AC 2010-90: INVESTIGATING HIGH SCHOOL STUDENTS' COMPUTING BELIEFS

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Abstract

Many projects throughout the United States are underway that seek to increase the appeal of computing as a field of study. This article reports the results of pre and post attitudes surveys which were administered before and after two interventions. One of the interventions was designed to change students' attitudes with respect to computer science and the other with respect to information technology. The two attitude surveys, as well as the interventions, differed primarily in the focus on computer science or information technology. Based on prior research using a factor analysis, the computer science survey successfully measures five constructs: confidence, interest, gender, usefulness, and professional stereotypes. Although the information technology instrument was designed to measure these same constructs, a factor analysis supports that this instrument measures a gender and general category construct, possibly indicating that students have a limited understanding of the field of information technology. The results from the current study indicate that for high school students, male attitudes were more strongly impacted by the computer science intervention whereas female attitudes were more strongly impacted by the information technology intervention.

Introduction

Current high school students grew up with technology and video games and through these experiences have come to know computing as fast-paced and exciting. Yet, their first programming experiences in either high school or college are often tedious and boring.[10,19,22,28] As young children, students learn to use the computer for entertainment with little exposure to the broader applications. Studies have found that many students lack confidence in their basic programming skills[21,22] and that the dot.com bust has had a negative impact on students' perceptions of the field and of professionals in the field. These factors are credited for the gradual decline in the number of students who are pursuing computer science degrees in the United States over the last eight years. [7, 9, 12, 26, 27]

Yet, the employment demand for science and technology majors is increasing. Many studies[7,9,12,37] have been designed that seek to acquire a better understanding of the cause of these declines, especially with respect to female students.[20, 31,32, 33, 35, 36] Women are severely underrepresented in computing[29], representing only 20% of computer science bachelor's degrees awarded across the nation in 2006.[25] Several qualitative investigations have focused on gender differences that may influence enrollment in computer science classes and in computing related degree programs.[3,4,23,30] High school girls, in particular, have identified the following reasons for their lack of interest in computing: i.) lack of female role models, ii.) limited or no knowledge of the applications of computing, iii.) interests in things other than computers, and iv.) a negative perception of computing as "nerdy".[18] The broader population of students has expanded this list to include: i.) a perception that the number of jobs in computing is decreasing, ii.) a general lack of familiarity with computing fields and iii.) incorrect perceptions that computing professionals spend the majority of their time programming and rarely use computing in problem solving.[5]

One method of reversing the damaging trend of decreasing numbers of students pursuing computing degrees in the U.S. is to change students' perceptions of computing fields. Computing is defined here to include computer science and information technology. The study presented here analyzes responses from two surveys that are designed to measure students' beliefs and attitudes with respect to computer science and information technology before and after interventions. Although both instruments were designed to measure the same five constructs, a factor analysis on the data sets confirms the existence of the five factors in the computer science version of the instrument but not in the information technology version.[14] Only two factors were found in the information technology version. The five constructs for computer science are:

Confidence Construct (C):	students' confidence in their own ability to learn computing skills;
Interest Construct (I):	students' interests in computing;
Gender Construct (G):	students' perceptions of computing as a male field;
Usefulness Construct (U):	students' beliefs in the usefulness of learning computing; and
Professional Construct (P):	students' beliefs about professionals in computing.

The two factors for the information technology survey are:

Gender Construct (G):	students' perceptions of computing as a male field; and
General Construct (N):	students' confidence and interests in computing and their perception of its usefulness.

The computer science instrument was originally designed for a first year college population[24] and has been adapted here for a high school population. The computer science survey can be found in Figure 1. The information technology survey is displayed in Figure 2 and was adapted from the computer science survey. This investigation reports the results of the information technology survey's first implementation on a student population.

High school was selected as the target population for this investigation because this is a period in which students are beginning to form opinions about future majors and careers. Understanding high school students' attitudes and beliefs toward computing can provide teachers and researchers with an understanding of how to encourage more students to pursue these fields. The study presented here was partially support by the National Science Foundation (NSF) (DUE-0512064; DRL- 0737679; DRL- 0623808). The ideas and opinions expressed are that of the authors and are not necessarily reflective of that of the NSF.

Research Question

The research question that guided this investigation is:

- Are the two intervention programs which target high school students' computer science and information technology attitudes equally effective for improving students' attitudes within the two fields?

Methods

This section begins with a description of the two surveys which were designed to measure high school students' attitudes and beliefs with respect to computer science and information technology. This is followed by a description of the participating student population, administrative procedure and analysis process.

Instruments

The original computer science instrument consisted of 38 statements and the information technology instrument consisted of 54 statements. Based on the results of a factor analysis which are reported elsewhere[14], the computer science instrument was reduced to 37 statements and the information technology instrument was reduced to 20 statements; see Figures 1 and 2, respectively. Both surveys are written using a Likert scale, also known as a summated rating scale (Strongly Agree, Agree, Disagree, Strongly Disagree). A neutral category was not used in order to force respondents to decide whether they agreed or disagreed. All statements were randomly placed on each instrument, with statements from the different constructs mixed.

Subjects

The data reported here is restricted to the students whose parents or legal guardians signed consent to participate in NSF, DRL- 0737679 or DRL- 0623808. No information is available on students whose parents or legal guardians did not provide written consent.

The computer science version of the attitudes survey was administered to 77 high school students who participated in one of four summer camps offered in 2008 in the following states: North Carolina, South Carolina, Mississippi, and California. Attending students ranged in grade level from high school freshman to high school seniors. All students had self-selected to enroll in a computer science summer enrichment program.

The information technology version of the attitudes survey was administered to 63 high school students who participated in a summer camp during the summer of 2008 in Indiana. Attending students ranged in grade level from high school freshman to high school seniors. The students self-selected to enroll in an information technology summer enrichment program.

Description of Interventions

Both summer camps were comprised of self-selected high school students and were one week in duration. The computer science camp was taught by high school teachers who, immediately prior, had participated in a two-week summer training session. The teacher training component of this program was focused on the instruction of how to program using the Alice three-dimensional software and on developing curricular materials for using this software in the high school classroom. In the third week, local high school students were invited to attend a summer camp in which the teachers worked with the students in short sessions. This provided teachers with the opportunity to teach using the Alice software and the students the opportunity to learn fundamental programming concepts in a fun and motivating environment. During the computer science summer camp, no attempt was made to inform students about careers in computer science. Also, these camps varied in implementation across teachers and sites. As part of the program's design, it was left to the participating teachers to determine what to teach.

The information technology summer camp was standardized and was taught by college faculty and educational consultants also using the Alice software. This camp introduced career opportunities in information technology to participating high school students with a primary focus on encouraging female students to consider information technology as a future career. Although there was both a teacher and a counselor component to this program, these groups did not instruct the student summer camp. For additional information on the larger program, see www.ITPossibilities.org[13].

An important aspect of the information technology camp was using the Alice software for story telling and in interactive gaming environments. The goal was not to convince students to become programmers but rather to demonstrate how the Alice software may be used as a tool, much like Microsoft Word, Publisher, and PowerPoint. By the end of the week, students created an animated Alice world that addressed one of the following questions:

- What is my dream job and how will I get it?
- How do I tell my version of my favorite story?
- How do I prepare for winning a competition or achieving a goal?

In addition to the Alice software, the information technology summer camp exposed high school students to the many unexpected benefits that information technology provides to society. Students listened to presentations made by professionals and participated in hands-on activities. Presenters, drawn from various fields, described how information technology is used in their job, increasing both the efficiency and quality of their work. For example, a police officer and a software developer jointly described mobile applications used to investigate crime scenes. As part of this presentation, the students were also able to try some of the software. Cyber forensics applications, such as the tracking of cell phones and other electronic devices, were discussed as methods for collecting evidence that is used in the prosecution of criminals. On the last day, parents and other family members attended a luncheon during which the events of the previous week were highlighted. The climax of this event was the presentation of the students' Alice worlds.

Confidence Construct: C1) I am comfortable with learning computing concepts. C2) I have little self-confidence when it comes to computing courses. C3) I do NOT think that I can learn to understand computing concepts. C4) I can learn to understand computing concepts. C5) I can achieve good grades (C or better) in computing courses. C6) I am confident that I can solve problems by using computer applications. C7) I am NOT comfortable with learning computing concepts. C8) I doubt that I can solve problems by using computer applications. C9) I do NOT use computing skills in my daily life. **Usefulness Construct:** U1) Developing computing skills will NOT play a role in helping me achieve my career goals. U2) Knowledge of computing will allow me to secure a good job. U3) My career goals do NOT require that I learn computing skills. U4) Developing computing skills will be important to my career goals. U5) Knowledge of computing skills will NOT help me secure a good job. U6) I expect that learning to use computing skills will help me achieve my career goals. **Professional Construct:** P1) A student who performs well in computer science is likely to have a life outside of computers. P2) Students who are skilled at computer science are less popular than other students. P3) Students who are skilled at computer science are just as popular as other students.	**Gender Construct:** G1) I doubt that a woman could excel in computing courses. G2) Computing is an appropriate subject for both men and women to study. G3) Women and men can both excel in careers that involve computing. G4) It is not appropriate for women to study computing G5) Men produce higher quality work in computing than women. G6) Men are more likely to excel in careers that involve computing than women are. G7) Women produce the same quality work in computing as men. G8) Men and women are equally capable of solving computing problems. G9) Men and women can both excel in computing courses. **Interest Construct:** I1) I would NOT take additional computer science courses if I were given the opportunity I2) I think computer science is boring. I3) I hope that my future career will require the use of computer science concepts. I4) The challenge of solving problems using computer science does NOT appeal to me. I5) I like to use computer science to solve problems I6) I do NOT like using computer science to solve problems. I7) The challenge of solving problems using computer science appeals to me. I8) I hope that I can find a career that does NOT require the use of computer science concepts. I9) I think computer science is interesting I10) I would voluntarily take additional computer science courses if I were given the opportunity.

Figure 1 – Computer science survey

General Interest Construct:

I1) I hope that my future career will require the use of information technology concepts.
I2) I like to use information technology to solve problems.
I3) I have a lot of self-confidence when it comes to computing courses.
I4) I do NOT like using information technology to solve problems.
I5) I am confident that I can solve problems by using computer applications.
I6) The challenge of solving problems using information technology appeals to me.
I7) Developing computing skills will be important to my career goals.
I8) I think information technology is interesting.
I9) I would voluntarily take additional information technology courses if I were given the opportunity.
I10) I expect that learning to use computing skills will help me achieve my career goals.

Gender Construct:

G1) Women are more capable than men at solving computing problems.
G2) Women are more likely to excel in careers that involve computing than men are.
G3) Women produce higher quality work in computing than men.
G4) I doubt that a man could excel in computing courses.
G5) It is NOT appropriate for women to study computing.
G6) Men produce higher quality work in computing than women.
G7) Men are more likely to excel in careers that involve computing than women are.
G8) Women produce the same quality work in computing as men.
G9) Men and women are equally capable of solving computing problems.
G10) Men and women can both excel in computing courses.

Figure 2 – Information Technology Survey

Administrative Process

The attitude survey was administered to each of the participating groups in a pre and post format. The pretest occurred prior to camp instruction; the posttest immediately following camp instruction.

Analysis Methods

Responses to each survey were converted to numerical scores. For positively phrased questions, "Strongly Agree" was coded as a "4", "Agree" as a "3", "Disagree" as a "2" and "Strongly Disagree" as a "1". Negatively phrased questions were coded in the reverse order such that a positive response always corresponded to a higher numerical value.

Coded responses were averaged over each construct producing an average response value for each student and each construct. Support for combining across constructs is provided through the results of the factor analysis.[14] Paired t-tests were used to compare pretest responses with posttest responses within each construct. Analysis of Covariance (ANCOVA) was completed with the pretest score as the covariate to compare responses between genders.

Results

This section begins with a description of the participating student population and is followed by a discussion of the results of the analysis of the responses to the computer science and information technology instruments.

Descriptions
Both surveys included three demographic questions at the end of the survey. The first question concerned gender. The second question asked students to report their current grade level with the four options of ninth, tenth, eleventh or twelfth grade. The final demographics question requested ethnicity with the following possible choices: i) American Indian; ii) Asian; iii) Black or African American; iv) Hispanic; v) White; vi) Multi-Racial; vii) Other, Please Specify; and viii) Choose not to Respond.

Forty-five percent of respondents to the computer science instrument were female. Forty percent of the computer science survey respondents were in ninth grade, twenty-four in the tenth grade, twenty-four in the eleventh grade and twelve in the twelfth grade. Approximately half (48%) of the respondents self-identified as white, twenty six percent as Black or African American, twelve percent as Asian, six percent as Other, with the remaining eight percent being American Indian, Hispanic, Multi-Racial, and Choose not to Respond.

Of the students that responded to the information technology survey, sixty-six percent of respondents were female. The respondents were distributed as follows among the four grade levels with nineteen percent in ninth grade, thirty-seven percent in tenth grade, thirty percent in the eleventh grade and fourteen percent in the twelfth grade. The majority of the respondents to the information technology survey self-selected as White (65%). Twelve percent self-selected as Black or African American, nine percent as Multi-Racial, seven percent as Asian and six percent as Hispanic. The remaining 1% of respondents chose not to respond as is indicated in Table 1.

Computer Science
This section addresses the results of the statistical analysis on the computer science instrument. Before intervention, males had an overall average response value of 3.215, with the most positive attitudes being for the gender construct, 3.497, and the lowest for the professional construct, 2.788. Here, the gender construct questions were scored such that gender neutral responses (e.g., males and females are equally likely to participate and perform well in computer science) received the highest scores. Females had an overall average response of 3.26. The most positive responses were in the gender construct where the average response was 3.71 and the lowest response average was in the interest construct, 2.839.

Paired t-tests were performed on the male and female responses for each question set within an intended construct. There was no statistically significant change in response score average amongst female respondents from pre-test to post-test. Among male respondents, the change in interest was the only statistically significant change in average response value, with a p-value of 0.0378. This represents an increase in average response score from 3.0023 to 3.1357.

Gender	Computer Science	Information Technology
Male	55%	34%
Female	45%	66%
Grade		
9	40%	19%
10	24%	37%
11	24%	30%
12	12%	14%
Ethnicity		
American Indian	1%	
Asian	12%	7%
Black or African American	26%	12%
Hispanic	3%	6%
White	48%	65%
Multi-Racial	1%	9%
Other	6%	
Choose not to Respond	3%	1%

Table 1 – Demographics Table

ANCOVA was performed on the construct scores of both male and females with the pretest score acting as the covariate. All residuals were normally distributed and all assumptions of the model were verified. Results of the ANCOVA suggested that the covariate was needed in the model. This indicates that there was a statistically significant difference between male and female responses with respect to all constructs measured by the pretest (all p-values were less than 0.001). After adjusting for the differences in pretest scores there was no statistically significant difference between males and females within any of the intended constructs on the posttest, p-values were all greater than or equal to 0.277. See Figure 3 for plots of the individual construct scores with pretest and posttest means for both male and female. As these graphs illustrate, male and female attitudes were approximately the same at the conclusion of the program when adjustments were made for pretest differences.

Information Technology

The average response value for males who completed the information technology survey before intervention was 3.364 and after intervention it was 3.404. Female respondents averaged 3.25 before intervention and 3.372 after intervention. Paired t-tests did not detect a statistically significant change in males average response rate in either of the measured constructs from the beginning to the end of the workshop. For female respondents, however, the general interest construct displayed an increase in average response values, from 3.0225 to 3.2512, with a p-value of the paired t-test of 0.002. Overall, female respondents displayed an increase in their scores with $p = 0.029$.

ANCOVA was performed on the construct scores of both male and females with the pretest score acting as the covariate. All residuals were normally distributed and all assumptions of the model were verified. Results of this analysis were very similar to that for the computer science survey. Results of the ANCOVA suggest the covariate is needed in the model, as all p-values were less than 0.001. After adjusting for the initial differences in pretest scores, there was no statistically significant difference between males and females within any of the intended constructs, p-values greater than or equal to 0.242, on the posttest scores. See Figure 4 for a plot of the confidence and gender scores with mean lines for both male and female.

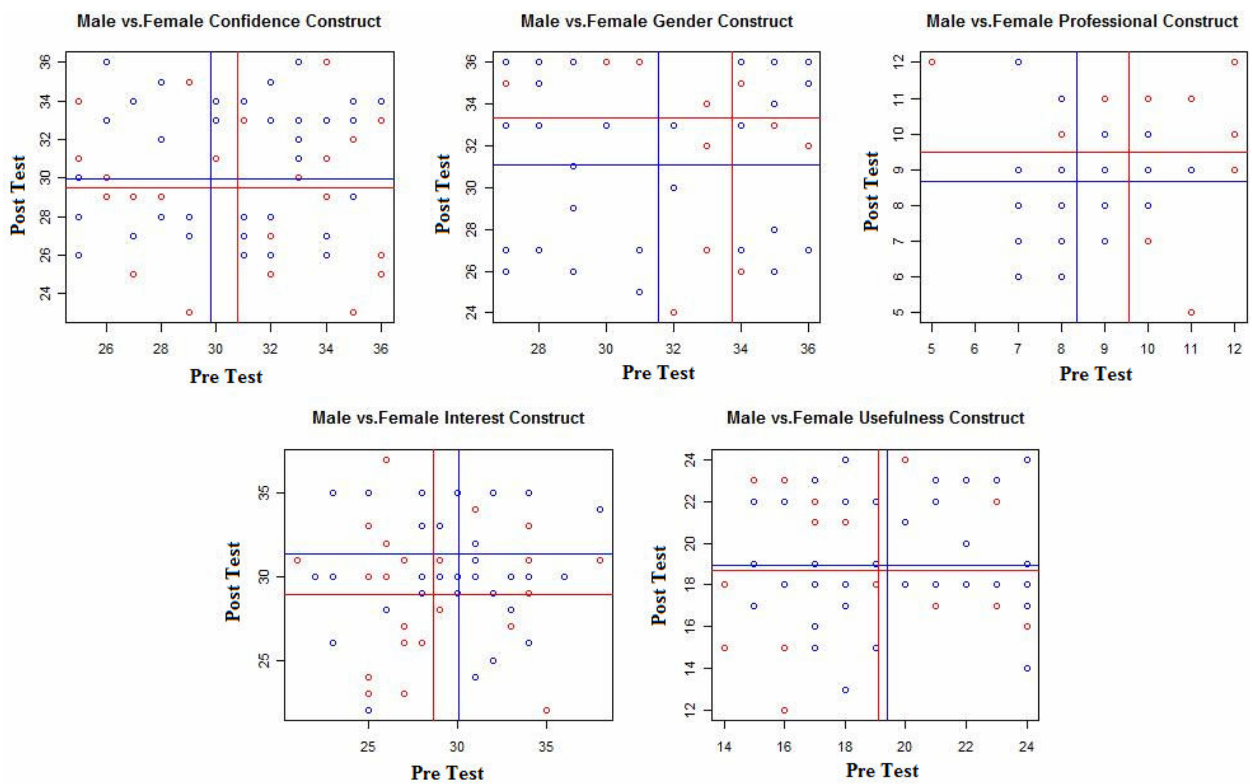

Figure 3 – Computer science construct responses with mean lines

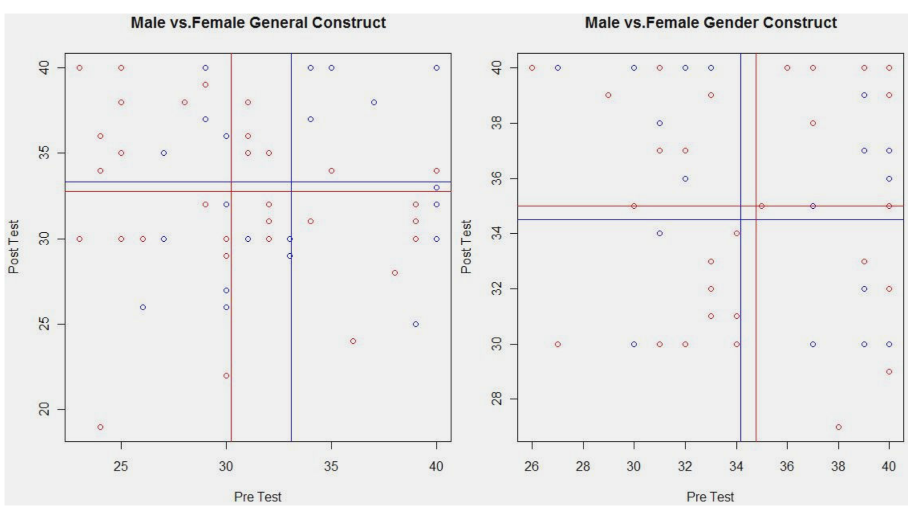

Figure 4 – Information technology construct responses with mean lines

Discussion

This article reports on the research efforts of two ongoing investigations, one addresses the attitudes held by high school students in computer science and the other information technology. Student attitudes towards these fields were measured through pre and post-test attitude surveys. Both instruments were administered during a summer workshop to self-selected high school students and both were analyzed using paired t-tests and ANCOVA. The design of each intervention was different, based on differences found in the literature that address the two fields. Therefore, this study compares differences found between the interventions rather than responses toward computer science and information technology. A contribution of this work is the questions that emerge through these comparisons and the avenues for future investigation. Additionally, this investigation adds to the evidence base that supports the effectiveness of the presented attitudes surveys.

On average, males who completed the computer science camp displayed evidence of improved attitudes with respect to the interest construct. For female participants, although attitudes in this construct improved, this was not found to be statistically significant; male and female attitudes were approximately the same at the conclusion of the program. For the information technology version of the camp, statistically significant changes were detected for female students but not for male students in response to the general interest construct. Females who participated in the information technology survey also displayed a general increase in their average scores across the two measured constructs.

Based on this analysis, the information technology camp had a stronger impact on the development of positive female attitudes with respect to information technology; the computer science camp had a stronger impact on male attitudes with respect to computer science. It cannot, however, be concluded whether it was the design of the camp or the appeal of the two subjects that influenced these results. Women may, in general, prefer information technology and this preference may be enhanced as they learn more about the field. Men may, in general, prefer computer science and this preference may be enhanced as they learn more about the field. This speculation is consistent with prior research[2,11,23,34]. Additionally, the design of the computer science camp did not directly target the development of students' knowledge with respect to career opportunities. This may have further influenced the outcomes reported here. The use of high school teachers rather than college faculty and educational consultants to provide instruction may also have influenced the results. The exact nature of the impact of these various factors is left for future research.

Another outcome of this investigation is the use of the two attitudes surveys, one in computer science and one in information technology, for the purpose of measuring change in students' attitudes from pre to post assessment on a high school population. Both of the interventions were short in duration; yet, the attitudes survey captured changes in the students' interests. Prior research has provided a foundation for the use of this instrument in measuring high school students' attitudes in computer science[14] and the findings of this investigation support the effectiveness of this instrument for capturing change over time.

A major goal of this investigation was to examine the use of the attitude survey for measuring the impact of two interventions, each implemented in a different field. A secondary outcome is the acquisition of a better understanding of the potential differences that may exist between student attitudes with respect to computer science and information technology. Based on the results, female students displayed more interest in information technology than did males; males displayed greater interest in computer science. Are these attitudes the result of gender differences in field preferences or are they the result of the interventions? Was the computer science intervention better designed to appeal to a male audience? Was the information technology intervention better designed to appeal to a female audience? Future research is needed to tease out the factors that contributed to these findings. One such investigation would be to include a parallel design in both fields, supporting controlled comparisons across interventions with respect to gender. The current investigation lays the foundation for such work and provides research based instruments to pursue these efforts.

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