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It is well known that today many countries in the world are facing a severe shortage of information technology professionals, including the United States. According to a report released by the U.S. Department of Commerce, the average annual growth rate for computer systems analysts, computer scientists, and computer engineers will top 100% by 2006. This means that more than 1.3 million new Information Technology (IT) workers will be needed to fill job openings and replace workers leaving the field (<http://www.informationweek.com/741/labor.htm>). A steady supply of IT

professionals to the business community is necessary for our nation to remain competitive in the global market.

Unfortunately, evidence shows that the nation's educational institutions are unable to meet the growing needs of the business community for outstanding technical professionals' (Camp, 1997). At a time when salaries of technology professionals are skyrocketing and sign-on bonuses and other perks are impressive, it comes as a surprise to many that more students are not flocking to computer science and information technology programs. One possible reason why high school students may hesitate to enroll in computer science programs is their negative perceptions about technology careers coupled with lack of understanding of the skills required to succeed in IT careers (Dohrenwend, 1965). Unfortunately, negative stereotypical images of computer users are more prominent in high school students than elementary school students and is in fact, most prevalent at the 10th grade level (Bradburn, 1983). Attitudes and perceptions toward specific careers have an enormous impact on the choices that high school students make, and in fact, attitudes sometimes play a greater role in career choice than classroom education, job opportunities, future career growth, and long-term earning potential (Campbell, 1950). Hence, the importance of shaping positive attitudes toward science and technology careers cannot be underscored.

Gender differences in attitudes toward computer usage and computer careers are another important issue that should be carefully addressed by educators and employers throughout

the country. "While sex may be taken to refer to the biological difference between males and females, gender should be taken to refer to the manner in which cultures define and constrain these differences" (Frenkel, 1990). An understanding of these differences is crucial if we as a nation are to succeed in enrolling greater number of women into science and technology programs.

The state of Nebraska, like many other states in the country, has invested, and continues to invest, significant dollars in information technology assets, including hardware, software, telecommunications, training, education, and people. The primary purpose of this research is to better understand attitudes and perceptions of high school students, particularly females and minorities, towards computer use and technology careers, in order to successfully attract the best and the brightest to the field. The results of this study will help educators, employers, and business and IT professionals not only in the state of Nebraska, but around the country, effectively understand and address student attitudes toward computers and their interest in technology careers.

Research Objectives

The broad objectives of this research were as follows:

- ¥ Gain a better understanding of attitudes, perceptions, and biases of high school students toward information technology careers and the skills perceived to be necessary to succeed in such careers.
- ¥ Investigate attitude differences related to gender, race, grade-level, and coed versus same-sex

schools with regard to computer usage and computer careers.

¥ Understand the forces that influence student attitudes toward technology and technology careers.

In particular, the following hypotheses were tested:

H1: There is no relationship between gender and level of interest in IT careers. There is also no relationship between same-sex and coed schools in terms of interest level in IT careers.

H2: There is no relationship between gender and students' perception of their ability to acquire skills necessary to succeed in IT careers. There is no relationship between same-sex and coed schools in terms of skill acquisition.

H3: There is no significant difference between grade levels in terms of students' interest in IT careers or their perception about skill acquisition. There is no relationship between same-sex and coed schools in terms of students' ability to acquire necessary skills.

H4: There is no relationship between race and interest in IT careers or skill acquisition.

H5: There is no relationship between interest in IT careers and a student's self-perception regarding his or her ability to acquire necessary technical skills.

Research Methodology

A Self-Report Survey Questionnaire with some structured (or closed) questions with pre-determined responses and several open-ended questions was designed and administered to high school students in Nebraska. The survey was pilot-tested on 113 students. Since structured questions alone fail to provide researchers with a rich variety of responses, open-ended questions were included to give respondents the opportunity to express their feelings, motives, or behavior spontaneously (Barba, 1994). Open-ended questions produce more self-revelations by subjects' (Glissov, 1994) and the ability to express their thoughts

and opinions, without inhibition. This allowed researchers in this study to capture and study nuances of perceptions and attitudes that usually go undetected in multiple-choice questions. This was particularly important for understanding gender differences since "descriptive paradigms" often clouds results, according to Robin Kay, a statistician at the University of Toronto who has studied more than 90 papers published in the mid to late 1980s (Breidenbach, 1997) on the subject. He recommends qualitative methods that focus on why there are behavioral differences rather than statistical methods that focus on what the behavior is, stating that "without a shift to qualitative methods, the field will continue to report only pieces of the puzzle and fail to develop a comprehensive theory." Past research on gender differences has involved numerically rated predefined attitude measurement tools toward computer use, rather than giving students an opportunity to express their ideas about computers. Hence this study makes an important contribution to the field and differs significantly and meaningfully from previous studies on the subject.

Respondent Profile Statistics

The population parameter was high school students in the state of Nebraska. Cluster sampling of high school students from across the state resulted in one public high school selected from each Educational Service Unit (ESU) outside the two largest metropolitan areas of Omaha and Lincoln. A total of 23 schools participated in the survey. One hundred copies of the survey were mailed to each school that agreed to participate in the survey. Teachers in appropriate classes distributed the surveys to their students and collected them at the end of the class period. A total of 1021 survey sheets were returned, of which 1006 were usable.

Different types of schools were represented in the study. 55.9% of the respondents were from public schools, 38.1% from parochial, and 6.1% from private schools. 83.7% of the respondents were from co-ed schools, while 6.9% were from all male and 9.4% from

all-female schools. 46.4% of the respondents were male. Further, 25.6% of the students were freshman, 26% were sophomores, 35.4% were juniors and 13% were seniors. Finally, 84.9% of the respondents were white, 10.2% were African-American, 2.7% were Hispanic, 1.3% was Asian American, and 0.7% was Native American.

In terms of the type of computer usage, 47.2% respondents indicated that they were most comfortable with IBM and IBM compatibles, while 17.9% preferred the Macintosh, and 34.6% indicated they were comfortable with both platforms. 54% of the respondents indicated that IBM was the predominant computer platform in their school, while 39% indicated Macintosh, and 6.8% indicated both platforms were used in their school. Pearson Chi-Square Tests reveal a significant positive correlation between computer platforms used in schools and platforms that students preferred.

Other Results

This section outlines the findings of this study as it relates to attitudes toward computer usage and computer careers.

Access to Technology. Access to technology is clearly an important issue and the primary source of access to computers is the school. Other places, in order of ranking, where students gained access to computers were home, middle school/junior high, at another individual's home, elementary schools, and work place. This rank order was similar for both males and females. See Figure 1.

Skill Acquisition

Where do students acquire technology skills? Who were the people responsible for helping them acquire necessary technology skills? Students were asked to list all their choices. This study shows that students acquire skills from a variety of sources. 22.7 % students indicated they were self-taught. Teachers, a friend or classmate, special computer training classes, father, and a relative were ranked next

in order. See Figure 2. There were no gender differences on this issue.

Primary Uses of Computers

Several research studies indicate that women use computers primarily for word processing and other mundane activities, while men tend to use computers for higher applications such as problem-solving and analytical thinking (Davidson, 1987). Our research, however, does not lead to this conclusion. When students were asked to list some primary uses of the computers, there was little variation between boys and girls. Word-processing, Internet surfing and computer games ranked as the top three computer applications for both boys and girls. See Figure 3.

Motivation factors

Using an open-ended question students were asked to identify all factors that would motivate them to seek IT careers. Their responses are shown in Table 4.

Not surprisingly, money was the number one motivating factor with college scholarship at a distant second and job availability and security tied for a close third motivating factor.

Skills necessary to succeed in IT

Students were asked the question, “What skills do you think are necessary for a career in information technology? Keyboarding was the number one choice of both girls and boys followed by computer skills and programming. Math was the fourth choice for both boys and girls. Refer to Table 5.

An examination of the mean ranks of Mann-Whitney U tests revealed that males rated themselves significantly higher than females in interest in having a career in information technology (534.36, 454.19, $p < .05$). Mann-Whitney U test is the appropriate alternative to the independent measures t-test because the data are ordinal numerical ratings.

Figure 1. Sources of access to computer technologies.

PLACE	FREQUENCY	
	Males (N=461)	Females (N=533)
High School	342	385
Home	253	306
Middle School/ Junior High	168	204
At Another’s Home	160	171
Elementary School	77	108
Job	23	23
Telemarketing	9	17
Other	28	31

(Respondents could select more than one response.)

Figure 2. Primary sources where respondents acquired computer technical skills.

Self-taught	229
Teacher	198
Friend or classmate	147
Special computer classes	135
Father	32
Relatives	57

Figure 3. Primary uses of computers by respondents.

Use of Computer	Males	Females
Word processing	287	323
Internet	258	290
Games	183	209
Reports/Projects	63	111
E-mail	56	96
Program	36	50
Drawing, charts, graphs	44	47
Chat	25	21
Make web pages	20	19

¹ Respondents could select more than one response

Parametric tests, such as t-tests and ANOVAS, require that data be interval or ratio.

A representative sample of students from one all-male school and two all-females schools responded to the survey. Our research shows that based on the Mann-Whitney tests, females in coed schools had a significantly higher level of interest in IT careers than females in all-female schools (268.36, 227.65, $P < .05$). Although there is a similar trend among males in coed versus same-sex schools, the difference is not significant.

Students self-ranking of their ability to acquire computer skills were quite high. More than 87% of the respondents rated their ability to acquire computer skills as average or 'above average' while 28.5% rated themselves as "very capable." An examination the mean ranks of Mann-Whitney test (491.94, 455.39) showed that males ranked themselves significantly higher than females in this area. Further, Mann-Whitney tests showed that females in coed schools rated themselves significantly higher than females in same-sex schools in their ability to acquire IT skills. While the results were similar for males, the difference was not significant. The Kruskal-Wallis Test showed no significant differences between racial groups' self-perception of their ability to acquire the skills for a technology career.

The Kruskal-Wallis Test, the non-parametric equivalent of ANOVA comparing two or more groups, revealed no significant difference between grade levels and interest in IT careers. The general belief that students nearing graduation may show higher level of interest in certain careers was not substantiated in this study. Further, no significant difference was found between grade levels and students' self-perception of their ability to acquire IT skills. In other words, higher-grade levels did not reveal a perception of greater ability to acquire IT skills.

Results of Kruskal-Wallis one-way analysis of variance show a significant difference ($p < = 0.05$) between Hispanics and other racial groups on the issue of interest in IT careers. In follow-up

tests comparing each racial group, Mann-Whitney Tests show Hispanics as having significantly higher mean rankings over all other racial groups in IT careers. There was no significant difference between other racial groups

An examination of the results of Spearman's Correlation Test indicates a weak positive correlation between a student's interest in a career in IT and self-assessment of their ability to acquire IT skills. In other words, a student's interest in IT careers does not necessarily translate into a strong perception of ability to acquire IT skills.

Implications and Recommendations

Although the sample for this study was Nebraska students, the implications of these findings are relevant to a national audience. The implications of

this study are categorized into five groups:

1. Women and computer education
2. Race, computer usage, and IT careers
3. Grade level and computer interest
4. Gender differences and skill perceptions
5. Coed versus same-sex schools

Girls and Computers

This research shows that level of interest in enrolling in IT programs and pursuing IT careers is significantly lower among girls than boys. National educational statistics substantiate this finding. Since 1985 the number of bachelor's degrees awarded in computer science has decreased and the decrease is occurring at a faster pace for women than men (Cone, 1998). A recent study by the American Associa-

Table 4: Reasons that would motivate students to pursue IT careers

Reasons	Frequency
Good money/benefits	207
College scholarship	28
Job availability/security	26
If it's fun	24
Already interested	24
Better understanding of field	21
Job availability/security	26
Job training, more opportunities, improved technology, variety, and others	41

Table 5: Students perception of skills necessary to succeed in IT careers

TYPE OF SKILLS	MALES	FEMALES
Keyboarding	208	264
Computer Skills/knowledge	144	165
Programming	82	99
Math	52	59

tion of University Women found that only a small percentage of girls are preparing themselves for high-tech careers, as evidenced by enrollment in high-level computer courses (Greis, 1992). What is disappointing and perplexing is that women who constitute 50% of high school computer science classes (Hill, 1997) appear to lose interest in computer science programs once they enter college. Ironically, science and engineering programs, other than computer science seem to attract more women. "We're up against something cultural," says George H. Friedman, director of undergraduate programs for the computer science department at the University of Illinois at Urbana-Champaign. "Somehow teachers or kids are pushing the idea that this is not a field for girls." (Owens, 1998)

Prior research cites several reasons why girls may not be attracted to computer science, including poor software, competitive environments, and lack of exciting computer science curriculum. "Girls' first exposure to computers is through "shoot-them-up" games which they find boring and repetitive", says Denise Gurer, Chair of ACM-Women program at the Association of Computing Machinery (ACM) and a computer scientist at SRI International (26). Other researchers argue that society's low expectation of women and stereotypical thinking of software designers is the problem, not the software itself (Rosser, 1997). These researchers argue that the word "student" is often replaced with "male" in the mind of the software designer, often leading to software products that fail to attract and sustain the attention of girls. (Sanders, 1998) Also, girls do better in collaborative environments although educational environments are geared for competition not collaboration (Sacks, 1993). While boys tend to thrive in such environments, girls often tend to recede into the background when the competition is fierce, certainly not for lack of computer skills. Finally, schools around the country sorely lack an exciting and engaging computer science curriculum. Computers are rarely portrayed as an exciting

and versatile tool that can make learning fun and contribute to life-long career success. Many schools fail to use computers to engage students in mathematics, science, social studies and literature; instead, schools seem to offer classes about computers, rather than their use and application, which is a turn off for many students, particularly women (Smith, 1996). This problem is further aggravated by low budget for computers, poor teacher training, and lack of mandatory requirements or minimum standards for computer science curriculum.

Even if the above tangible problems were addressed, researchers doubt that women will rush to enroll in computer science programs. Instead they indicate that the underlying subtle thinking that men are somehow superior to women is the bane of many societies around the world, and schools and universities are easy victims of this old and antiquated mental framework. "The subtle influences do not arise out of an evil male conspiracy to keep girls and women out of computing, math, or science. The notion that the gender imbalance is men's fault has a certain elegant simplicity that is tempting to many, but it is simply not valid. The truth is far more interesting and complex than that. The overwhelming male presence in computing is a chicken-and-egg issue. Because mostly boys and men use computers, girls conclude that computing is not appropriately feminine, which leads them to decline computing opportunities available to them, which leaves computing environments male, which leads girls to conclude." (Perritt, 1997) This problem will continue unless educators bring an "active feminist orientation" into the classroom and deliberately encourage girls to view technology careers as an exciting and suitable option.

Race and Computers

Racial differences in computer usage and technology careers have not been extensively studied, although this issue deserves immediate national attention (Smith, 1996). However, it is well understood and widely accepted that children of race face more barriers

to education and career success than Caucasian children. Such barriers include poverty, lack of role models, lack of parental encouragement, and limited access to technology and other educational resources. Racial inequities exist not only in terms of access to technology, but unfortunately also in terms of how that technology is used once it is made available. Urban schools with predominantly African American and Hispanic students use computers for tutorial and rote drill-and-practice programs, while suburban schools with predominantly white students from higher-income families have been generally found to use computers for problem-solving and programming (Sacks, 1993). The consequences of such discrepancies are detrimental and far-reaching. More research is needed in exploring racial differences in computer usage, attitudes and career choices.

An encouraging finding of this study is that Hispanics showed a higher level of interest over all racial groups in IT education and careers. As the Hispanic population in Nebraska and around the country continues to increase, this finding holds great promise.

Grade Level and Computer Interest

Our research showed no significant difference between grade levels and interest in IT careers. In other words, students' level of interest in IT did not change as they were nearing graduation. This finding has significant implications for educators and business professionals who have a stake in encouraging and attracting students to IT professions. There is a growing discussion in the academic and business community that career counseling must start in the early school years, in fact, as early as elementary school. In a study that aimed to determine if children stereotyped technology-related careers, specifically computer careers, it was found that 5-th grade students depicted 32 different careers as being associated with computer usage while 12-th grade students depicted only 10 different careers as being computer related. This indicates that younger

children see computers as a career tool rather “than as a machine that defines a separate career”(Stan, 1997). Since children are more open-minded and malleable in their early years, career education must start in elementary school, with special programs to attract girls into science and engineering disciplines.

Prior research also shows middle school years are particularly critical to the education process, a time when many girls drop out of math and science (Sacks, 1993). “Beginning usually in the middle school grades but sometimes earlier, girls are significantly underrepresented in after school computer clubs, as computer contest participants.”(Stan, 1997) A similar survey of middle-school children is under consideration.

Gender Differences and Skill Perceptions

Our research shows that although students in general gave themselves high marks in terms of their abilities to acquire technical skills, males tended to rank themselves much higher than females. This confirms findings from previous research that girls rate their skills and abilities much lower than boys even when the groups being studied are fairly well matched (Breidenbach, 1997) and in particular, girls display greater insecurity and lack of self-confidence during transition periods, like entering middle school, or high school, or college (Frenkel, 1990). In studies where computer use was associated with programming, gender differences were more prominent and striking than in non-programming activities (Campbell, 1996).

Several interesting gender differences contribute to this paradox. For example, research shows that while girls rely on computers mostly for word processing, boys use computers as problem-solving tools (Rosser, 1997). Male students use computers in math and science for collecting and analyzing data, doing calculations, modeling and simulations, and writing reports significantly more than female students. In other words, since boys use computers for more complex

analytical tasks, their confidence in their IT skills may be higher than girls. Studies also show that girls tend to perceive the high-tech world as “masculine” and rate themselves consistently lower in computer skills and competence than boys. In the public school system, girls are short-changed, especially in the areas of math, science and technology (Camp, 1997). Finally, computers should be more readily accessible to students. There is a strong positive correlation between the time that girls spend on computers and their attitude toward computers. “Their need for same-sex peers at this age is extremely strong. Girls reported that their girlfriends’ lack of interest in computing was far more powerful in discouraging their computer use than any other factor.”(Frenkel, 1990)

Coed Schools versus Same-sex Schools

Although previous studies have shown that female scientists and engineers are more likely to be products of single sex schools than co-educational schools, (10), our findings were different. Girls in coed schools showed higher level of interest in IT and ranked their ability to acquire IT skills higher than girls in same sex schools.

Recommendations

It is widely known that the shortage of IT professionals is on the rise and the problem is likely to become more acute in the coming millennium. Unless we as a nation address this problem vigorously and diligently, our national competitive posture may be seriously affected. Schools must assume an action-oriented agenda and faithfully execute it if we are to make progress on several critical issues raised in this study. We recommend a 5-point action agenda below:

1. **Develop a high standard, uniform mandatory computer science high school curriculum**
A well-thought out, mandatory, leading edge computer science curriculum should be implemented throughout the nation. This curriculum should be developed

and implemented in elementary schools, middle schools, and high schools.

2. **Identify and implement software that has appeal for both genders**

Software that is a turn off for either sex does not serve students well. Instead software should be intellectually challenging, yet appealing to both sexes. Educators can be proactive and demand such software from software designers and marketers.

3. **Make computers exciting and challenging for students**

Simply introducing computers and computer-related concepts will not do. Instead, teachers should focus on computer applications in all subjects. Computer exposure should be intellectually challenging and appealing to students from all economic and social backgrounds. In particular, more research is needed to understand why girls tend to under-estimate their skill set and ability to become great scientists.

4. **Develop and implement a vigorous computer career-counseling program**

Our students are still quite ignorant about computer science careers. The fact that many students in this study chose keyboarding as one of the most important skills necessary to succeed in IT careers underscores the importance of IT career education. Active partnership between business and education is required if students are to understand the versatility of computers in different careers. The long-term value of computers for career growth and success should be emphasized.

5. **Explore race differences and interest in computer careers**

More research is needed to understand racial and cultural factors and their influence on attitudes towards computers and computer careers. This is necessary if teachers are to be better prepared to face a diverse class-

room and tap into the potential of every student.

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