They not only provided demographic information but answered questions related to their computing attitudes, beliefs, and behaviors. The majority of the questions used in the Web survey were adapted from appropriate published research instruments, with the permission of the author or authors. The research team developed the others. Only part of the data from the larger data set is presented here. The computing discipline with the largest number of participants was CS (n = 618). Table 2 shows the AIT majors (found in the published catalog of the college or university) and the respective numbers of undergraduate participants in those majors (n = 262).

4. DEMOGRAPHICS

There were 89 females (34%) and 173 males (66%) in the AIT group (n = 262). The CS group (n = 618) had 188 females (30%) and 430 males (70%). The average age of the AIT group was 21.89 with a minimum age of 17 and a maximum age of 62. The average age of the CS group was 20.99 with a minimum age of 17 and a maximum age of 52. In both groups, the years in school ranged from 1 to more than

5 years with an average of 2.92 years for the AIT group and 2.73 years for the CS group.

Table 2. The AIT group

Major	#
Computer Information Systems	22
Computer Science with Information Systems option	16
Computer Information Science	11
Computer and Information Science	44
Computer Science with emphasis in business	39
Information Science	3
Information Systems	13
Information Systems and Decision Sciences	2
Information Systems Engineering	1
Business Administration with Information Systems Technology	7
Business Information Systems	1
Business Administration Business	8
Management Information Systems	13
Information Technology	45
Industrial Computer Systems	19
Telecommunication Systems Management	9
Telecommunications Management	5
Digital Arts and Sciences	4

The vast majority of the undergraduates in both groups were US citizens or permanent residents (AIT: 229, 87.4%; and CS: 569, 92%), with the remaining having student visas. Again for both groups, the vast majority of the undergraduates were single (AIT: 232, 88.5%; and CS: 555, 89.9%), with the remaining indicating engaged, cohabitating, married, divorced, or other. A small number of undergraduates in each group had children (AIT: 16, 6.1%; and CS: 39, 6.3%). The ethnic composition of both groups is presented in Table 3. The vast majority of the African Americans attended an HBCU and the vast majority of the Caucasians attended PWIs. Table 4 presents the AIT and CS ethnic distributions by university type.

Table 3. Ethnic distribution in sample

	AIT		CS	
Ethnicity	**#**	**%**	**#**	**%**
African American	108	41.2	277	44.8
Asian	11	4.2	35	5.7
Caucasian	98	37.4	233	37.7
Hispanic	16	6.1	23	3.7
Others*	29	11.1	50	8.1

* Multi-racial, Native American-Eskimo, Pacific Islander, and other (e.g. African)

Table 4. Ethnic distribution by university type

	AIT		CS	
Ethnicity	**HBCU**	**PWI**	**HBCU**	**PWI**
African American	90	18	268	9
Asian	0	11	10	25
Caucasian	2	96	4	229
Hispanic	7	9	13	10
Others*	18	11	38	12

Students choose their majors in a variety of ways; one way that is often cited in CS research is the influence of another person (Margolis & Fisher, 2002; Beyer et al., 2003). To get an appreciation for any human influences that might have guided an undergraduate into the computing discipline, the question was asked as to whom that person might have been. Table 5 shows the top three responses (out of 20 possible choices) for each group.

Table 5. Primary influence in choice of discipline

#1	**AIT**		**CS**	
Influence	**#**	**%**	**#**	**%**
No one influenced me in choosing my discipline	81	30.9	165	26.7
Biological mother	54	20.6	121	19.6
Biological father	37	14.1	115	18.6

The students were also asked, if they had a computer in the home, who the "computer expert" was. Multiple selections were allowed from the categories of mother, father, self, sister, brother, no one, and other. Of the 711 students who did have a computer in the home when they were between the ages of 6 and 13, Table 6 shows the top three responses for each group to the computer expert question.

Table 6. Computer expert in the house

	AIT		CS	
Computer expert	**#**	**%**	**#**	**%**
self	88	33.6	242	39.2
father	33	12.6	76	12.3
self and father	11	4.2	51	8.3

5. BEHAVIORS

There were 169 students who indicated that they did not have a computer in their home when they were between the ages of 6 and 13. A chi-square test of independence was conducted to see it there was a difference between the 56 AIT and 113 CS students. No significant difference was found ($\chi^2(1)$ = 1.13, $p > .05$). A chi-square test was also conducted using ethnicity (as in Table 3) as the sole independent variable, and a statistically significant difference was found ($\chi^2(4)$ = 48.07, $p < .001$). More than half of the students (52.1%) who did not have computers in the home when they were between the ages of 6 and 13 were African Americans (88) while only 19.5% (33) were Caucasians.

The "tinker factor" refers to taking mechanical or electronic objects apart to see how they operate. It is often cited as behavior demonstrated early in childhood development for those who eventually major in CS (Margolis & Fisher, 2002; Beyer et al., 2003). Students in the survey responded to a question regarding the tinker factor. The vast majority of undergraduates in both groups had taken mechanical or electronic objects apart (AIT: 210, 80.2%; CS: 515, 83.5%). A chi-square test of independence was calculated comparing the response of AIT and CS students. No significant difference was found ($\chi^2(1)$ = 1.42, $p > .05$).

The majority of undergraduates in the AIT group (140 or 53.4%) were employed, but the majority of undergraduates in the CS group (323 or 52.3%) were not employed. Nonetheless, a chi-square of independence comparing the two groups indicated no significant difference ($\chi^2(1)$ = 2.39, $p > .05$). Of the 140 AIT and the 295 CS students who were employed only 174 were employed in their discipline. These were 49 (35%) AIT students and 125 (42.4%) CS students and again a chi-square test showed no significant difference in the groups ($\chi^2(1)$ = 2.15, $p > .05$).

6. BELIEFS

Bandura (1977) introduced self-efficacy theory into the psychological literature 30 years ago. Self-efficacy focuses on the cognitive means people use to guide their own behavior. For a particular domain, self-efficacy is an individual's belief in her or his ability to produce a desired effect in that domain. The student self-efficacy domains analyzed in this paper are math self-efficacy and computer self-efficacy. Both domains have been cited as having an influence on women either entering or achieving in CS. Margolis and Fisher (2002, p. 38) wrote, "Girls who lack confidence in their math abilities are probably less likely to take optional math-related courses, including computer science." Beyer et al. (2003, p. 52) wrote, "Low computer confidence among women is a major barrier to women's achievement in CS."

Math self-efficacy

To measure each student's beliefs in her or his ability to solve problems involving arithmetic through, at most, basic algebra, a math self-efficacy scale (Kranzler & Pajares, 1997) was incorporated into the web survey with the permission of the scale's developers. The 18-item math self-efficacy scale is well known and has established psychometric properties. However, due to an analysis of pilot data collected in Spring 2004, researchers decided to reduce the scale from 18 to 14 items. This did not significantly affect the scale's psychometric properties; the Cronbach's alpha for the modified 14-item math self-efficacy scale was 0.938. In this segment of the survey, students were presented with items called task-statements and asked to indicate how confident they were in their ability to accomplish the task. Examples of task-statements are: (1) Determine the gas mileage for a car that travels 240 miles on 10 gallons of gas, and (2) Determine the savings on the purchase of a $200 book if you are to receive a 25% discount. Student responses were recorded on a Likert-scale with values ranging from 1 to

10, where 1 was "no confidence" and 10 was "completely confident".

An independent-samples *t* test was calculated comparing the mean math self-efficacy score of the AIT students to that of the CS students. With equal variances not assumed, no significant difference was found ($t(417) = 1.95$, $p > .05$). The mean of the AIT students ($m = 8.53$, $sd = 1.53$) was not significantly different from the mean of the CS students ($m = 8.74$, $sd = 1.26$). Even though there was no significant difference found in the math self-efficacy between AIT and CS students, a 2 (gender) × 5 (ethnicity) between-subject factorial analysis of variance (ANOVA) was calculated comparing the math self-efficacy scores according to student's gender and ethnicity. The main effect for gender was not significant ($F(1,870) = 0.04$, $p > .05$). The main effect for ethnicity was also not significant ($F(4,870) = 1.27$, $p > .05$). Finally the interaction of gender and ethnicity was not significant ($F(4,870) = 0.59$, $p > .05$). Thus, it appears that neither the student's gender nor ethnicity has any significant effect on the observed math self-efficacy scores.

Computer self-efficacy

Researchers developed a 7-item computer self-efficacy scale to measure each student's belief in her or his ability to use a computer. The computer self-efficacy items were the following statements:

1. I feel confident explaining why a computer program (software package) will or will not run on a given computer.
2. I am very confident in my abilities to use computers
3. I feel confident in trouble-shooting software problems on the computer.
4. I feel confident organizing and managing files on a computer.
5. I can make a computer do what I want it to do.
6. I consider myself a skilled computer user.
7. I feel confident describing the function of computer hardware (e.g., USB, CD-ROM, DVD Drive, Wireless Card).

This scale was based upon the work of other researchers (Torkzadeh and Koufteros, 1994; Cassidy and Eachus, 2002; Beyer et al., 2003), an understanding of present day computer literacy levels, and the analysis of data obtained in Spring 2004 pilot study. For each item, the Likert-scale values ranged from 1 to 7, where 1 was "strongly disagree" and 7 was "strongly agree". To control for affirmative bias, the computing self-efficacy statements were placed randomly among statements in the survey investigating other variables. Findings suggested that the psychometric properties of the scale reached acceptable levels. Reliability as measured by Cronbach's alpha, which was 0.892, indicated internal consistency.

An independent-samples *t* test was calculated comparing the mean computer self-efficacy score of the AIT students to that of the CS students. With equal variances not assumed, no significant difference was found ($t(449) = 1.42$, $p > .05$). The mean of the AIT students ($m = 5.68$, $sd = 1.12$) was not significantly different from the mean of the CS students ($m = 5.80$, $sd = 1.01$). As before a 2 (gender) × 5 (ethnicity) between-subject factorial ANOVA was calculated comparing the computer self-efficacy scores according to student's gender and their ethnicity. A significant main effect for gender was found ($F(1, 870) = 28.53$, $p < .001$). Female students had lower computer self-efficacy ($m = 5.41$, $sd = 1.10$) than male students ($m = 5.92$, $sd = 0.97$). There was also a significant main effect for ethnicity ($F(4, 870) = 2.65$, $p < .05$). However, there was no significant interaction of gender and ethnicity ($F(4, 870) = 1.92$, $p > .05$). A post-hoc analysis (Tukey's HSD) was done on ethnicity. African American students had lower computer self-efficacy ($m = 5.56$, $sd = 1.00$) than Caucasian students ($m = 5.98$, $sd = 1.03$).

7. PERCEPTIONS

In selecting a major in CS, a concern women voice is the lack of role models, that is, either CS female peers, contemporaries, or faculty members. At many universities across the US, both females and males in CS have assumed the role of mentor, providing encouragement and support to women seeking to major in CS. According to Townsend (2002, p. 57) having role models and mentors "A women can transform herself from a perspective filled with isolation and discouragement to a better vantage point where she gains confidence and sees herself as belonging to a community that supports her." The type of university (HBCU or PWI) that a student attends can be an expression of a desire for role models or for mentoring. It is noteworthy that at HBCUs more women receive Bachelor's degrees in CS than men, while at PWIs the opposite is true; furthermore, HBCU faculty have a long and recognized tradition of mentoring their students (Lopez and Schulte, 2002). Factors such as discipline, gender, and university type can influence the way students view their world.

As part of the larger study, researchers wanted to investigate the perception that members of different computing disciplines had regarding the number of women having Bachelor's degrees in CS, the group most frequently reported on in the popular press. In open response mode, students were asked to provide two estimates: (1) What percent of Bachelor's degrees in CS are awarded to women? (2) What percent of Bachelor's degrees in CS are awarded to African American women? By analyzing responses to these questions researchers measured the differences in perceptions between the AIT and CS group, males and females, and those who attend HBCUs and PWIs as well as any interactions. One student of the 880 in the sample did not respond to these questions.

A multivariate analysis of variance (MANOVA) was conducted because the two dependent variables – the estimated percent of Bachelor's degrees in CS awarded to women and the estimated percent of Bachelor's degrees in CS awarded to African American women – are certainly gender related. The independent factors were discipline (AIT or CS), gender, and university type (HBCU or PWI). A main effect was significant for gender (*Lambda*(2, 870) = .99, $p < .01$) and university type (*Lambda*(2, 870) = .82, $p < .001$) but no significant difference was found between the AIT and CS groups. There was only one interaction of significance and that was discipline and university type (*Lambda*(2, 870) = .99, $p < .01$). A follow-up univariate ANOVA indicated that the responses to the percent of women awarded Bachelor's degrees in CS were not significantly influenced by discipline; however, there was a significant difference between the AIT and CS groups in responses to the percent of African American women awarded Bachelor's degrees in CS ($F(1, 871) = 4.43$, $p < .05$). The total sample perceived the percent of women awarded Bachelor's degrees in CS ($m = 25.53$, $sd = .615$) to be higher than the percent of African American women awarded Bachelor's degrees in CS ($m = 14.99$, $sd = .518$).

8. DISCUSSION

Demographically the AIT and CS groups in the sample were surprisingly homogeneous. Both groups had approximately the same gender distribution and averaged about the same age and year in school. Both groups were composed mainly of US citizens or permanent US residents and they were single. Approximately 6% of the undergraduates in each group stated that they had at least one child. The ethnic composition of both groups was also remarkably similar, in particular, among the larger ethnic groups of African Americans and Caucasians. The majority of the African Americans in both the AIT and CS groups did attend HBCUs while the majority of the Caucasians in both groups attended PWIs. The influence attributed to others in guiding students in both the AIT and CS groups toward their respective choice of discipline was also quite similar, as was the person at home who was considered the computer expert.

Although less than 20% of the students in the entire sample did not have a computer in the home when they were children, there was no significant difference in proportions between those that selected a major in AIT and those that selected a major in CS. However, taking this portion of the sample as a whole, there was a significant difference found along ethnic lines. More of the students not having a computer in the home as they were growing up were African American than Caucasian. The behavior manifested in taking mechanical or electronic objects apart to see how they worked was not significantly different between the AIT and CS students. There was also no statistical difference in the number of AIT and CS students who were employed while being undergraduates, and there was no statistical difference in the groups who were employed in their discipline.

There was no statistical difference between the AIT and CS students in their beliefs about being able to do basic math successfully. When the groups were viewed as one with gender and ethnicity being considered as influencing factors in the sample's math self-efficacy, no significant difference in gender or ethnicity was found. Furthermore, there was no statistical interaction between the factors. There was again no difference between the AIT and CS students in their beliefs about being able to use computers. As before, the factors of gender and ethnicity were investigated taking the AIT and CS groups as a whole. In this investigation, both gender and ethnicity showed significant differences, but there was still no significant interaction between the two. Replicating the findings of many other researchers, females were found to have a lower computer self-efficacy than males, and African American students had lower computer self-efficacy than Caucasian students.

Perceptions, though they can be far from reality, play a central role in US culture. Abraham Lincoln, 16th President of the US, noted the impact in a now famous quotation, "Character is like a tree and reputation like the shadow. The shadow is what we think of it; the tree is the real thing." The AIT and CS groups think along similar lines with regard to the percent of women and African American women being awarded Bachelor's degrees in CS, and it is not "the real thing." There were significant differences found in the perceptions of women versus men as well as those attending HBCUs versus PWIs.

9. CONCLUSION

The similarities between AIT and CS students in this sample are many. This is somewhat reassuring since their common root is in computing. Since some US research is indicating that there is a reasonable supply of women and minorities in the AIT pipeline, then the present findings suggest that the decline of women in the CS pipeline might not be based on any similarities found here between AIT and CS students. Instead the differences might be more fundamental such as the interests, goals, and expected outcomes of AIT students as opposed to CS students. Research along these lines still needs to be accomplished.

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