Girls Who Draft: A STEM Outreach Initiative

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Abstract

Engineering and Engineering Technology are essential to a functioning society leading to these professionals to be highly sought after in the workplace. Recent data shows that, despite many Science, Technology, Engineering and Mathematics (STEM) initiatives over the past decade to increase the number of those entering into the Engineering and Engineering Technology fields, the percentage of women engineers (and computer scientists) remains fairly low. Several reasons contribute to the low number of women in these fields, such as support of supervisors/co-workers, perceptions of working environments/conditions, and lack of awareness of what engineering/technology careers entail.

It is important to set up and execute STEM outreach activities to encourage young women to become more involved in engineering/technology fields. By setting up STEM programs offered specifically to young women, young minds are given an opportunity to get hands on experience as to some of the duties of what a career in engineering could entail, helping clear away confusion regarding the field. Programs like these would also offer a kind of support system between fellow students and the teacher, helping encourage young women to stay involved in the field. This paper describes such a program implemented in a University in Louisiana. The program employs female students currently attending an engineering technology program at a university to teach young women from neighboring schools how to design and draft using computer applications such as Autodesk AutoCAD. The program, named "Girls Who Draft", aims to stimulate awareness regarding career options in engineering/technology, motivate more young women to pursue careers in these areas, and to recruit more female students into the university program to eventually graduate with a degree in these high demand fields. The program is structured so that young women from nearby schools come for a 2-hour block to one of the departments' computer labs that have the AutoCAD software available. The engineering technology faculty and students provide these young women with a hands-on introduction to drafting. Future expansions of "Girls Who Draft" plan include multi-day and multi-session formats where more detailed content can be explored.

Introduction and Background

The National Academy of Engineers forecasts that engineers and technologists will continue to operate in a rapidly changing innovation environment[1]. This is compounded by globalization of economies, diversity of social and business groups, multidisciplinary research trends, and cultural and political forces. Engineering systems are of increasing complexity in energy, environment, food, product development, and communications[1]. Hence, it is imperative to introduce engineering and technology practices beyond undergraduate education, especially to young women, where students can experience the iterative process of designing, analyzing, building and testing. There is a growing importance for engineering practice, but the engineering profession seems to be held in low regard compared to other professions and industry tends to view engineers and technologists as disposable commodities[2]. This coupled with confusion regarding the career has potentially discouraged the interest of young women in these fields.

Engineering Technology prepares graduates with knowledge skills and technical problem solving abilities necessary to success in a wide range of engineering technology disciplines[3]. The specific ABET Engineering Technology Accreditation Commission (ETAC) student outcomes for Engineering Technology are[4]:

a. An ability to select and apply the knowledge, techniques, skills, and modern tools of the discipline to broadly-defined engineering technology activities
b. An ability to select and apply a knowledge of mathematics, science, engineering, and technology to engineering technology problems that require the application of principles and applied procedures or methodologies
c. An ability to conduct standard tests and measurements; to conduct, analyze, and interpret experiments; and to apply experimental results to improve processes
d. An ability to design systems, components, or processes for broadly-defined engineering technology problems appropriate to program educational objectives
e. An ability to function effectively as a member or leader on a technical team
f. An ability to identify, analyze, and solve broadly-defined engineering technology problems
g. An ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature
h. An understanding of the need for and an ability to engage in self-directed continuing professional development
i. An understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity
j. A knowledge of the impact of engineering technology solutions in a societal and global context
k. A commitment to quality, timeliness, and continuous improvement

The field of manufacturing is wide, and engineering and technologists must understand the processes and materials involved in the creation of a useful product[5]. The emergence of non-traditional education providers (such as online and hybrid) poses challenges for US higher education institutions. To remain competitive, US universities should re-adapt the way education is delivered, and develop curricula that meets the core competencies required in the market place[6]. At a time when local, state, and national resources for education are becoming increasingly scarce, expectations for institutional accountability and student performance are becoming more demanding. There is a need for more educational innovations that have a significant impact on student learning and performance[7]. Programs that focus on teaching students in a more personal and interesting manner are a good example of such innovations.

The percentage of women involved in various STEM fields remains relatively low, especially in engineering. However, K-12 female students involved in mathematics and science courses tend to perform on par with their male counterparts, with female students showing a higher tendency to enroll in advanced science courses (22% female versus 18% male). The exception to this is computer science and engineering courses, in which male students are more likely to enroll than female students with engineering at 3% versus 1% and computer science courses at 7% versus 4%. In higher education women earned 57.3% of bachelor's degrees in all fields in 2013 and 50.3% of science and engineering bachelor's degrees. However, while women receive over half of bachelor's degrees awarded in the biological sciences, they receive far fewer in the computer sciences (17.9%) and engineering (19.3%). This trend reflects upon the workplace in these fields

with women making up only 29% of the science and engineering workforce, with relatively low shares in engineering, around 15%. The need for more educational opportunities for female students in fields of Science, Technology, Engineering and Mathematics (STEM) is present and there is a need for programs to help correct this trend[8].

There are currently some STEM outreach programs in place within the United States. The United States Naval Academy (USNA) is the host of a STEM Summer Camp program. The program is success-oriented and project based and creates a STEM focused curriculum for students in grades 9th, 10th, and 11th. Students over the course of the program learn real-life applications of math and science principles within lab facilities that provides a more unique learning environment than a traditional classroom. The United States Naval Academy's summer camp program is ranked among the top five "Best Undergraduate Engineering Programs" by the *U.S. News & World Report*[9].

The USNA also offers a program called “Mini-STEM” in which high schools are invited to send small groups of students to visit USNA. The students stay overnight and are given tours of the engineering and lab spaces. Students also get to engage in interactive science and engineering activities. These programs are just one of a few STEM outreach programs in place at the USNA and more programs can be found put in place by other organizations across the country[10].

There are also short-term STEM projects that occur over hour blocks instead of in the form of weekend programs, such as the Hour of Code movement. Hour of Code is a global movement that seeks to raise awareness and involvement of computer science in schools. Northwestern State University of Louisiana partook in this STEM project and organized an event in which fifth graders were taught the basics of code by students and faculty from the Computer Information Systems department of Northwestern. This project exposed young students to basic coding in an effort to spark interest in computer science among the students and take the seemingly complicated nature away from the act of coding[11].

Another STEM outreach program that occurs at Northwestern State University is a program called Girls Who Code. Girls Who Code takes place once a week over the course of a semester during which students from the Computer Information Systems teach young women from the local middle school how to code. Girls Who Code is an organization started in 2013 that has since spread to about 25 states teaching young women to code. Girls Who Code teaches the middle school students coding languages and helps facilitate an interest in STEM, specifically computer science[12].

Despite the many STEM outreach programs put in place around the country, the number of female engineers in the workplaces remains relatively low. There has been a significant improvement compared to the 1980's, during which only about 5.8% of engineers were woman, but the numbers remain relatively low with female engineers only making up about 14% of the engineering workforce within the United States. Suggested reasons for this phenomena include lack of female role models and young women having fewer technological problem solving opportunities throughout K-12 than when compared to their male counterparts[13].

To attempt to combat the lack of female engineering students within an Engineering Technology department at a University of Louisiana, the department developed a “Girls Who Draft” program, which is partially motivated by the Girls Who Code program. This program teaches

young women how to use Autodesk AutoCAD. Drafting using AutoCAD is one of the courses commonly taught to entering freshmen in engineering and engineering technology programs.

This research takes a pragmatic approach to develop a two-hour STEM outreach workshop. The paper proceeds by discussing the method used to carry out the research. After that it provides a summary of the results. The paper concludes by a discussion of the key findings and provide directions for future development of the workshop.

Method

This paper uses a case-study approach. A faculty team of the Engineering Technology department worked with members of their industry advisory committee and undergraduate students in the program to develop a new a STEM outreach initiative targeted at young women. The team researched similar programs available nationwide, including existing STEM outreach efforts at the institution, and reviewed the university documentation and catalog information (including course descriptions and dependencies, course syllabi, course competencies, and course assignments). The faculty team then identified a sophomore level female student from the department to be a facilitator for the young women from the local middle and/or high schools.

The program is designed in the format of two-hour blocks during which the facilitator teaches the students the selected lesson for the week. The facilitator starts by putting together a lesson plan for the week's lesson and an accompanying Power Point. The students arrive at the selected facilities at the chosen day and time and the facilitator starts by giving the students an introduction to the chosen lesson. Once the introduction is complete the facilitator then proceeds to cover key components of the lesson, these lessons may cover multiple features of the chosen software at a time.

Upon completion of the lesson the students are assigned an activity relevant to material covered. The activity is to be completed by mainly the students, though the facilitator may assist when asked by a student. The completed assignments are then turned into the facilitator who proceeds to review the assignments to determine not only how the students are preforming but if a previous lesson need to be covered again for the students or if the class may move on. Upon the completion of the workshops students are given one final activity to complete themselves, with no assistance from the facilitator, to gauge how well the subjects taught by the facilitator have been absorbed by the students.

Results and Discussion

The program overall seems a solid way to build a foundation of learning for young women interested in STEM fields. The lesson plans are well suited for beginners and those with no prior experience with drafting programs, a sample lesson plan used is shown in Figure 1.

Girls Who Draft

Girls Who Draft Lesson Plan:

Objective: Introduce students to basic features of AutoCAD

Time: 2 hours

Materials: Computers, AutoCAD software, and pamphlets of key information.

Procedure:

10 Minutes: Introductions

20 Minutes: Teach students basics of navigating AutoCAD, such as: Start-up, previewing and opening drawing file, viewing details (e.g., Zoom), saving drawings, and exiting.

40 Minutes: Cover the user interface, what the ribbon is and the features inside of it, the lay out tabs, view cube, crosshairs, title bar, etc. and explain workspaces, toolbars, and pallets.

20 Minutes: Explain basic commands line commands within AutoCAD.

Practice:

30 Minutes: Have student complete drawings based on pamphlets provided to students.

Figure 1. Girls Who Code Lesson Plan

There is an assignment given at the end of every lesson, as expressed above in the lesson plan, that acts as a method to evaluate the students' progress each session. There is also an assignment given towards the completion of the workshop that allows for the evaluation of the students' overall progress along with a survey to see how much impact the workshop had on the students and their interest in STEM fields. Figure 2 provides an example of a student using Autodesk-Autocad software.

Once feedback has been obtained from the students via the given surveys the surveys are reviewed by both the facilitator and the department head. The feedback is reviewed for comments and suggestions, which are all documented. The suggestions are then examined individually to see what changes are needed to be done to the program to help improve it and make it a more effective STEM outreach program.

Table 1 provides a comparison of Girls Who Draft with some existing STEM outreach programs.

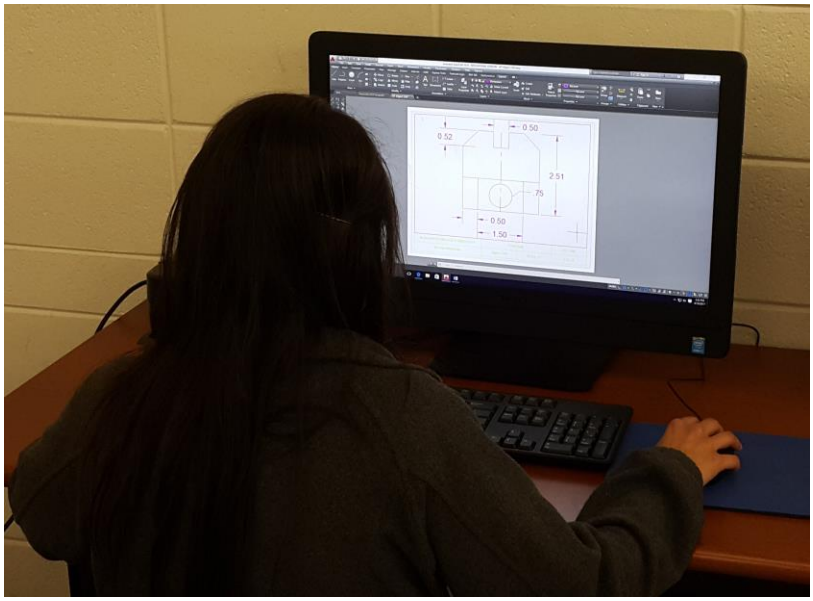

Figure 2. A student Using Autodesk Software

Table 1. STEM Outreach Programs Comparison

Program:	**Length of Time:**	**Subjects Covered:**	**Reoccurring:**
STEM Summer Camp program[10]	Four to five days per session	Various subjects on STEM, such as Energy and Light, Infrastructure, Flight and Fluids	Yes, yearly
Mini-STEM[10]	Two to three days	Various subjects on STEM	Yes
Girls Who Draft	Two hour blocks	Drafting using AutoCAD and Autodesk	Yes, weekly and by semester
Hour of Code[11]	One hour	Basic coding	Yes, yearly
Girls Who Code[12]	One hour blocks	Beginning code using the various languages	Yes, biweekly and by year

Table 2 provides Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis for Girls Who Draft.

Table 2. SWOT for "Girls Who Draft" Program

Strengths (Internal, Positive)	**Weaknesses (Internal, Negative)**
• **Knowledge:** Girls Who Draft is facilitated by a student chosen by faculty with in the engineering department which helps to ensure the student is knowledgeable about what they will be teaching • **Class Size**: The class sizes of 10 to 15 students allow for each student to obtain the attention needed for success in the program • **Internship:** Girls Who Draft offers the student facilitating the ability to list the program as an internship for the department on future resumes	• **Class Size**: While the size of the class allows for a more hands on approach it limits how quickly impact from the program can be seen • **Location:** Students must travel to the department facilities to be able to access the required equipment for the lessons, such as the AutoCAD software • **Student Facilitator:** While the chosen facilitator may be knowledgeable in the subjects being covered, they may not be prepared to teach
Opportunities (External, Positive)	**Threats (External, Negative)**
• **Relationship**: Girls Who Draft allows positive relationships to be formed between the department and the surrounding K-12 schools • **Teaching Material**: Girls Who Draft will cover a curriculum not typically offered by the schools the students attending are from	• **Travel:** Traveling to a university campus might be discouraging to some participants

Upon analyzing the data from executing the Girls Who Draft program, several opportunities of improvement exist, such as:

- Putting together a pamphlet of information and a brochure regarding the program and what it will be covering to provide to faculty at local schools
- Promotion of the Girls Who Draft and Engineering/Technology program offerings
- Installing software in a computer lab at schools that may reduce travel on students

Future expansions of "Girls Who Draft" include multi-day and multi-session formats where more detailed contents can be demonstrated.

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