Encouraging Talented High School Girls towards a Career in Computing through a Broader Understanding of the Field

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Encouraging Talented High School Girls towards a Career in Computing through Broader Understanding of the Field (Research to Practice)

Abstract

In this paper, we describe our experiences with a weeklong summer program aimed at talented young women who have demonstrated interest and ability in STEM fields, including an interest in computer science. Because they have many talents and interests, this type of student often has difficulty deciding on a career objective. We hypothesized that an effective way to crystallize their interest in computing is to give these young women a broader view of what computing is and what a career in a computing field has to offer. The course we developed was based on a combination of project work developing mobile apps using the MIT App Inventor, a series of research presentations, presentations by local industry representatives, and interactions with successful female role models working in different segments of the computing industry. We achieved our goal of persuading highly accomplished high school girls to seriously consider a career in computing. We share our experiences and the reactions of the students. We conclude with suggestions for other ways these activities might be used to encourage young people, particularly young women, to consider computing careers.

1. Introduction

The percentage of students studying computer science who are female remains low. The Taulbee Survey[1] has shown slight annual increases recently, but still less than 13% of the students receiving B.S. degrees in computing in 2011-12 were female. At Michigan Technological University, we have struggled with even lower percentages of women in our undergraduate computing programs. Isolated efforts to increase the number of women enrolled in our programs have resulted in small gains, going from a low of 10 undergraduate women out of 327 majors (3%) and only two women in our first year class (1.5%) in 2004 to 26 undergraduate women out of 334 majors (7.8%) with nine first-year women (8.7%) in Fall 2012. To strengthen our efforts to increase the number of women in our undergraduate programs, we applied for and were selected by the National Center for Women and Information Technology (NCWIT) to be a NCWIT Pacesetter organization in 2012. Pacesetter organizations commit to increasing the number of technical women. Our specific goal is to increase the number of first year females enrolled in our computing programs. One of our activities aimed toward increasing female enrollments was a scholarship-based summer program offered during July 2013. This paper describes the program and our observations about its effectiveness.

The focus of this study was the seventh offering of a weeklong workshop for high school females. Previous offerings were held in 2000 and 2001 and then again in 2005, 2006, 2007, and 2008. Since all programs were scholarship-based, we have been able to consistently attract an academically talented pool of students. Although there have been many technology changes since the first program in 2000, as well as changes in student exposure to and interest in computing, we were able to draw on the previous experiences when designing the program for the summer of 2013. The second author has been involved with all the course offerings.

2. Related Work

Many precollege outreach courses designed to expose students to computing present a very programming centric view of computer science. Often these courses focus on video game programming because there is clear interest in such courses. These courses are ideal for engaging students who enjoy video games, but are likely of less interest to other students. Since studies suggest that fewer girls play video games compared to boys[2-7], a video game-based programming centric course is likely to attract a smaller percentage of women. This is consistent with the experience at our university. We have offered video game development courses to middle and high school students for many years and have consistently attracted nearly all male students.

More recently other types of programs have been developed in hopes of attracting a broader audience. In particular, mobile app development has become quite popular as a means of engaging young students[8-11]. In some cases these camps are focused at increasing the students' confidence in doing computing[8]. In general these authors report students' comfort with computing is increased after engaging in app development.

Several studies have found that women do not go into computing fields due to inaccurate perceptions of life and career prospects in computing and a "nerdy" image of computing professionals[12, 13]. One factor affecting the appeal of a field is its image in the media. A spate of forensic crime investigation shows in which the forensic investigators are portrayed heroically makes it easy to aspire to those professions or at least visualize one's participation in them[14]. Even much smaller fields like nuclear physics or archeology have the occasional female role model – Denise Richards plays an attractive, smart and successful nuclear scientist in the Bond movie *The World Is Not Enough*[15] and Noomi Rapace plays the attractive archaeologist in *Prometheus*[16].

The image of computer science in the popular media is still typically that of "geeky" males with women viewed as outsiders. In addition, the media tends to focus on video game programming (shows like *Dads*[17]), IT support (shows like *The IT Crowd*[18]) or hacking. The few female characters with a supposed computing interest or background are gamers or hackers. Examples include the character of "Codex" in *The Guild*[19] and the character of "Penelope Garcia" in *Criminal Minds*[20]. In *The Guild* Felicia Day plays a multi-player online game addict who prefers to play games alone with virtual social contact rather than meeting people face to face. *Criminal Minds* is a show centered on using behavioral and forensic psychology to catch psychopaths in which Garcia is a "geeky" hacker with a gaming obsession who is also very lonely. Thus many young women are exposed to an image of women in computing that they do not identify with nor aspire to. They are not exposed to successful female computing professionals who are sociable or play a central role in solving problems or positively impacting others. Neither are they exposed to a realistic picture of the broad range of computing careers. Supporting the impact of this, studies show many women do not pursue computing fields due to a lack of exposure to the breadth and diversity of the field[21-24].

When designing programs to attract students to the field, it is also helpful to consider retention. One of the key factors identified as a contributor to the retention of women in computer science is exposure and access to role models[22, 25-27]. In addition, there is evidence that indicates many

students lose interest in programming after the first year in computer science as a notion of service is missing[8, 28].

Based on the literature, we felt it important to develop a course that would expose the students to a broad array of computing topics and careers. In addition, we wanted the girls to see multiple role models to counter the stereotypical images that are reinforced in the media. In particular, we wanted role models, of different ages and with different experiences, who could talk about their jobs, as well as their personal and social lives, portraying a realistic image of successful women in computing. Focusing on mobile app development seemed a natural way to provide an opportunity for all the students to create something in a limited amount of time, but also foster confidence in those students who had limited previous programming experience. Because of the flexibility of app development, it also allows students to develop an app in an area of interest. Finally, it provided an opportunity to encourage the students to consider users and the notion of service through computing.

3. Course Description

3.1 Our Environment

Michigan Technological University enrolls approximately 7,000 students primarily in STEM degree programs. Approximately 25% of the overall student body is female. The University is located in the Upper Peninsula of Michigan in the town of Houghton with a local population of about 15,000. Major metropolitan areas are a substantial distance away. Detroit is 550 miles away and the nearest major cities, Minneapolis, MN and Milwaukee, WI, are each approximately 350 miles away. This remoteness adds some particular challenges when offering summer programs. On the other hand, our University has a well-established Center for Pre-College Outreach and has been offering on-campus, summer programs since 1973.

3.2 Participants

Applications for this scholarship-based program were solicited via multiple channels including mailings to Computer Science Advanced Placement teachers in the region, emails to lists of students generated by our Admissions office, and via social media and the web. All channels resulted in some applications. The selection criteria included both an objective evaluation of the applicant's academic record and activities, as well as a subjective evaluation of the likelihood that the student might be interested in or develop an interest in a career in computing. Our experiences from past programs taught us that students who are expressing a strong interest in another field are not likely to change their minds even if they demonstrate the potential to succeed in computing.

Our final selection consisted of 19 students who were academically strong and had a wide range of interests. The average GPA for the group was 3.87. Many of the students had taken either Advanced Placement or Honors courses including calculus, statistics, chemistry, physics, environmental sciences, and history. Most of the students had some programming experience with some students knowing two or three programming languages; a few had no programming experience. In addition nearly half of the girls play at least one musical instrument; some were

clearly quite accomplished musicians. Finally, the girls participate in a wide range of sports including soccer, volleyball, swimming, dance, track, even hockey, as well as a wide range of other extracurricular activities. Many of the students expressed interest in participating in our program because they were considering computer science amongst other fields of interest to pursue as a career. Some of the other career possibilities mentioned included engineering, science, mathematics, mechanical engineering, nuclear engineering, and biomedical engineering.

3.3 Considerations in Designing the Program

As stated in the introduction, we had previous experiences teaching this type of summer program. Based on these experiences, we identified several issues to consider.

Choosing to develop mobile apps was a natural solution to problems we had in the past related to doing a project. One such challenge is designing a programming project for groups of students who have varying levels of programming knowledge. In addition, students with programming experience are usually familiar with different programming languages. Finally, we want the students to have the feeling of satisfaction from completing a project, but we also want time to incorporate a number of other activities into the week.

A second issue was providing role models for the students. In previous offerings of this type of course, we had matched each student with an alumna and the pairs corresponded over the week via email. This worked well in some cases if the matched pair had common interests. But overall the students had limited exposure to the breadth of possibilities. Attempts to have each student share information about her alumna's career were not effective at conveying accurately what the alumna did nor the alumna's enthusiasm for her work.

Even though we are located in a very rural community, there are a wide range of opportunities for our computing majors to gain valuable work experience while a student. We wanted to expose the girls to these opportunities. In past years, we did this by touring several of the local facilities. However, because our student population is predominately male, the local facilities are primarily staffed by males. Our experience from these earlier courses taught us that touring facilities that have males working in cubicles only serves to perpetuate the stereotypes about the field.

3.4 The Curriculum

We ultimately based the week on four types of sessions: guest speaker sessions, industry role model sessions, project work, and tours.

Each day included one guest speaker. Guest speakers were computer science professors and graduate students who are actively involved in research. They each presented and demonstrated approachable material related to their research areas. Topics covered included data mining, virtual reality, data visualization, artificial intelligence and self-stabilization. These sessions typically started with the speaker explaining some core concepts of the topic, its relevance in computer science and the world at large and some current research, followed by a related

demonstration and/or activity.

The industry role model sessions were conducted with alumnae from industry via video conferencing. Nine one-half hour sessions were spread across the week. The industry role models were selected to broadly represent career possibilities and experience levels. Corporations represented included Google, Microsoft, NASA, Netflix, Amazon, Adventium Labs, SRT Solutions and Next Century. The role models were in a broad range of positions from director and IT management lead to project manager, tester, developer, scientist, and entrepreneur. Years in the field ranged from less than one year to over 30 years of experience. The role models described their typical work day, what they like about their work, what skills they use, how they became interested in computing and their journey and lessons learned along the way.

We decided to have the students use MIT App Inventor for their team projects. Students were able to work at their own speed using a selection of the tutorials provided with the App Inventor library to gain familiarity with the features of App Inventor. On the third day, teams of two to four students were formed and each team began to construct an app of its own choosing. Each team was given a mobile device to encourage them to incorporate additional features in their app, such as using the accelerometer and inbuilt camera. By the end of the fourth day, students were expected to have fully working apps to be demonstrated on the last day.

Friday morning was tour time. The students first visited the local public library where senior citizens from the local community come to learn how to use computers. Some groups demonstrated their mobile apps to a few of the interested senior citizens. This was a great opportunity to expose the students to the idea of non-expert users and how they are affected by technology.

This was followed by a visit to our sponsor's local facility. Jackson (our sponsor) is a multi-billion dollar provider of retirement solutions, headquartered in Grand Rapids, MI. They recently opened an office in Houghton and currently have approximately 40 university students working locally on projects with full-time staff at their main headquarters. Our students were given a presentation on how a financial services firm has benefitted from using technology to enhance their business practices, as well as some discussion on their software process.

We next had a panel consisting of representatives from other local offices and companies. With a little effort, we were able to get a mix of male and female panelists. Each panelist talked about the company he or she worked at and the types of software development they were involved in. These local firms added to the diversity of opportunities that the students saw. When the industry speakers concluded, we switched the focus and gave the students the opportunity to demonstrate the mobile phone apps they had created to the professionals.

4. Evaluation

For assessment purposes, we used three sets of survey data from the students to assess their position on computing at different times relative to the program. First, the students were asked to answer a few questions about their computing experience and interests in the initial application for the course. In addition, each participant was asked to fill out a pre course survey to gauge her

expectations of the course and a post survey about each of the sessions and her overall experience. In addition, we evaluated the apps that the students created.

4.1 Application Data

As part of the application process, the students were asked about their exposure to computing and career plans. Amongst the selected students, there were only four that had little or no exposure to programming. Most of the girls had taken a high school computing course and in some cases they had two or three years of computing instruction. Two of the girls had taught themselves how to program. The most frequently mentioned language that the students knew was C++, followed by Java. Other languages mentioned included Basic, Pascal, HTML, Alice, Python and Scratch. Five of the girls indicated plans to go into computer science as a career. Many were trying to decide between computing and other scientific or engineering fields.

When asked what led to their interest in computing or programming, most of the students cited a general interest in science and the ability to design and create systems. Only one of the applicants said her interest came from playing video games and her story was quite unique. As a child suffering from a degenerative disease that restricted her ability to move, she said she spent a lot of time sitting indoors or at the hospital where playing video games was something she could be good at in spite of her illness.

4.2 Pre Survey

On the first day, the students were asked to fill out a survey to learn about their expectations, perceptions and motivations. All 19 students in the course responded to the survey. Some questions had multiple choice answers and some were open ended.

In order to be able to confirm our understanding of the students' preparation for the week, we asked them to rate their exposure to computer science. Eight out of 19 students answered that they had "Some basic programming experience in at least one programming language" and five students answered "Substantial programming experience and/or broad knowledge of computing". Only four indicated "Almost no exposure". See Table 1.

We were interested in determining each student's current thoughts concerning computer science as a career and if she had already made up her mind about a career choice. Table 2 summarizes the answers for this question. Thirteen of 19 students were considering computer science, but had not made a decision yet. This is what we expected to see based on our selection criteria.

Table 1. Answers to Question "How would you rate your exposure to Computer Science"

Answers	N (out of 19)
Substantial programming experience and/or broad knowledge of computing	5
Some basic programming experience in at least one programming language	8
Some familiarity with some logical constructs but not with a programming language in full	2
Almost no exposure, just personal interest	4

Table 2. Answers to Question "How seriously have you considered a career in computer science?"

Answers	N (out of 19)
I am planning to go into a career in Computer Science	6
I am considering Computer Science among many other fields	13
Almost Never	0
I like Computer Science but don't want a career in it	0
I am not seriously thinking about a career yet	0

Research has demonstrated that having female mentors or role models in a field can encourage female students to enter the field[22, 27]. We thus asked if the students knew any women in computing. Eleven of 19 students did not know any women in computing. Two of the girls said their mother was in the field and four of them indicated they had a female computer science teacher. Both of the students with mothers in the field and one with a female teacher were among the six students who were definite about a career in computing. One of the remaining students committed to a career in computing also indicated she knew someone in the field. This contrasts with the group of students who were considering computing along with other fields. In this latter group, only five of the 13 students knew a female in computing and three of those five mentioned that it was a teacher. Thus the vast majority of this group has no role model in the field. It is also important to consider that a computer science teacher may be inspirational as a woman in computing, but she may not be seen by the girls as a role model for a computing career if they are not interested in teaching.

Table 3. Answers to Question "Name some fields in Computer Science that you have heard of"

Answers	N (out of 19) Includes overlap
Computer programming/ programming	10
Computer/software engineering	7
Video game design	6
Web design/programming	3
Information Technology	3
Bioinformatics/cyber security/analyst/robotics	1 or 2 each

We found that most students had a fairly narrow perception of computing. When we asked the students to name computing fields that they had heard of, the most common answers were programming, video games, software or computer engineering and websites. Two mentioned robotics, one of them had attended a short robotics course before. A couple mentioned very specific jobs such as Help Desk Manager and Online Assistance. See Table 3.

4.3 Post Survey

The post survey was presented to the students in the last hour of the final day of the course. Most students answered the survey immediately, but some answered it over the next couple of weeks. Seventeen of the 19 participants responded to the final survey. The post survey asked several questions about their overall experience and also asked the students to share their reflections on each session. They were encouraged to use their notes to help recall their reactions to the individual sessions.

We found that at the end of the week, students had a broader perception of computing and were able to name fields within the discipline besides programming. Table 4 lists the top 4 answers given by students. In addition, students listed a much richer set of career possibilities including technical consultant, project management, and product testing.

When asked if they were now considering a career in computer science, 10 students out of the 17 respondents said that they were now considering computer science as a career and six students said they knew they wanted to be in computer science before the course started. One student said that she was not really considering computer science.

Table 4. Top 4 answers to Question "Name some fields in Computer Science that you have now heard of"

Answers	N (out of 17)
Artificial Intelligence	9
Virtual Reality/ Virtual Environment	8
Data Mining	8
Visualization/ data visualization	6

When asked what their favorite part of the course was, eight students said meeting the representatives from industry and getting to ask questions and eight students said that they enjoyed making the phone apps the most. There were some students who said they enjoyed both activities equally. See Table 5.

Table 5. Top answers to Question "What was your favorite part of the course"

Answers	N (out of 17)
Meeting speakers from industry / role models / alumni	8
Making phone apps / android app	8
Making friends / working together in teams	1 each

When asked what they thought of women in the computer science industry, one student reflected that "The people in the field really, really love their job. The women in these fields are treated more fairly than in other fields." And another student reflected "I think that after this course I learned how important us ladies are for the computer science jobs and how many successful ladies are already in jobs around the world."

When asked what they learned in the course, one student said "…that women in the field love their jobs. Also, it's possible to do anything with a CS degree." Another student said "I have learned a lot about different careers that are in the Computer Science course…" and another student reflected "I have learned about the many job opportunities that are involved with computer science, how important it is in society, all the intelligent women that have chosen this path or are considering it…" Most students spoke very favorably about being able to interact

with so many different types of role models from industry and also learning about how different companies are and how they operate and learning about how computer science affects the world.

4.4 Student Apps

In addition to exposing the students to app development, our goals for this activity included broadening their perspective on programming to include additional aspects of software development such as working in teams, identifying the target audience for an app and considering usability issues. In addition, we hoped that students would develop sufficient confidence and interest to explore and incorporate features of the phone not covered in the basic tutorials.

Our students self-selected into six groups ranging in size from teams of two to teams of four. They worked amongst themselves to determine what app they would develop. They were given some guidance on implementing certain features and on determining a feasible scope for the app.

We found that all teams met our expectations. For example, the group of two students who enjoyed "chibi" cartoons, made the multi-screen Chibi Scene Creator app which comes with instructions and different backgrounds on which users add chibi characters (see Figure 1). It also allows users to take pictures and create their own backgrounds. These students identified their target users as other young people who enjoy chibi characters from Dr. Who. The other apps developed included:

- The Joke Box - a joke app which has different categories of jokes as buttons. They identified their target audience as "geeky students"

- a Shopping Cart app aimed primarily at the elderly which uses visual icons instead of typing to allow users to select what they need to add to their shopping list

- a multi-screen visual cookbook app for Potions from Harry Potter that comes with directions and designed for Harry Potter fans

- PokeCapture – an eight-level game app incorporating randomly moving Pokemon characters for Pokeman fans (see Figure 1)

- the Unit Converter app for units of area, temperature, distance, weight, currency, and speed designed for anyone who likes to travel.

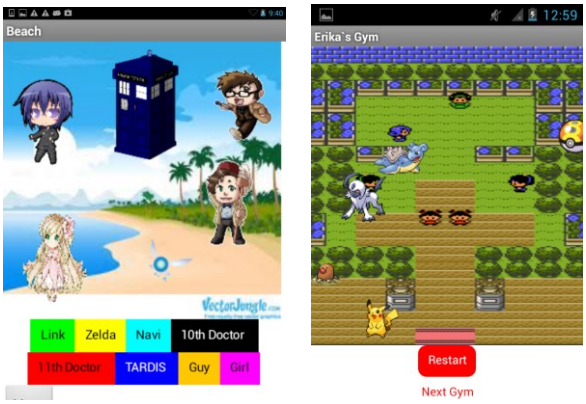

Figure 1: Left- Chibi Scene Creator; Right – PokeCapture game

5. Reflections and Conclusions

Overall, the week surpassed our expectations. Based on the feedback from the students and our observations, these young women ended the week with a much more mature and accurate understanding of what computer science is and the wide range of career opportunities available. Perhaps more than typical high school students, this group of very talented young women demonstrated great interest in their future careers, particularly through the questions asked of the industry role models. And yet, this group of young women, who had all indicated some interest in a computing career prior to coming to this program and in most cases had some formal education in programming, had little real knowledge about computing careers. As one student stated, "I learned that the options for computer science goes farther than most people think and therefore you have a lot more career options than we are usually led to believe". It is clear this caliber of student has many career options available to her. The evidence from our program indicates that many of these young women may have decided to go into, or not go into, computing based on an incomplete and inaccurate picture of the field. This suggests that in order to attract students to computing, methods need to be identified to get more accurate career information to high school students.

It is worth noting, we had only one case where interest in computing arose from video gaming. This stresses the need for portraying an image of the field that is much broader than video game development. If we don't, we risk losing students unnecessarily from the small pool of students who have actually experienced programming.

Although we had a few technical glitches, having the alumna talk to the students via Skype or Google Hangout had some unexpected benefits. In most cases, the alumna was calling in from work or home so the students got to see the alumnae in their actual work or home environments. Even though often all that was visible was just a small part of a conference room or office, this provided a peek into the different work and life styles. Also, perhaps because the alumnae were in comfortable surroundings, the presentations seemed very relaxed and comfortable compared with many alumnae classroom visits that we have seen. The students were quite at ease with this

mode of interaction.

We included alumnae role models from across the experience spectrum. Although the students indicated they could relate better with the younger role models, including role models in more senior positions was clearly necessary to show the students that one doesn't necessarily write code for 40 years in a computing career. Since the students reported that they liked seeing people who enjoy their jobs and are excited about their work, it is important that role models are carefully selected. Another beneficial message that came from the role models was that to succeed in the computing field, one should be strong technically but also have good communication skills and be able to work well in teams. Some students said this was surprising to them.

One unexpected issue was the disappointment expressed by some students when they discovered that they would not learn a "new programming language". We might have been able to minimize the disappointment had we discussed MIT App Inventor as a visual language or talked about prototyping tools. The disappointment seemed short-lived since once the students started going through the tutorials for MIT App Inventor, they enjoyed being able to make responsive applications so easily. Indeed the day before they were supposed to present their apps to the industry representatives, students requested access to the lab in the evening and stayed until their 10:00 pm curfew so they could add additional features.

The one student who indicated on her post evaluation that she wasn't considering a career in computer science added more evidence supporting an observation we had made during previous course offerings. This particular student had surprised us the first morning of the workshop when she stated that she was going to be majoring in math. We had observed in previous workshops that students who have expressed a planned major or career choice prior to coming to our summer program were not likely to change their mind. We had, therefore, screened student applications for an openness to considering computer science as a career choice. Rereading this student's application more carefully after her proclamation, it became clearer that her professed interest in programming was based on a belief that it was a subfield of mathematics.

In summary, we found that our mix of app development, research sessions, industry role model chats and industry tours was effective in giving highly talented and motivated students a better understanding of the computing field. We want to emphasize that even this very talented and programming savvy group of young women had minimal knowledge about computing careers and the breadth of the field. As this type of individual has many interests and career options, it is important that we as a community identify ways to get better career information more widely known.

In future summer offerings we plan to use a standardized instrument for assessment, such as the Computer Science attitude survey[29] in order to more accurately gauge changes as well as to enable us to compare our results with other methods. We also hope to track the attendees of our workshop to determine their ultimate choice of major in college.

The types of activities that we incorporated into our weeklong program can be used in isolation or in different combinations in other contexts. For instance, we recently did a daylong program

for female high school students who have been accepted into our department for the next academic year. Based on our experiences from the summer program, we planned the day to include an overview of the department, short research presentations/demos, Skype interviews with three alumnae, and tours of our local industries. Since we only had four students and a parent with each participant, it isn't possible to make broad conclusions about the effectiveness of this structure in general. But at least for this offering, the program worked very well for both the students and the parents. Again it seemed important to have a mix of activities. Three of the four attendees completed our post survey: one indicating an appreciation of the alumnae sessions, one valuing most the information about the local industries, and one the departmental opportunities.

Recalling that within our group of attendees, those who came to our summer program planning to go into computing were almost twice as likely to have had a role model in the field as those considering computing among other fields, we are looking to identify ways to provide more students with role models in computing. We believe this could have a significant impact on their interest in the field. One idea that we are considering is developing a role model speaker series in collaboration with one or more high schools. The goal would be to provide role model volunteers who would videoconference with a high school computing class or computer club providing them with career information and answering the students' questions about the field.

We found MIT App Inventor to be a good, free and easy-to-use tool for use by high school students. Because of the visual nature of the tool, it can be used in a range of outreach activities. Developing simple mobile apps can be fun and engaging. Once developed, these apps can be shared easily with friends, instilling a greater sense of pride and enthusiasm for making them.

6. Acknowledgements

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