MEASURING THE IMPACT OF A HIGH SCHOOL INTERVENTION ON STUDENTS' ATTITUDES IN INFORMATION TECHNOLOGY: VALIDATION AND USE OF AN ATTITUDE SURVEY

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Abstract

Attracting and retaining women and minorities in science, technology, engineering and mathematic (STEM) fields is a common challenge faced by today's universities. In response, various projects that are underway across the nation seek to increase these groups' interests in and, hopefully, their eventual participation in STEM. A challenge to these efforts has been measuring, in the short term, the impact of educational programs on students' interests with respect to STEM fields. Many of the current attitude surveys are outdated or have limited validity. This paper describes the validation of an attitude survey which was designed to measure high school students' attitudes with respect to the field of information technology (IT). The attitude survey contains two researcher-defined factors: general interest in IT and perception of gender stereotypes in IT. The attitude survey successfully captured differences in students' attitudes across year of program implementation and ethnicity in a high school IT educational program.

Introduction

Over the last several decades, there has been a shortage of female and minority students who pursue careers in information technology (IT) in the United States. Based on data provided by the National Science Foundation (NSF), only 25.3% of all mathematics and computer science (CS) bachelor degrees granted in 2008 were awarded to women, yet women comprise more than 50% of the U.S. population. The number of females pursuing degrees in mathematics and CS has been declining since 1991. While 37.8% of all mathematics and CS degrees in 2008 were awarded to minorities, less than 25% of these same degrees were awarded to minority females.[1] Additionally, researchers have found that compared to male undergraduates, female undergraduates prefer to use less technology in their courses, have weaker skill levels and reduced comfort levels with respect to data processing, and, in general, are exposed to fewer online courses and computers at home.[2,3] Compared to non-minority students, minority students are less likely to have grown up with a computer at home and often have had fewer online library experiences. Minority students are also less likely to self-identify as being skilled with email, but are more likely to identify themselves as having competence with technology in general.[3]

Researchers have determined that early classroom exposure to computers and programming may impact the rate at which female and minority students select to pursue careers in IT. In a survey by [4], 651 college students responded to questions concerning interest and enjoyment in computers and computer programming. While approximately 70% of the students surveyed enjoyed using computers and described themselves as "computer confident," only 30% had completed at least one computer programming course in high school. Interestingly, only 42% had a positive understanding of what is involved in computing careers and only 27% of the students surveyed expected to major in science, technology, engineering or mathematics (STEM).[4]

In order to attract students to IT, researchers have found that students need to be provided with positive experiences in computing at a young age. One example of such efforts includes introducing students to the Alice software, a three dimensional programming environment which uses a drag-and-drop editor. Students can learn the algorithmic reasoning of programming through the Alice software without experiencing the frustration of syntactical errors. Additionally, in order to make computing more appealing as a career choice, students and their teachers need to know the potential career options in IT. Showcasing opportunities in IT or other STEM-related fields may peak students' interest and participation in computing.[5,6,7,8,9,10]

A challenge to these efforts is measuring and quantitatively capturing the impact of these efforts on students' perceptions of STEM fields. Some researchers have sought to measure changes in students' attitudes toward IT or CS using descriptive methods.[6,9] Although descriptive statistics are useful for describing changes among a given set of participants, they have limited use in terms of generalizing to a broader population. Other researchers have developed their own instruments to measure changes in attitude toward IT or CS.[4,11,12,13] These instruments often lack the evidence necessary to support the validity of the conclusions drawn. For example, the results from the survey used in [11] indicate that non-CS male students have more confidence in using computers than female CS students. The appropriateness of this conclusion is dependent on the quality of the questions or statements that were posed. Without an analysis of this quality, conclusions can only be made with caution. A common and acceptable method of examining the appropriateness of the questions or statements posed with respect to the construct of interest is the use of a factor analysis and the analysis of reliability coefficients. Other methods include expert review, a review of the literature, and the use of triangulation methods. Many studies fail to provide such evidence.

Another concern is the use of outdated instruments or instruments that are external to the field. For example, the study in [14] used a revised version of the Fennema-Sherman Mathematic Attitudes Scale (1976) to measure students' confidence in CS. Although the original instrument has a strong evidence base to support its validity, there is little evidence to support that a revision and application to CS would result in valid results. Additionally, this instrument was written over 30 years ago, raising concerns as to the appropriateness of the questions with respect to the current generation.

Since IT is a rapidly evolving field, outdated instruments are unlikely to offer researchers accurate information. Investigator-developed instruments, on the other hand, may be up-to-date but often lack evidence of the instrument's validity and reliability. Instruments that are not valid result in misleading information; instruments that are not reliable result in imprecise information. In any of these cases, the investigator is left with an incomplete or inappropriate understanding of the population's attitudes with respect to IT.

Due to the lack of up-to-date, valid and reliable assessment instruments to assess students' attitudes with respect to CS, the NSF funded the Collaborative Research: Assessing Concept Knowledge and Attitudes in Introductory Computer Science courses in 2005 (DUE-0512062). This project was based at the Colorado School of Mines and was led by Moskal; additional collaborating institutions included Ithaca College, Saint Joseph's University and Georgia Tech.[15] This project began with a thorough review of the computing literature concerning students' attitudes and beliefs. Specific attention was given to the research on attraction, retention and gender issues in CS. A primary source that informed this work was the work of Margolis and Fisher, see [16-17]. A fifty-two statement CS attitude survey was developed based on that literature review and was designed to measure five constructs: 1) Confidence in learning CS, 2) Perceptions of CS as a male dominated field, 3) Beliefs in the usefulness of learning CS, 4) Interests in CS and 5) Beliefs about professionals in CS. These constructs emerged as potentially important based on the literature review. For more information on the development, design, expert review and validation of this instrument, see [7,15,18]. Based on these studies and with respect to computer science, this instrument appears to be adequately measuring four of the five constructs. The only construct that continues to have statistical concerns is beliefs about professionals in CS.

In 2008, the NSF funded the Surprising Possibilities Imagined and Realized through Information Technology (SPIRIT), based at Purdue University (DRL-0737679). One of the goals of this project was to improve participating teachers' and students' attitudes with respect to IT, and to statistically measure this improvement with an IT attitude survey. Unfortunately, the same problems that existed in CS with respect to validated attitude surveys were also true in IT: there were no up-to-date, validated surveys that measured students' attitudes toward IT. Also, since much of the research in CS is indistinguishable from the research in IT, the decision was made to redesign the CS attitude survey which was discussed in the previous paragraph for use in IT. The approach used was to change the term "computer science" to "information technology" throughout the instrument. When tested on a high school student population, however, it was found that the five original factors reduced to a two factor solution when implemented in IT.[7] The constructs measured through the IT survey are: 1) gender stereotypes and 2) general interest in IT. This resulted in the removal of the professional factor, as it was not functioning as expected, and the confidence, beliefs of usefulness and interest factors were combined and reduced to form a single general interest factor. As such, the IT attitude survey cannot separately evaluate students' confidence in learning IT, beliefs of usefulness in learning IT and interest in IT. Removal of the professional factor may be indicative that students do not know what it means to be a professional in IT and that the constructs are ill-defined for a high school population.[7] In comparison, a survey of 836 high school students from California and Arizona in 2006 found that the top reason for not pursuing a career in CS was not wanting to spend their entire day, every day, in front of a computer.[9] The current article reviews the reduction of the original survey to two factors, and describe both the validation and the results of using this survey for the SPIRIT summer 2008 and 2009 program.

Research Questions

This paper describes the validation of the revised attitude survey which was designed to measure high school students' attitudes with respect to the IT field. This survey was administered to high school students who participated in the SPIRIT program during the summers of 2008 and 2009. This paper reports the results of using this instrument to measure changes in high school students' attitudes from the beginning to end of the program. The research questions addressed are as follows:

- Do results from a factor analysis on the IT attitude survey support the existence of the two proposed factors?
- Based on factors underlying the IT attitude survey, is there a measurable change in students' attitudes with respect to IT after completing the SPIRIT summer workshop?
- Based on this same instrument, do attitudes differ across gender, ethnic group, the year of implementation, or level of understanding of programming concepts?

Methods

The first section that follows describes the development of the IT attitude survey based on the previously validated CS attitude survey. This is followed by a description of how the IT instrument has been examined for its validity and reliability and how it has been revised based on these results. Both the original and the revised versions of the CS instrument are displayed in Table 1 and the revised, most current IT version is displayed in Table 2. The second section that follows describes the use of the IT attitude survey as part of the SPIRIT program.

Original Design

The original CS attitude survey was developed and its validity examined as part of the NSF-funded Collaborative Research: Assessing Concept Knowledge and Attitudes in Introductory Computer Science courses in 2005 (NSF, DUE-0512062).The original survey, displayed in Table 1, had 52 Likert-scaled statements with the following categories: strongly agree, agree, strongly disagree, and disagree. In order to develop this instrument, a thorough review of CS recruitment and retention research was completed, with an emphasis on gender equity issues. For a detailed description of the development process, see [18].

Guided by the research and expert feedback, this instrument was designed to measure the following five constructs: 1) confidence in learning CS, 2) Perceptions of CS as a male dominated field, 3) Beliefs in the usefulness of learning CS, 4) Interests in CS and 5) Beliefs about professionals in CS.[15] Factor analyses supported the existence of these factors for high school and college populations in CS; however, the professional construct was only weakly supported.[15,18] Cronbach's alpha statistics were further used to confirm its internal consistency. Based on the results of these analyses, potentially faulty statements or statements which did not align with the intended factor were removed, and the instrument was reduced to 32 statements. In Table 1, a strike through a statement indicates that it was removed based on results from this statistical analysis.

Validation and Revision

As discussed, this survey was originally developed to assess attitudes with respect to CS. However, there is a great deal of overlap between the research on CS and IT. In many articles the generic term "computing" is used for both fields. This makes it challenging to distinguish between the results within each field. In order to measure students' attitudes within IT, the target construct for SPIRIT, the phrase "computer science" was replaced by "information

Table 1. Original and Reduced CS Attitude Survey.

Confidence construct (C):	
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 have a lot of self-confidence when it comes to computing courses.~~
C6	I can achieve good grades (C or better) in computing courses.
C7	I am confident that I can solve problems by using computer applications.
C8	~~I am uncertain that I can achieve good grades (C or better) in computing courses.~~
C9	I am not comfortable with learning computing concepts.
C10	I doubt that I can solve problems by using computer applications.
Interest construct (I):	
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.
Gender construct (G):	
G1	I doubt that a woman could excel in computing courses.
G2	Men are more capable than women at solving computing problems.
G3	Computing is an appropriate subject for both men and women to study.
G4	~~It is not appropriate for men to study computing.~~
G5	~~Women are more capable than men at solving computing problems.~~
G6	~~Women are more likely to excel in careers that involve computing than men are.~~
G7	~~Women produce higher quality work in computing than men.~~
G8	Women and men can both excel in careers that involve computing.
G9	~~I doubt that a man could excel in computing courses.~~
G10	It is not appropriate for women to study computing.
G11	Men produce higher quality work in computing than women.
G12	Men are more likely to excel in careers that involve computing than women are.
G13	Women produce the same quality work in computing as men.
G14	Men and women are equally capable of solving computing problems.
G15	Men and women can both excel in computing courses.
Usefulness construct (U):	
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	~~I use computing skills in my daily life.~~
U4	My career goals do not require that I learn computing skills.
U5	Developing computing skills will be important to my career goals.
U6	Knowledge of computing skills will not help me secure a good job.
U7	I do not use computing skills in my daily life.
U8	I expect that learning to use computing skills will help me achieve my career goals.
Professional construct (P):	
P1	~~Doing well in computer science does not require a student to spend most of his/her time at a computer.~~
P2	A student who performs well in computer science will probably not have a life outside of computers.
P3	~~To do well in computer science, a student must spend most of his/her time at a computer.~~
P4	A student who performs well in computer science is likely to have a life outside of computers.

P5	~~Being good at computer science is a negative quality.~~
P6	Students who are skilled at computer science are less popular than other students.
P7	~~Being good at computer science is a positive quality.~~
P8	Students who are skilled at computer science are just as popular as other students.
P9	~~Students who are skilled at computer science are more popular than other students.~~

technology." Additionally, some statements were revised to contain the more general term, "computing," which is used in both the CS and IT fields. The current version of the IT attitude survey is a subset of statements from the original 52 statement IT survey.

Participants' responses to the statements in the attitude survey were mapped to a numerical value between one and four, with higher values reflecting more positive attitudes. In other words, a positively worded statement was scored a four for strongly agree, a three for agree, a two for disagree, and a one for strongly disagree. A negatively worded statement was scored a four for strongly disagree, a three for disagree, a two for agree, and a one for strongly agree. A high score for a gender statement reflected a gender neutral, rather than a gender biased, response.

The SPIRIT program and Participating Population

The SPIRIT summer program was one week in duration for students, and was taught by college faculty and educational consultants. All participants were volunteers. Since the SPIRIT program was targeted at female high school students, the majority of student participants were female. The use of volunteers results in a sample of convenience and therefore limits the extent to which these findings can be generalized beyond the participating population.

An important aspect of the SPIRIT program was the use of the Alice software to create animated stories. According to [19], female students enjoy using software to create stories and to communicate their ideas. The goal of using the Alice software in this study was not to convince students to become programmers but rather to demonstrate that the Alice software may be used as a tool to convey information, much like Microsoft Word, Publisher, and PowerPoint are used. Students were given the task of creating an Alice world that either illustrated a popular story or described a personal career goal.

Students also completed a pre and post program Concept Exam, which assessed basic understanding of programming commands in Alice. SPIRIT's goal was to show students how to use Alice as a tool to develop interactive, animated stories, *not* to learn programming. As such, SPIRIT administrators did not expect students' scores to improve by much, and when the Concept Exam was administered, participants were reminded that their performance had no impact on the program administration or their qualifications for attending the program.

In addition to the Alice software, the SPIRIT program exposed participants to the many unexpected benefits that IT provides to society. Researchers have found that understanding the interpersonal applications of a given career is important for increasing female interest in that career.[20] Presenters were drawn from various fields, such as theater, cyber forensics and robotics, to describe how IT increased both the efficiency and quality of their work. IT was described as a "business skill" that could lead students to project management, even if they did not excel in math or science. Emphasis was placed on the importance of communication in both career networking and the IT field. Future entrepreneurs learned that a degree in IT could help give them an edge in the business world by meshing technology with communication. As a further emphasis, students were informed that a degree in Computers and IT at Purdue University consisted of one part liberal arts, one part business and one part technology. Given that student participants were volunteers and most likely entered the program with an interest in IT, change in general interest in IT was not expected to be large.

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. For more information on the SPIRIT program, see [21].

The 2008 summer program was attended by a total of 68 high school students, of which 23 were male and 45 were female. The large representation of girls is a reflection of the success of a recruitment process that focused on females. Of the 68 total students, 45 identified themselves as Caucasian. Attending students varied in grade from 9th to 12th. All appropriate human subjects procedures were followed. Signed assent forms were received from student participants and consent forms from their guardians.

The 2009 summer program was attended by a total of 74 high school students, of which 22 were male and 52 were female. Of the 74 total students, 43 identified themselves as Caucasian. Attending students varied in grade from 9th to 12th. All appropriate human subjects procedures were followed. Signed assent forms were received from student participants and consent forms from their guardians.

Revision of IT Attitude Survey

Initial revisions to the IT attitude survey were based on data collected during the summer of 2008. Two statistical techniques were used to examine the instrument's reliability and validity: Cronbach's alpha and exploratory factor analysis (EFA). An EFA was performed on the pre-summer program data in order to confirm that the attitude survey was measuring the correct constructs without program intervention. For more information on EFA, see [22]. Statements that did not load at the 0.40 cutoff were removed from the survey. As was discussed in [7], only the gender construct loaded as expected. Based on these results, the IT survey was reduced to 20 statements, consisting of two confirmable factors: gender stereotypes (G) and general interest (I) in IT. The professional construct was removed and the confidence, beliefs and interest constructs were combined into a single measurable factor. Table 2 contains the reduced IT attitude survey for students, with statements divided by factor.

Administrative Process

The IT attitude survey administered during the 2008 summer program contained the original, full length survey of 52 statements. For the summer of 2009, the shortened IT attitude survey, consisting of 20 statements, identified through the EFA and Cronbach's alpha, was administered.

Incomplete responses were excluded from the following analysis. A total of eight students from either summer 2008 or summer 2009 did not complete either the pre or post IT attitude survey, and were omitted from the dataset. Two additional students did not indicate their ethnicity and were omitted from the linear regression analyses.

Table 2. Reduced Student IT Attitude Survey.

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

Results

The first section that follows reports the results of a confirmatory factor analysis (CFA) on the pre IT attitude survey data collected in 2008 and 2009. The second section uses linear regression to examine the importance of various student factors on the results of this analysis. The final section examines the changes in students' responses from pre to post assessment within each given year. In other words, the sections that follow address the three research questions.

Factor Analysis

As was discussed in the "Methods" section of this paper, an EFA completed on the IT attitude survey data from the summer 2008 SPIRIT program resulted in the reduction of the 52 statement survey to a twenty statement survey with two factors: gender stereotypes (G) and general interest in IT (I). The summer 2009 survey data was coded in the same manner as described in the "Methods" section. For the current investigation, a CFA was completed on the covariance matrix from the reduced IT attitude survey for both the summer 2008 and 2009 program. Summer 2008 data was included in the CFA in order to examine how the IT attitude survey performed across both years of implementation.

In order to establish the reliability of the instrument, Cronbach's alpha values were calculated and these are displayed in Table 3. For both the pre and post survey, each Cronbach's alpha was above the acceptable level, indicating that the IT attitude survey is reliable and internally consistent.

Table 3. Cronbach's alpha values for IT survey.

	Pre	Post
Survey data	**Cronbach's α**	**Cronbach's α**
Interest (I) Factor	0.9129	0.9035
Gender (G) Factor	0.8489	0.8509
Overall	0.8876	0.8693

Based on previously discussed theory and evidence, a two-factor model was specified in which statements I1 through I10 loaded onto the latent variable of general interest in IT (factor I), and in which statements G1 through G10 loaded onto the latent variable of gender stereotypes in IT (factor G). Factors I and G, as well as statements I4 and I5, were permitted to correlate. Additional parameters were added to the model due to large modification indices. Table 4 contains the two-factor structure results for the pre and post IT attitude surveys.

Table 4. CFA results for IT survey.

Parameter	Pre	Post
λI1	0.56	0.61
λI2	0.64	0.55
λI3	0.68	0.72
λI4	0.71	0.78
λI5	0.69	0.67
λI6	0.78	0.81
λI7	0.68	0.77
λI8	0.79	0.73
λI9	0.68	0.55
λI10	0.66	0.56
λG1	0.89	0.89
λG2	0.91	0.77
λG3	0.92	0.91
λG4	0.35	0.58
λG5	0.11	0.43
λG6	0.26	0.58
λG7	0.21	0.52
λG8^	0.26	0.29
λG9^	0.17	0.17
λG10^	0.17	0.13
δI4,I5^	0.15	0.02
δI9,I10	0.51	0.23
δG6,G7	0.56	0.49
δG8,G9	n/a	0.46
δG9,G10	n/a	0.62
δG8,G10	n/a	0.32
ϕGI^	0.02	0.11

^ indicates insignificance at cutoff level of 0.30 for both pre and post

Table 5. Goodness-of-Fit Indices for IT survey.

	SRMR	RMSEA	Bentler's CFI
Pre	0.1507	0.1093	0.7958
Post	0.1087	0.0837	0.8860

Goodness of fit for the pre and post IT attitude survey was evaluated with three different measures: standardized root mean square residual (SRMR), comparative fit index (CFI) and root mean square error of approximation (RMSEA).[23] In order for model fit to be considered appropriate, SRMR should be less than or equal to 0.08, RMSEA should be less than or equal to 0.06, and Bentler's CFI should be greater than or equal to 0.95.[23] Table 5 contains the goodness of fit indices for the pre and posts IT attitude surveys. For both the pre and post IT attitude surveys, the goodness-of-fit indices are approaching but have not reached specified levels. This indicates that caution is warranted when interpreting the results of the factor analysis.

For the pre and post IT attitude survey, all statements in the general interest (I) factor loaded as expected, supporting the use of the statistical analyses that are reported in the next sections. Statements G5, G6 and G7 did not load significantly onto factor G for the pre IT attitude survey, but did load significantly for the post survey. Statements G8, G9 and G10 did not load significantly onto factor G for either the pre or post IT attitude survey. A qualitative analysis of these statements supports their fit within factor G; however, additional analyses will be completed on the data collected during the summer of 2010 to examine whether these statements are functioning as expected. Although caution must be taken in the interpretation process, the use of the statistical analyses reported in the results section is supported.

The pre IT attitude survey was not able to converge on a solution when parameters $\delta G8,G9$, $\delta G9,G10$, and $\delta G8,G10$ were included in the model. This raises concern of participants' consistency in their pre survey responses. The insignificant correlation between statements I4 and I5 ($\delta I4,I5=0.15$ for pre, $\delta I4,I5 = 0.02$ for post) also raises concern of participants' consistency because statement I4 is the negative equivalent of statement I5. Due to potential inconsistency in participants' responses and the instability of factor G, caution must be taken in the interpretation process of the following analyses. The small correlation between factor I and factor G ($\phi GI =0.02$ for pre, $\phi GI =0.11$ for post) provides evidence that factor I and factor G can be analyzed separately in the following statistical analyses.

Linear regression analyses

Nested F tests were used to determine if gender, ethnic group, year of implementation and Concept Exam scores were significant factors in predicting IT attitude survey difference scores in the regression model. Second-order interactions were included in the full model.

Results from linear regression analyses indicate that ethnic group and year of implementation had a statistically significant influence on factor I changes (p=0.0225 and p=0.0054, respectively). Gender and Concept Exam scores did not significantly contribute to the explanation of differences in factor I scores. Gender, ethnicity, year of implementation and Concept Exam scores of participants did not significantly contribute to the explanation of differences in factor G scores.

Table 6 contains differences in mean factor scores across the year of program implementation. All students and minority students in particular in 2008 experienced a significant change in factor I scores (p=0.0052 and p=0.0093, respectively). Non-minority students did not experience a significant change in factor I scores in 2008 (p=0.1600). No significant changes in factor I scores were found in 2009. Minority students entered the SPIRIT program with a higher general interest in IT in 2009 compared to 2008. Also, students entered the SPIRIT program with a more positive perception of gender stereotypes in IT in 2008 compared to 2009. Compared to students' mean difference scores in

Table 6. Mean Factor Score Differences across SPIRIT implementation.

	Year	Participants	#	Pre	Post	Difference	P-value
Factor I	2008	All Students	60	21.23	22.67	1.44	0.0052*
		Minority Students	21	20.57	23.14	2.57	0.0093*
		Non-minority Students	39	21.59	22.41	0.82	0.1600
	2009	All Students	71	21.99	22.04	0.05	0.9437
		Minority Students	27	22.41	21.11	-1.30	0.0548
		Non-minority Students	44	21.86	22.61	0.75^	0.0866
Factor G	2008	All Students	60	17.27	17.20	-0.07^	0.9408
	2009	All Students	71	14.39	14.83	0.44^	0.1948

^ indicates data was not normally distributed by Shapiro-Wilk test;
in this case a Wilcoxon signed rank test was used
* indicates statistical significance at an alpha level of 0.05 with Bonferroni correction

2008, students in 2009 experienced less of a positive attitude change with respect to general interest in IT, but a greater positive attitude change with respect to gender stereotypes in IT.

Comparing Means across Years

Since the interaction term between ethnic group and year of implementation was significant for changes in factor I scores, means were compared across the corresponding groups: non-minority students from 2008, minority students from 2008, non-minority students from 2009 and minority students from 2009. Figure 1 contains a boxplot summary of these groups. In order to control the simultaneous error of pairwise differences to 0.05, Tukey's Honest Significant Differences (HSD) were calculated. A significant difference was found across year of implementation for minority students' changes in factor I scores. No such difference was found for non-minority students. In other words, the manner in which the program was implemented in 2008 as compared to 2009 may have had an impact on minority students' general interest with respect to IT but not with respect to non-minorities.

Conclusions

Based on the results from the CFA, it can be concluded that the revised 20 statement survey addresses the two intended factors, general interest (I) and gender stereotypes (G) in IT. Several statements with respect to factor G, however, did not load significantly for either pre or post data but appear to appropriately fit factor G based on the qualitative analysis. The appropriateness of these statements with respect to factor G will be re-examined using the 2010 data. All factor I statements loaded as anticipated. Given these findings, there is evidence to support that this instrument can be validly used on the participating population of students to examine IT attitudes with respect to general interest and gender stereotypes in IT; however, the evidence is stronger with respect to factor I. This result supports the use of this data to respond to the remaining research questions for this population of students.

Examining pre to post assessment differences revealed that all students, including minority students, experienced significantly positive changes in factor I scores in 2008 (p=0.0052 and p=0.0093, respectively). None of the other pre to post comparisons for factor I or G in 2008 and 2009 were found to be significantly different from zero. Results from linear regression analyses indicate that ethnic group and year in which a student participated in the program did have a statistically significant influence on changes that were witnessed in general interest in IT (factor I). The gender and difference in Concept Exam scores of participants did not significantly contribute to the explanation of differences in factor I scores. Gender, ethnic group, year of attendance and difference in Concept Exam scores of participants did not significantly contribute to explanations of differences in students' perceptions of gender stereotypes in IT (factor G).

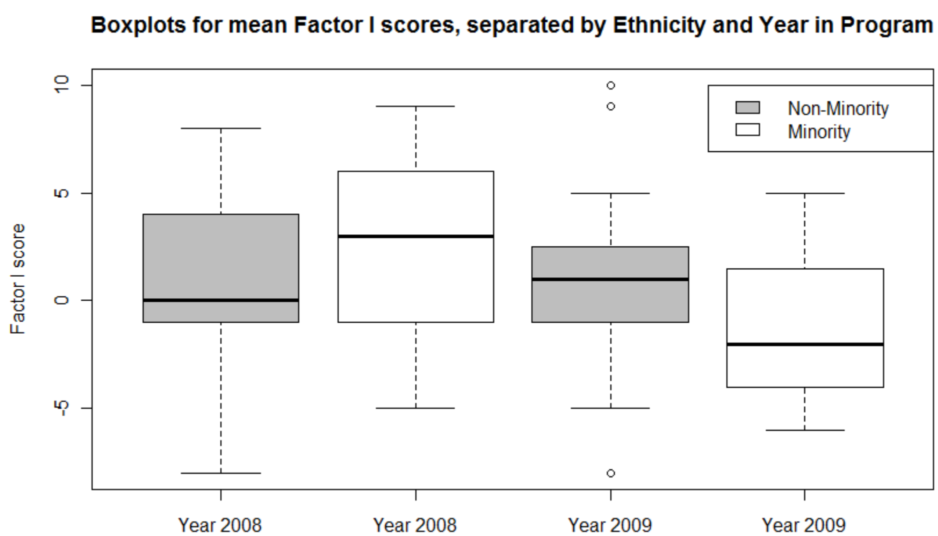

Figure 1. Boxplot Summary, Factor I.

There are several potential explanations for the witnessed differences in factor I scores for minority students between years of implementation. One explanation is that in 2008 the full 52 statement IT attitude survey was administered to the students. In 2009, the reduced survey was administered to the students. Although this analysis focused on the same 20 statements for each year, the completion of a more detailed instrument in 2008 could have had an unintended impact on students' responses. Another difference between the implementation of the two summer programs was that, based on the student identified concerns in 2008, the length of lectures was reduced and hands-on activities were improved in 2009. Presenters in 2008 stressed the positive impact that IT had on people's lives, while in 2009, with a shift from less lecturing to more hands-on activities, presenters may have unintentionally shifted the focus from the societal impact technology had to technology for the sake of technology and entertainment. Also in 2009, students gave poor feedback for four presentations which were delivered by graduate students who did not adequately prepare and had problems arise. Still another factor may have been the enthusiasm of the instructors that surrounded the implementation of the project and the goals of the project during the first year. The instructors may have unintentionally changed their instructional approaches from 2008 to 2009 in a manner that impacted minority appeal. Yet another explanation may be that between the summers of 2008 and 2009, awareness of and interest in IT had increased for the overall general population. As such, incoming students in 2009 were more interested in IT and thus had less improvement to make. The authors would like to note that money was used as an incentive for students to participate in SPIRIT, and this may have had an impact on students' motivation of learning about IT. Also, combining all minorities into one subgroup in these analyses may have diluted results within each specific minority group. The authors acknowledge that any of these factors could have impacted the results reported here. Future research is necessary to tease out the influencing factors.

Significance

A major contribution of this research is the on-going development and analysis of an IT attitude survey. The evidence presented here supports the existence of two factors within the survey, each of which can be measured independent of the other on the participating population of students. The use of this survey within the given student population did provide evidence of differences that were witnessed across populations. Although this research did not result in the identification of the causes that contributed to the witnessed differences, the survey itself did capture these differences, providing direction for future research. As with any instrument, the validation of this instrument and the collection of evidence to support valid interpretations is an ongoing process. Future research is encouraged that examines the effectiveness of this instrument on different student populations and across other similar IT or CS attitude surveys in order to reduce mono-operation and mono-method bias.

In summary, the IT attitude survey does appear to be functioning correctly with respect to at least one of the two factors, Factor I. Factor G also appears to be functioning correctly, but future research is desirable. Significant differences across student groups were captured in the latent factors of the attitude survey. Analysis of the IT attitude survey with 2010 data is currently underway. It is anticipated that this will reveal additional information concerning the underlying latent factor structure.

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Bibliography

1. National Science Foundation, Division of Science Resources Statistics. 2008. C-14: Science Bachelor's degrees, by race/ethnicity, citizenship, sex, and field: 2008. http://www.nsf.gov/statistics/wmpd/sex.cfm#degrees

2. Katz, R. N. 2006. The ECAR study of undergraduate students and information technology, 2006. *Educause Center for Applied Research*, December: 1-11.

3. Messineo, M. and DeOllos, I. Y. 2005. Are we assuming too much? Exploring students' perceptions of their computer competence. *College Teaching, 53*(2): 50-55.

4. Rowell, G. H., Perhac, D. G., Hankins, J. A., Parker, B. C., Pettey, C. C., and Iriarte-Gross, J. M. 2003. Computer-related gender differences. *Proceedings from SIGCSE'03*, Reno, Nevada, February 19-23.

5. Backnak, R., Chappa, E. and De La Rosa, K. 2009. Exposing K-12 students to science and engineering. *Proceedings from 39th ASEE/IEEE Frontiers in Education Conference*, San Antonio, Texas, October 18-21.

6. Cantrell, P. and Ewing-Taylor, J. 2009. Exploring STEM career options through collaborative high school seminars. *Journal of Engineering Education*, *98*(3): 295-303.

7. Heersink, D. and Moskal, B. 2010. Measuring high school students' attitudes toward computing. *Proceedings from SIGCSE'10*, Milwaukee, Wisconsin.

8. Maxim, B. R. and Elenbogen, B. S. 2009. Attracting K-12 students to study computing. *Proceedings from 39th ASEE/IEEE Frontiers in Education Conference*, San Antonio, Texas, October 18-21.

9. Rursch, J. A. and Jacobson, D. 2009. IT-adventures: turning high school students "on" to information technology. *Proceedings from 39th ASEE/IEEE Frontiers in Education Conference*, San Antonio, Texas, October 18-21.

10. Weinberg, J. B., Pettibone, J. C., Thomas, S. L., Stephen, M. L., and Stein, C. 2007. The impact of robot projects on girls' attitudes toward science and engineering. *Proceedings from Robotics Science and Systems (RSS) Workshop on Research in Robots for Education*, Georgia Tech, Atlanta, GA.http://www.roboteducation.org/rss2007/fullpapers/WeinbergRSS2007_Final.pdf

11. Beyer, S., Rynes, K., Perrault,, J., Hay, K. and Haller, S. 2003. Gender differences in computer science students. *Proceedings from SIGCSE'03*, Reno, Nevada, February 19-23, 2003.

12. Beyer, S., DeKeuster, M., Walter, K., Colar, M. and Holcomb, C. 2005. Changes in CS students' attitudes towards CS over time: an examination of gender differences," *Proceedings from SIGCSE'05*, St. Louis, Missouri, February 23-27, 2005.

13. Lewis, C. 2007. Attitudes and beliefs about computer science among students and faculty. *Inroads – the SIGCSE Bulletin, 39*(2): 37-41.

14. Young, B. J. 2001. Gender differences in student attitudes toward computers. *Journal of Research on Computing in Education, 33*(2): 204-216.

15. Moskal, B., Behrens, N., Guzdial, M., Tew, A., Dann, W. and Cooper, S. 2005. Collaborative research: assessing concept knowledge and attitudes in introductory computer science," *NSF*, DUE-0512064.

16. Margolis, J., Fisher, A. and Miller, F. 2000. Caring about connections: gender and computing. *IEEE Technology and Society Magazine*, Winter: 13-20.

17. Margolis, J. and Fisher, A. 2003. *Unlocking the Clubhouse: Women in Computing*, MIT Press: Cambridge, Massachusetts.

18. Hoegh, A. and Moskal, B. 2009. Examining science and engineering students' attitudes toward computer science. *Proceedings from 39th ASEE/IEEE Frontiers in Education*

conference, San Antonio, Texas, October 18-21.

19. Hanor, J. H. 1998. Concepts and strategies learned from girls' interactions with computers. *Theory into Practice, 37*(1): 64-71.

20. Morgan, C., Isaac, J.D. and Sansone, C. 2001. The role of interest in understanding the career choices of female and male college students. *Sex Roles, 44*(5/6): 295-320.

21. Harriger, A. 2008. Finding success through SPIRIT. *Journal of STEM Education, 9*(3,4): 31-36.

22. Costello, A. B. and Osborne, J. 2005. Best practices in exploratory factor analysis: four recommendations for getting the most from your analysis. *Practical Assessment Research and Evaluation*, *10*(7).

23. Brown, T. A. 2006. *Confirmatory factor analysis for applied research*. New York: Guilford Press.

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