AC 2009-482: SURPRISING POSSIBILITIES IMAGINED AND REALIZED THROUGH INFORMATION TECHNOLOGY (SPIRIT): ATTRACTING HIGH SCHOOL STUDENTS TO INFORMATION TECHNOLOGY

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Abstract

There has been a significant decline in the number of female students who are interested in pursuing majors in the fields of Information Technology (IT). Additionally, the supply of students educated in IT is less than the current employment demand. The primary goal of the SPIRIT program is to increase high school students’ interests in IT through direct interventions and through secondary contact via high school teachers and guidance counselors. Selected high school students were invited to attend a summer workshop in 2008. Multiple forms of assessment, including pre and post assessments, attitudes measures and self-report, were used to evaluate the impact that the summer workshops had on participants’ IT attitudes and performances. The qualitative and quantitative measures used in this investigation indicate that both the students’ attitudes and performances improved from beginning to end of the one week summer workshop.

I. Introduction

Compared to the current employment demand for information technology (IT) professionals, the number of students selecting to pursue degrees in IT in the United States is inadequately low.\textsuperscript{1,2,3} Using statistics collected and published through the National Science Foundation, the number of bachelor’s degrees awarded across the nation in computer science rose by less than one percent between 1997 and 2006. Yet, the demand for IT professionals is growing. Many authors have argued that this marginal growth is inadequate to meet U.S. industrial needs.\textsuperscript{3}

The statistics with respect to the percentage of women pursuing IT careers is of even greater concern. In 1997, 27% of awarded computer science bachelor’s degrees throughout the nation were awarded to women. This percentage remained approximately constant until 2003 at which point it began to drop.\textsuperscript{4} Between 2003 and 2006, both the percentage of women and the number of women receiving bachelor’s degrees in computer science decreased. By 2006, only 21% of awarded bachelor’s degrees across the nation in computer science were awarded to women; this reflects a numerical difference with over 6000 fewer degrees being awarded to women in 2006 than in 2003. According to an article in the \textit{New York Times}, the gap between males and females pursuing computing degrees has recently reached 25 year all time high.\textsuperscript{5} Women, as a subpopulation, are severely underrepresented in IT fields and their participation is decreasing. Women account for only 20% of the IT workforce in the United States.\textsuperscript{6} Yet, it is well recognized that women offer to IT viewpoints that are different from males, and these diverse perspectives are necessary to the advancement of the field.\textsuperscript{7}

Research [8] in computer science education has provided insight into the problems that need to be addressed in order to increase the participation of both males and females in computer science. Several researchers have found that students, especially women, lack confidence in their
ability to learn computing concepts.\textsuperscript{8,9} Also, computer science is perceived by many as a career that is appropriate for men but not for women.\textsuperscript{8,10} Margolis and Fisher have further found that women seek majors for which they know the practical applications. According to Yasuhara \cite{11}, many students, regardless of gender, opt out of a computing major due to a lack of knowledge of the career potentials available in this field. Women may also select not to participate in IT because there are very few female role models in the field.\textsuperscript{8}

SPIRIT is a three year project, funded by the National Science Foundation, designed to combat the declining interest in IT careers discussed here. According to Pollock et al. \cite{12}, the pipeline of students interested in pursuing a major in the IT fields narrows significantly at the high school level. This is especially true for girls who in 2003 comprised only 6\% of the students nationwide completing the Advanced Placement Computer Science exam.\textsuperscript{13} The current study focuses on this critical transitional point, high school, and uses the factors previously identified as a framework for an intervention. The goals of the SPIRIT program include \cite{14}:

- Improving female students' understanding of the wide ranging career opportunities in IT.
- Improving the attitudes of female students regarding the computing disciplines.

To achieve these goals, high school teachers, counselors and students, attended the SPIRIT summer workshops in 2008. These workshops provided an overview of career possibilities that are made available through the study of IT fields. Participants attended talks given by IT professionals and directly learned IT concepts through the use of the Alice software. Alice is a three-dimensional, animation software, created by the late Randy Pausch at Carnegie Mellon University, that employs a drag-and-drop editor.\textsuperscript{15} The Alice software has been successfully used to teach basic programming skills in a variety of settings.\textsuperscript{16,17,18} Many high school students participating in the SPIRIT summer workshop had no prior programming experience. The Alice software’s drag/drop editor eliminates common syntax errors committed by novice programmers, thus reducing student frustration. This article presents the results of the student portion of the first SPIRIT summer workshop.

The research questions addressed here are:

1. Did the SPIRIT summer workshop improve participating high school students’ attitudes with respect to IT careers?
2. Did the SPIRIT summer workshop improve participating high school students’ knowledge of how to program using the Alice software?
3. What changes can be made to the SPIRIT summer workshops to further improve students’ attitudes with respect to IT careers and their knowledge of the Alice software?

Similar workshops will be offered over the next three years and the findings presented here will be used to improve their design and implementation. The results and opinions expressed herein are that of the authors and do not necessarily reflect that of the NSF.
II. Methods

This section describes the design of the 2008 student portion of the SPIRIT summer workshop, the target student population, and the quantitative and qualitative methodologies that were used.

A. Workshop Design

The 2008 SPIRIT summer workshop consisted of a two week summer institute. Teachers participated in the full two week program while guidance counselors and students participated in the second week only. During week one of the workshop, teachers were educated about IT careers and the integration of the Alice software in their classrooms. Counselors and students attended only the second week of the workshop. They received basic instructions on Alice from the SPIRIT teachers. During the second week, students, teachers and counselors also attended presentations by IT professionals in areas such as robotics, law enforcement, health care and many others. By the conclusion of the summer workshop, students, teachers and counselors each created an individual project with the Alice software. The students were encouraged to develop an accompanying PowerPoint presentation. At the conclusion of the workshop, students had an opportunity to show their projects to family members and other guests. More information about the overall SPIRIT approach is available in [19]. This paper focuses on the student component of the second week of the workshop, which was primarily designed to introduce high school students to the career possibilities in IT. The list below outlines the types of educational activities in which all students participated:

1. Guest Speakers
   a. IT Healthcare
   b. Digital Forensics
   c. Mobile Forensics
   d. IT Career Opportunities
   e. IT & Robotics
   f. Early IT Careers Panel
   g. Telecommuting & IT
   h. IT Professional Do’s and Don’ts
   i. Visualization Lab Tour

2. Hands-on, computer-based sessions
   a. Alice introduction
   b. Diet management with cell phones
   c. Computing tools to support healthcare
   d. Computing tools to support special needs
   e. Robotic simulations
   f. Data management
   g. Developing video games for the PC or Xbox
   h. Web Mashups with Popfly
   i. Second Life

3. Interactive, critical thinking exercises (non-computer-based)
Additionally, a variety of evening activities kept the students quite busy throughout the week:
1. Pizza party
2. Bowling
3. Team-building activities & dinner hosted by industry partner
4. Picnic & project development
5. Developing your elevator speech sponsored by industry partner

B. Population

The target population for the SPIRIT project is high school students, with an emphasis on female students. The workshop was designed to appeal to females, although recruitment efforts were made to the broader population. Sixty-eight high school students completed the student portion of the summer workshop. The grade level and gender breakdown of these students is provided in Table 1. One student did not complete the entire program and therefore, this student’s results are not included as part of the analysis.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshmen</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Sophomore</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Junior</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>Senior</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

Note: one subject was identified as a trade school student

C. Quantitative Methods

Two instruments were used to quantitatively evaluate the summer workshop: an Attitudes Survey and a Concept Exam. Both the Attitudes Survey and the Concept Exam were administered at the beginning (pre) and the end (post) of the summer workshop to the participating students. Each is described in the sections that follow.

a. Attitudes Survey

Currently, there is no available, validated instrument to measure high school students’ attitudes with respect to IT. However, as part of another funded NSF grant an attitude survey is being developed and validated to measure students’ attitudes with respect to computer science. For the purposes of the current investigation, this survey was modified so that its questions reflected IT rather than computer science. The modified version of the Attitudes Survey employs a Likert scale with four options, Strongly Agree, Agree, Disagree, and Strongly Disagree. Questions on this instrument are phrased in both positive and negative forms and, in all cases, scoring is adjusted such that the higher score indicates a more positive response. For each question, the participant’s response is mapped to a numerical value of 0 to 3. The highest score, or the score reflective of the most positive attitude, is three, the lowest, or the score reflective of the most negative attitude, is zero. Composite scores for the survey are determined by summing the scores for each answered question. In addition to the Likert-scale survey, the Attitudes Survey contains three short-answer questions regarding an individual’s self-report of their attitudes towards IT.
b. Concept Exam

The Concept Exam is a multiple choice assessment whose content is specific to the Alice software. This exam was written using guidelines for creating effective multiple choice questions, and reviewed by experts in the field of IT.\textsuperscript{21,22} This instrument’s effectiveness for measuring changes in students’ knowledge with respect to the Alice software has been supported by prior research.\textsuperscript{18}

D. Qualitative Methods

Two methods were used to qualitatively evaluate the summer workshops. These are described in the sections that follow. The information acquired through these instruments is formative in nature and will be used to improve the implementation of future workshops.

a. Focus Groups

The first qualitative method was the completion of focus groups, or semi-structured group interviews with small sets of students. A member of the evaluation team completed these focus groups with participants during a three day period near the end of the summer workshop. In order to maintain anonymity, participant names were not made available to the evaluator and no personal identifying information was recorded during the sessions. In addition, no workshop personnel were permitted in the room at the time of the focus groups. The student focus group participants were randomly selected, minimizing bias in responses. Each group met with the evaluator for thirty to forty-five minutes.

Three sets of students were interviewed. These groups contained nine, seven, and three students, respectively. The second group was exclusively female. A semi-structured interview format was used, responding to the same set of base questions.

b. End of Program Evaluation

All students completed an End of Program Evaluation on the last day of the workshop. This self-report, written instrument was analyzed using the method of emergent categories; the responses were examined for common themes, and coded based on those themes. The purpose of this instrument was to solicit feedback from participants concerning their workshop experience.

III. Results

This section is divided based on the assessment method used. Specifically, this section provides a detailed summary of the results concerning the outcome of the Attitudes Survey, Concept Exam, Focus Groups, and End of Program Evaluation.

A. Attitudes Survey

In order to measure change in attitudes, difference scores from pre to post administration of the Attitudes Survey were examined using a two-tailed, paired t-test on student data. Only
participants who completed both the pre and post survey were included in this analysis. These
groups were further divided into male and female groups and re-tested. The student pool was
large and diverse enough to separate and test the outcomes for the ethnicities of White and
African American. When sample sizes were small, box plots were constructed to establish
normality before the tests were completed. All analyses were completed using R and the results
are displayed in Table 2.

As indicated in Table 2, a statistically significant positive change was identifiable for all tested
student groups, with the exception of African Americans. The overall male group could not be
statistically tested due to the sample size and the existence of outliers in the data. The reader will
notice that there was an increase based on descriptive statistics from pre to post assessment for
all groups. The lack of statistical change for the African American group may be a result of an
inadequate sample size.

Table 2. Student performance on Attitudes Survey

<table>
<thead>
<tr>
<th>Student Attitudes</th>
<th>N subjects</th>
<th>Mean Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Students</td>
<td>67</td>
<td>5.46</td>
<td>0.005*</td>
</tr>
<tr>
<td>Students – Female</td>
<td>44</td>
<td>7.84</td>
<td>0.002*</td>
</tr>
<tr>
<td>Students – Male</td>
<td>23</td>
<td>0.91</td>
<td>***</td>
</tr>
<tr>
<td>Students – Caucasian</td>
<td>43</td>
<td>4.84</td>
<td>0.008*</td>
</tr>
<tr>
<td>Students – African Americans</td>
<td>8</td>
<td>2.25</td>
<td>0.679</td>
</tr>
</tbody>
</table>

* indicates significance at $\alpha = .05$
***indicates that sample size was less than thirty and the data contained outliers

The final three statements on the Attitudes Survey required a short response from the participants
and are as follows:

- Please describe the characteristics of a person with a career in IT.
- In your opinion, what are examples of careers in IT?
- Describe, in detail, how you would encourage women to pursue a career in IT.

Responses were analyzed and summarized for emergent themes. One evaluator examined all of
the data within and identified the common themes. This evaluator then defined the themes and a
second evaluator independently categorized the student statements based on these themes. The
second evaluator correctly matched the responses to the categories for 90% of the student
responses. The resultant student themes are listed in Tables 3-5 for each of the three questions,
along with the number of occurrences of a response. This data was originally analyzed to
determine whether there was a change in student responses from pre to post administration.
Because no change was apparent, the student responses are reported here across the two
administrations.

Table 3. Please describe the characteristics of a person with a career in IT.

<table>
<thead>
<tr>
<th>Themes</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed computer skills</td>
<td>22</td>
</tr>
<tr>
<td>Problem solving skills</td>
<td>92</td>
</tr>
<tr>
<td>Do not believe there are any special</td>
<td></td>
</tr>
<tr>
<td>characteristics or attributes</td>
<td>6</td>
</tr>
</tbody>
</table>
Table 4. In your opinion, what are examples of careers in IT?

<table>
<thead>
<tr>
<th>Themes</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming</td>
<td>46</td>
</tr>
<tr>
<td>Forensics</td>
<td>25</td>
</tr>
<tr>
<td>General technology: gaming, graphic design, web creation, teaching technology</td>
<td>31</td>
</tr>
<tr>
<td>All jobs have IT related characteristics</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 5. Describe, in detail, how you would encourage women to pursue a career in IT.

<table>
<thead>
<tr>
<th>Themes</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate options, opportunities for success</td>
<td>20</td>
</tr>
<tr>
<td>Teach them the benefits of IT in their career</td>
<td>55</td>
</tr>
<tr>
<td>Stress equality between male and female</td>
<td>13</td>
</tr>
<tr>
<td>Demonstrate the financial benefits of IT</td>
<td>7</td>
</tr>
</tbody>
</table>

B. Concept Exam

In order to measure change in conceptual knowledge, difference scores were examined from pre to post administration of the Concept Exam using a two-tailed, paired t-test. Only participants who completed both the pre and post survey were included in this analysis. Subgroup analyses, as defined in the previous section, were also completed. All analyses were completed using R and the results are displayed in Table 6. As these tables indicate, a statistically significant positive change was identifiable for all student groups.

Table 6. Student performance on Concept Exam

<table>
<thead>
<tr>
<th>Student Concepts</th>
<th>N subjects</th>
<th>Mean Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Students</td>
<td>67</td>
<td>2</td>
<td>0.000*</td>
</tr>
<tr>
<td>Students – Female</td>
<td>44</td>
<td>2.52</td>
<td>0.000*</td>
</tr>
<tr>
<td>Students – Male</td>
<td>23</td>
<td>1.26</td>
<td>0.009*</td>
</tr>
<tr>
<td>Students – White</td>
<td>43</td>
<td>2.14</td>
<td>0.000*</td>
</tr>
<tr>
<td>Students – Black</td>
<td>8</td>
<td>1.88</td>
<td>0.044*</td>
</tr>
</tbody>
</table>

* indicates significance at $\alpha = .05$

C. Focus Groups

The method of emergent categories was used to analyze the focus group responses for the participating students. Table 7 lists the common themes that emerged during the focus group discussions with the students. The sections that follow summarize the comments within each category.
Table 7. Focus Group Emergent Themes

<table>
<thead>
<tr>
<th>Theme</th>
<th>Number of Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyment/Usefulness of Alice software</td>
<td>14</td>
</tr>
<tr>
<td>Increased knowledge of IT careers</td>
<td>5</td>
</tr>
<tr>
<td>Perceptions of IT students</td>
<td>4</td>
</tr>
<tr>
<td>Reaction to Attitudes Survey/Concept Exam</td>
<td>6</td>
</tr>
<tr>
<td>Presentations</td>
<td>7</td>
</tr>
</tbody>
</table>

Note: Nineteen students were interviewed through focus groups.

In general, the students indicated that they enjoyed using the Alice software, and believed it to be an effective tool for teachers to use in the classroom. However, they felt that students with no programming experience would struggle with the software and would require more instruction than was provided at the workshop. Students also commented that, prior to attending the workshop, their perceptions of IT careers and students who would attend this workshop was consistent with common stereotypes, e.g., nerdy, boring. Upon completion of the workshop, they were surprised that the majority of students attending were similar to themselves, sharing a variety of interests. The students also expressed that they did not feel that the speakers were age appropriate; they wanted younger speakers with whom they could relate. They also requested more hands-on activities.

The students also commented that the workshop had broadened their understanding of the jobs available in IT. Many were surprised to learn that there were jobs available in IT other than programming. A student group that contained only females commented that they particularly enjoyed the topics of forensics, and collaboration with IT careers. These females also commented on the quality of the presentations; when a presentation was well done, the career that was being discussed became more exciting.

D. End of Program Evaluations

At the conclusion of the SPIRIT summer workshops, each student was asked to provide written feedback on their learning experiences. Student responses were analyzed for themes, and the following themes reoccurred: Logistics, Activities, Alice/Other Software, and Speakers/Presentations. Table 8 provides a summary of the number of responses that referred to each theme and the sections that follow provide descriptions of the responses within each theme.

Table 8. Summary of responses to the End of Program Evaluation

<table>
<thead>
<tr>
<th>Themes</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistics</td>
<td>26</td>
</tr>
<tr>
<td>Activities</td>
<td>52</td>
</tr>
<tr>
<td>Alice / Other Software</td>
<td>17</td>
</tr>
<tr>
<td>Speakers / Presentations</td>
<td>11</td>
</tr>
</tbody>
</table>

- **Logistics.** Students requested more time with speakers; this could be accomplished by reducing the number of speakers.
- **Activities.** Students requested more hands-on activities and more interaction with the speakers during presentations.
• **Alice/Other Software.** The students wanted to learn more about the Alice software and have more time to work with this software. The Power Point presentations were less appealing, and some students requested their removal.

• **Speakers/Presentations.** Many of the students reported that the speakers were interesting; however, some of the speakers became too technical for the students’ current level of understanding.

### IV. Conclusions

Based on the analysis of student data collected in the summer 2008 workshop, there is evidence to support that progress has been made toward the attainment of the SPIRIT goals. Students’ responses from the short answer Attitudes Survey questions indicated that they have expanded their awareness of what constitutes an IT career, and the appeal of IT careers. Based on the outcomes of the Attitudes Survey, there is also evidence to support that female student attitudes improved concerning IT careers following the summer workshop. Based on prior research, the importance of improved attitudes in both of these areas is essential to the goal of increasing the future pool of IT majors.\(^8,11\) Male students could not be statistically tested with respect to attitudes due to the existence of outliers. A paired t-test detected a statistically significant increase on the attitudes survey from pre to post assessment for female students. In fact, with the exception of African Americans, all student groups that could be statistically tested displayed improved attitudes. The failure to find a statistical significant difference with respect to African Americans could be the result of a small sample size. An implication of this outcome is that future studies are needed which examine the impact of such efforts on African American populations, with careful attention to sample size.

Through the Concept Exam, there was also evidence to support that students’ content knowledge with respect to the Alice software improved as a result of the summer workshops. All students displayed a statistically significant increase from pre to post assessment on the Concept Exam. This was true for both male and female students, as well as for the various ethnic subgroups. Given that the Alice software was originally developed for a college population\(^{15,16,17,18}\), an implication of this finding is that this software can be introduced at a much younger age, in this case high school. Additionally, students were able to display increases in their knowledge in as little as a week of instruction. In summary, based on the analysis of the first summer workshops, there is evidence to support that significant advancement has been made toward the attainment of the SPIRIT project goals.

The formative component of the evaluation provides information that can be used by the investigators to increase the impact of these workshops even further. For example, the participating students desire more hands-on activities and more time with the speakers. Both of these requests reflect an interest in the activities on the part of the participating students. As is often the case with a high school audience, the speakers cannot be young enough. Although the investigators sought speakers at the beginning of their careers with significant accomplishments, the students still wanted younger speakers. This may be accomplished by including college students who are majoring in IT as part of the summer workshop, linking high school and college with a career in IT. A similar approach is likely to be appropriate to other high school
interventions which share similar goals. Even without these changes, the SPIRIT workshops appear to be accomplishing their goals with respect to the participating student groups.

Bibliography


