TechGirl: A Website for Middle-School Girls Interested In Science and Engineering

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Abstract

TechGirl is an exciting, dynamically evolving, interactive website dedicated to helping middle school girls learn about science and engineering. It is intended to help them develop an appreciation for the beneficial impact of science and engineering on society, and to encourage them to consider a possible career in science and engineering. The site contains three major parts: a role-playing game, a science/engineering knowledge game, and biographical sketches. A discussion of the site, initial assessment, and the initial impact on young women will be discussed in the paper.

Keywords: Women in Engineering, Middle School Education, Interactive Website

I. Introduction

Studies have shown that middle school is a critical time in human development that often determines life orientation and long-term success. In particular, middle school girls' experiences with math and science during this time could set them on a course that does not include much math and science later in their life. Studies show that math and science teachers treat girls and boys differently in the classroom, including making more eye contact with the boys, paying more attention to the boys, and challenging boys to find the right answer, while girls get sympathy [1]. Astin and Astin found, as have other studies, that boys tend to operate the equipment while the girls record data and write reports. They saw that a loss in self-confidence from differential treatment appears to begin around the seventh grade and continue through high school [1]. The most striking differences between boys and girls are not in achievement or opportunities to learn, but in their attitudes toward science and mathematics [2]. Research has continually shown that women are significantly less confident than men in their math and science abilities, even when they receive the same grades [3, 4, 5, 6, 7]. Margolis and Fisher conclude from this research that girls in elementary school generally like math, but by high school they are less likely than boys to feel competent in math, despite their higher grades [3]! Margolis and Fisher [3] also report that Koch [8], a

teacher at a predominantly white middle-class school reported the behavior of seventh and eighth grade boys and girls with computers in their classrooms and found that the boys naturally took over the computers.

Through web searches with key words (including engineering, science, and women) and through presentations about women in engineering, we have identified nearly 60 websites that may be of interest to young women interested in learning more about engineering. Furthermore, our research has shown that there is relatively little information on the web regarding science and engineering careers targeted for middle school girls, and none of it is interactive. TechGirl is a unique resource that will help to fill this resource gap.

Women constituted only 20.2% of those awarded bachelor degrees in engineering in 2001 [9]. Of the Fall 2001 American freshmen, 13.2% of the men said that engineering would be their probable career, while only 2.5% of the freshmen women said so [10]. An additional 8.3% of the men said that their probable career would be as a computer programmer or analyst, while only 1.4% of the women said so [10] Interest in engineering careers among college freshmen remains at a 25-year low [11,12]. Minority women made up only 4.8% of the 1995-96 freshman engineering class [13] and received only 3.5 % of the Bachelor's degrees in engineering in 2000 [9] and 3.3% in 2001[9]. To maintain the necessary supply of scientists and engineers in the U.S., and to ensure that technical problems are approached from a variety of perspectives, women must be recruited into science and engineering careers in greater numbers.

Girls and boys are attracted to the computer for different reasons. "As early as kindergarten, girls use the computer eagerly and skillfully for writing their stories, but boys race to the computers for free time and play (18)." [3] Research indicates that the ideal adventure game for girls would be similar to real-life as well as some new areas to explore. Boys, on the other hand, prefer violent feedback, killing the player, and having the game stop if there is a wrong answer [3]. Girls avoid computers because of the negative image of the computer nerd, not because they find it hard: instead, they find them boring. Girls say they are too smart to waste their minds and time on something that only boys without a life find fascinating [14]. Research has shown that the women who were leaving SMET majors in university had equal if not higher GPAs than those who did not leave. They left because they found it dull and intellectually numbing, rewards were low compared to the effort, and the teaching was poor [15].

Research suggests that a crucial intervention point for encouraging girls to pursue math- and science-related fields is during middle school. In a middle school with seventh and eighth graders with computers in their classrooms, Koch found that the girls were not at the computer in math or technology class free time [8]. The girls worked on their math in the math class free time or helped other female students with their projects in the technology class free time. The boys, however, were always at the computer during the free time. In this study, unless the girls were assigned a specific time on the computers, the boys monopolized the computers [8]. As early as the seventh grade, boys plan to study more math than girls do [16]. From sixth to twelfth grades there is an overall decline in both male and female students' liking and enjoyment of math [17]. Students reported that math became more difficult, that they received less support from parents, teachers and peers for studying math, and that math became more anxiety provoking over time. Female

students reported that math was more difficult than did male students, and females rated themselves as more anxious in quantitative situations than males, even though math ability was approximately equal [18]. High school girls perceive math to be less useful than boys do [4], and value math less than boys do [12]. The Women In applied Science and Engineering (WISE) Program conducted a survey of freshman females who had participated in the WISE Bridge Program just prior to entering the College of Engineering and Applied Science (CEAS) at Arizona State University (ASU). In that survey, a question was asked as to when the young women became interested in science and engineering. Every person who responded indicated that they became interested in engineering and science between the ages of 13-17 [19].

The significant difference between male and female science students is not ability, but self-confidence. The loss of confidence by women is most dramatic in fields dominated by men [3]. A major factor in why there are so few women in computer science is that the female students in high school and college not only lack confidence in math and science, but when they compare themselves to males, many of whom have been consumed with tinkering with computers from a very small age, they immediately conclude that they cannot compete [3]. If we can interest young women in engineering and computer science at an early age, they will be more likely to have a vision to persist in these fields, even if their self-confidence is not as high as that of the young men.

The middle school years are a critical time for forming identities, some of which may be counter productive to success in schools and others may reflect gender stereotypes. In order to promote gender equity, a 1996 report by the American Association of University Women, *Girls in the Middle,* recommends that programs be developed that 1) stress role playing and activities that are nontraditional, 2) build math and science skills, 3) expose girls to role models and mentors, and 4) address girls' developmental and intellectual needs [20]. We believe that our TechGirl website will accomplish all of these goals.

As part of the process for development of an effective website, it is critical that there is an ongoing assessment of other web based resources, since the World Wide Web is changing on a daily basis. We have compiled a list of relevant web sites, and we continue to monitor those and to search for others. Meetings with our many assessment groups (middle school girls and teachers, high school girls and teachers, college women, and professional engineers) have helped us build this list. Also, extensive discussions with those groups led us to focus on the three components of TechGirl: role-playing game, knowledge game, and biographies. Our discussions with those groups and our searches have consistently shown that each of the three key components of TechGirl is unique. Although there are several biography sites for women, we have not found any that are written for middle-school girls and that show typical women at many stages of their careers, from high school to college to professional life. Similarly, we have not found any science knowledge games that are geared towards middle school girls and are consistent with their curriculum. Finally, we have not found any role-playing games for girls that allow them to experience a career in science and engineering. So, although we will continue to search for new sites or ones that we have missed, we believe that the TechGirl website will be an important addition. Also, by providing links from TechGirl to many other sites (and vice versa), we will increase the visibility of TechGirl, which is found at http://techgirl.eas.asu.edu/.

II. Project Overview

From discussions with several focus groups, including middle school girls, middle school teachers, and engineering college women, it was recognized early in the development process that the success of a website which effectively attracts, retains, and educates middle school girls depends on the following six key components. *First*, it must have compelling activities and information that encourage girls to become interested in science and engineering. *Second,* access to on campus resources with extensive expertise in recruitment and retention of women of all backgrounds into science and engineering would be critical to long-term success. *Third*, the website must develop using feedback from all the major targeted constituents. *Fourth,* the website must have the support of the educational community, a mechanism to educate the educators in regards to the website location, and website content and methods to effectively assess the educational utility of TechGirl. *Fifth*, the website must have a computational infrastructure that allows for expansion and continuous change. *Finally*, since a website is not an isolated resource, but must exist in a highly competitive and integrated environment, ongoing assessment of other current and future web based resources is necessary to promote long-term success.

The project team included four female college students from various areas of engineering who focused on the content and a female graduate in computer science who worked on the computational infrastructure. Professors Adams, Anderson-Rowland, and Wagner supervised the students and the project. After initial conceptualization, identification of appropriate campus resources, extensive research of the web and interactive sessions with the primary expected constituents of the proposed website, the following elements of an effective website were identified:

1. Biographies of women in science and engineering
2. Science/engineering knowledge game
3. Engineering Encounters, a role-playing game about careers in science and engineering

Underlying each of these sections is the need to present the engineering and science disciplines in a light that reinforces the helpful and supportive aspects of the fields and to demonstrate the beneficial effects they can have on society. As has been widely published recently, surveys have found that many young women are discouraged from pursuing technical fields because the fields do not reinforce common goals of many women, including ecology, family, and interpersonal communication. The website design is intended to strongly underscore the positive components of a career in the technical fields.

III. Biography Component

Our evaluation of women's biographies on the web indicate that there are relatively few such sites, that they tend to focus on exceptional people, and they are written at a level above that of middle school girls. Therefore, we decided it was important to create a set of inspiring biographies of typical women scientists/engineers that would appeal to middle school girls.

The TechGirl website contains biographies of women at different stages of their careers, including high school, college, and professionals, representing a diverse set of career interests and a diverse set of ethnic backgrounds, including especially underrepresented minorities. Each biography is divided into several small sections to make it more readable/appealing to middle school girls. These sections include family background, education, hobbies/interests, college/career info (if appropriate), and future plans. We plan to have each biography include two photos of the person, one at school/work and one portraying their life outside school/work, such as a hobby or time with friends or family. In addition, the web site contains submission guidelines for each age group (middle school, high school, college, and professionals), so that individuals can easily submit their own biography and "Be a TechGirl too!"

IV. Science/Engineering Knowledge Game

Our goals for the game were: 1) to make something enjoyable that middle-school girls would like to play many times, 2) to expose them to many interesting areas of science and engineering, 3) to increase their knowledge in science and engineering, 4) to be age-appropriate, and 5) to build their confidence in their technical ability. After many discussions with many groups, we finally decided on a game format where the players choose from many technical categories, and then typically answer ten questions from those area(s). The current categories include math, physics, chemistry, earth science, biology, electricity, human anatomy, computer science, inventors/inventions, science/engineering careers, and miscellaneous. We have created over 400 questions, and are continuing to add more. Each question is multiple choice, with correct answers yielding enthusiastic responses such as "Awesome! You earned a point," and incorrect answers receiving an encouraging statement and the correct answer with an explanation, such as "Good try! The correct answer is ...." The comments such as "awesome" and "good try" are randomly drawn from the appropriate database, using comments that would appeal to middle school girls. We have also added in comments from other languages, along with the English translation, such as "Wunderbar (German for wonderful)!" We have found that the variety of praise and encouragement makes the game much more fun and rewarding, and strongly encourages repeated play. At the end of the game, the players are told how many points they have earned, and given a chance to play again, submit a comment, submit their own question, or go to another part of the TechGirl website. Our initial testing of the full game on a small group of middle school girls has shown that girls like to play it many times (it is addictive!), each time trying to do a little better or trying a new section. A high degree of success is important to their self-esteem, so we are keeping most of the questions easy, with a few more challenging ones. Overall, our pilot study showed that this game makes learning interesting and pleasant.

In terms of content, most of the questions have been based on math/science curriculum content appropriate for middle school students. Where possible, we have emphasized questions that we think will be especially appealing to young girls. For example, "Which type of engineer would be involved in the development of new cosmetics?" or "The development of which of the following medicines has allowed us to prevent almost all cases of polio, a disease which used to cripple tens of thousands of children?" Some questions are light-hearted, some are challenging, and some are easy (so that everyone can at least get some right, which is important).

V. Engineering Encounters

The most unique and important aspect of our web site is Engineering Encounters, a role-playing simulation of careers of women in science and engineering. The concept is similar to the extremely popular Oregon Trails; a simulation used by millions of middle school students in their social studies classes to simulate pioneers traveling west in the 1800's. Another good analogy is Life, a popular board game that has existed for over 40 years, in which players begin in college and play out events in their life, from marriage to children to career successes and failures. Feedback from all our different groups, including middle school girls and teachers, counselors, and college women has consistently shown this to be the most appealing aspect of our web site.

The key requirements for our game were that it: 1) be enjoyable to play, 2) provide examples of the wide diversity of science and engineering career paths, 3) demonstrate the benefits of a technical career (challenge, satisfaction, contribution to society, salary), 4) illustrate different options in life (marriage, children, job changes, starting a business), 5) instill a sense of confidence that the player could be successful in a technical career, and 6) instill a sense of power over the choices in their life, as well as demonstrate consequences of those choices.

In our simulation, players begin with a character who is a middle school girl with a unique biography. They can select her background (name, brothers/sisters, parent status (single, married, orphaned, etc.), geographic area, names of friends, name of pet), or they can have the computer randomly select their background. They are then presented with a series of events in middle school, high school, college, and their careers. After being presented with an event, the player chooses how they respond to that event, and then find out what happens to them. Some example events include:

Middle School: " Choose one of the following classes: Math, Technology, Science, Advanced Math"

(Choice: technology): In technology class, the teacher passes around prosthetic limbs for the class to see. He starts, "Building an artificial arm is a difficult process and many factors have to be considered. They include factors like how heavy the arm can be without hurting the patient's shoulder or elbow, what material can be used to make the arm durable, washable, and movable. These are just a few of many factors to consider." He suddenly points to you and asks: "What type of engineer do you think builds these prosthetic arms and limbs in order to help people function as normal as possible in life?"

Choice: Chemical Engineers, Biomedical Engineers, or Software Engineers.

High School: "Which of the following science electives would you like to take: biology, physics, chemistry?"

(Choice: biology): **"**Your biology class is learning about DNA this week. Every cell in your body has DNA; it stands for 'deoxyribonucleic acid', and it is a biological code your body uses to determine your height, your eye color, your hair color and your

skin tone, as well as millions of other things that make you unique. What kind of a scientist would most likely study DNA?"

Choice: Geologist, Physicist, Geneticist;

(Choice: Geneticist): "Great! You know your professions well. Ever consider being a geneticist yourself?"

High School: "You really would like to attend college, but you don't have the cash, so you: fill out a FAFSA form, join the ROTC at the university, or get a job."

(Choice: FAFSA) "The FAFSA form is a free application for federal student aid and is offered to help students pay for university tuition. One month later you get a reply in the mail and the letter says that you were accepted! In addition to a gift and a student loan, you will have a work-study job so that you can work with a professor on a paid research project. Way to go!"

College: "It is the night before your calculus exam. Do you want to study alone in the library, work with a study group, or go to a party with your friends?"

(Choice: party) "You have a fun time with your friends, but you are so tired the next day that you sleep through your alarm and miss the exam. You go to the professor and confess what happened, and after a long talk she allows you to take a make-up exam the following day. This time you study hard and pass the course with a B."

First Job: "When you graduate with your chemical engineering degree, you have received job offers to work at an oil refinery in Saudi Arabia, a perfume factory in Paris, and a microelectronics company in Phoenix."

(Choice: microelectronics) "You enjoy working in sunny Phoenix, and you do well at the company. You discover a new way to make the microelectronics chips that uses much less water to clean them, so that you save money and help the environment. The company is very pleased and gives you a reward of a swimming pool in your backyard."

Mid-Career: "Your daughter asks you: What do you do at work? Do you give her a one-hour lecture, take her to the office for a day, or tell her you don't have time to explain?"

(Choice: take her to work) "You head to your research lab and show her the project you and other engineers are working on. It's a design for a longer lasting pacemaker, a device to keep your heart beating normally when it can't do so on it's own. You tell your daughter that pacemakers are implanted in the body and replacing old batteries is difficult so your team is making batteries that last up to 20 years instead of today's 5 or 10 - year batteries. You really enjoyed taking your daughter to work today and she thanked you for it."

Career Finale: "You are working on a method to reduce global warming due to excess carbon dioxide. Three options include storing it underground in old natural gas pockets, storing it at the

bottom of the ocean, and reacting it with magnesium carbonate (a common rock) to form a stable mineral."

(Choice: reacting it with magnesium carbonate) "Your team is successful in developing an inexpensive process to crush the rock and react it with magnesium carbonate. Moreover, you discover that the product can be used as filler in drywall construction for homes. Your team earns the Environmental Design Award, and you retire knowing that you helped prevent global warming (end game)."

The goal of Engineering Encounters is to provide an enjoyable simulation of events that could happen to them, so that they learn about issues in science and engineering in an interactive way. It is not trying to teach science and engineering, but rather expose students to the impact of science and engineering in their daily lives. By providing them with their own characters and allowing them to make choices, they become more involved and interested in the game.

Although many of the questions in Engineering Encounters relate to science and engineering, there are also many of a more personal nature, from choosing a date for the prom to deciding how to spend your salary. We also include options such as having a job while going to high school or college. Discussions with students clearly show that they want a mix of questions; much like life includes a wide range of academic, work, hobbies, and family/social experiences. We want to encourage them to think that scientists and engineers can have a fun life outside of work, too. We want to have a wide variety of game events available, so that each game is different and to encourage students to return many times to Engineering Encounters, so that they have many opportunities to discover the tremendous breadth of opportunities awaiting them. Also, they will be able to choose a short, medium, or long game, and they will be able to change the percentage of questions in each category (middle school, high school, college, career), since our surveys have shown a lot of variance in what they want. Increasing their ability to tailor the game to suit their preferences will enhance its playability and encourage them to return many times.

In summary, Engineering Encounters provides middle school students with a unique opportunity to experience what could happen to them, so that they develop a positive view of careers in science and engineering.

VI. Links to Relevant Websites

At present nearly 60 websites have been identified as relevant to Tech Girl and have been linked. We expect that middle school and high school girls that are interested in our website would probably also be interested in investigating other sites about science and engineering. The websites have been divided into the following categories for ease in identification: Science and Engineering Competitions, Learn Some Stuff, Women in Engineering, Cool Puzzles and Games, Teacher Links, and Experiments Just for You. We intend to make sure that our website is a link from each of the sites that we have identified. We plan to continue to add websites to our list.

VII. Formative Assessment

TechGirl has undergone extensive formative assessment since its conception. The authors have held several dozen meetings with groups of middle school girls and teachers, high school students and teachers, and college women in engineering. These meetings began with the early conception of the project, and have continued as the site has evolved. In general, the middle school girls have been very interested in the site. Currently the major feedback has revealed the following:

1) The Science and Engineering Knowledge Game has been demonstrated to be effective
2) The Biography section would benefit from more biographies
3) The Role-Playing game would benefit from more events, so that it can be replayed many times
4) All of the sections would benefit from improved graphics

Overall, one of the most important outcomes of these assessments is that different girls like different approaches to learning about science and engineering. One girl may prefer the biographies, while another may prefer the knowledge or role-playing game, so it is important to offer several options. The Biographies and Knowledge game have generally been appealing to 50-75% of the survey respondents. The Role-Playing game concept has consistently been the most popular, typically appealing to 80-95% of the respondents. Detailed results of our assessments will be published in an upcoming paper.

Subject to further support of the project, we will address the concerns listed above. We would then expand the site by adding more biographies, questions, and role-playing events. We would also add pictures to go with the biographies. We would also like to add daily diaries of women as they transition from Middle School through High School and into College. We would also continue to expand our links to other websites giving information about engineering that would be of particular interest to young women.

VIII. Conclusion and Future Plans

In summary, TechGirl is a website designed to interest middle school girls in science and engineering. Its key features include a role-playing game, a knowledge game, and a biography section, each tailored specifically for middle-school girls. It will continue to evolve as students and teachers submit new role-playing events, knowledge questions, and biographies, and the graphics will be upgraded significantly. Future work on the site includes using middle school girls as consultants and also as hands-on designers and site developers. Plans also include adding a high school section to TechGirl.

Although much work is yet to be done on TechGirl, the reaction of the girls who have tried the website has been very positive. The knowledge game is “fun,” the role-playing game “gives you a chance to try out different careers,” and the biographies “help you learn about what other girls like in science and engineering.” The girls also like that the site tells them about engineering.

In much the same way that Oregon Trail has reached millions of students to teach them about being pioneers in the Old West, we hope that TechGirl will be used in school and in the home to

encourage millions of girls to consider being pioneers at the forefront of science and technology.

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Biographies

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Meena Nimmagadda is a graduate student working on her Master's degree in Computer Science. She earned her Bachelor of Technology degree from Sri Venkateswara University College of Engineering, India. She is presently doing her thesis on "Women in Computer Science: A Comparative Study between the US and India." Meena was the person primarily responsible for designing and constructing the website.

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