Making Stars: A Manufacturing Outreach Session

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Abstract

A Manufacturing and Mechanical Engineering Technology outreach session was implemented in Summer 2015 as part of two different camps directed at underrepresented groups. In one, over 90 high school students were introduced to an overview of manufacturing processes, experienced metal forming and resistance welding, and viewed the CNC process. The schedule permitted all the students to experience these activities in a relatively short time. This paper will discuss the preparation required, the specific forming and welding activity, and the online game, and its applicability to project management and manufacturing, as well as the scheduling challenges. Feedback from the participants and suggestions for improvement for future offerings are provided.

Introduction

Faculty in engineering are often asked to participate in outreach activities for their respective institutions, particularly to support recruiting of women and underrepresented groups to the field. The challenge can be to go beyond lab tours and demonstrations, particularly for larger groups of students. Faculty in the Manufacturing and Mechanical Engineering Technology (MMET) program at Texas A&M University developed an outreach experience incorporating components of a standard MMET lab exercise, as well as traditional demonstrations to create an integrative view of manufacturing. This experience was delivered to high school students with little or no background in manufacturing processes or concepts.

The first iteration of the activity was focused on the hands on component, in which the participants manufactured steel stars from sheet metal using the resistance welding process. They were able to take the stars home as a remembrance of their experience. With careful scheduling, and practice, the same hands- on activity was introduced to over 90 students in less than 4 hours, as part of a greater exposure to manufacturing. Feedback was very positive, and new activities are being developed as a result.

Background

Hands-On Activities as an Essential Component for Effective STEM Outreach

Based on a number of models reviewed by Jeffers et al[1] on outreach activities for K-12 programs, as well as the authors' previous work[2], it has been observed that these outreach workshops need to have a strong hands on component delivered as a group activity, since children enjoy and gain immense knowledge when interacting with others. Other effective outreach activities (delivered at partner universities) can include contests, mentoring arrangements, tours of university labs, development of educational/teaching materials, etc.[3,4], as long as an appropriate hands-on component is included.

Another effective component of STEM-related outreach activities, especially in those pertaining to manufacturing engineering technology-related outreach[5,6,7] include projecting positive female role models in faculty[8] and student volunteers[2,8] – the impact of their participation was assessed through surveys. Within such manufacturing-related outreach workshops[9,10,11], it was observed that generating a souvenir as part of the student activity which the student actively contributed in fabricating[9], resulted in serving as an effective motivator or trigger for sustained interest in STEM-related fields.

Women in STEM Fields[2]

Studies performed at a number of universities across the country show bias in the enrollment of female students in the fields of science, technology, engineering and mathematics (STEM). In the Dwight Look College of Engineering at Texas A&M University, the number of female students enrolled has remained fairly constant, between 17.3%-19.6% from 1993-2009, as compared to 80.4%-82.7% male students enrolled during the same time period[12]. The national average of female engineers in the same time period is 17%-19.6%. While early education and family background influence a student's decision to enter the STEM fields, a report published by the American Association of University Women also found that a student's belief in his/her own intelligence, stereotypes of engineers/physicists/mathematicians, along with an individual's self-evaluation and spatial skills play an important role in the decision to join associated STEM fields[13].

A number of research articles published discuss the reasons for low percentage of women in the STEM fields. Data included in a historic national report which interviewed over 1 million high school students found that while there was a 20% increase in interest in STEM careers by high school students since 2004, the interest of female students was a mere 14.5% as compared to 39.6% male students[14].

In research published by StemConnector[14], there is a clear indication of the gender gap with regards to interest in STEM prevailing among high school students. A significantly larger number of boys (33%-45%) showed interest in STEM as compared to girls (11%-16%), during the years from 1997-2016. It was also observed that a greater number of high school freshmen showed interest in STEM, but lose interest in the fields by their senior year. This is a clear indication that while it is important to introduce concepts of STEM and hands-on work for students, desired results cannot be achieved by a one-time effort. In order to make students maintain a continued interest in the field, there should be hands-on activities, competitions, guest speakers, university visits and associated activities for youth throughout their school years. Further, a distribution of the interests in the various fields of STEM as expressed by high schoolers was carried out by StemConnector – while male students showed a much higher interest in engineering (18%-26%) followed by technology (7%-17%), female students showed a high interest in science (6%-11%) with equal interests in math, engineering and technology (1%-4%).

Factors Contributing to the Gender Gap in STEM Fields[2]

Some factors pointed out by Blickenstaff[15] include the fact that engineering and math have been predominately seen as "masculine" fields. Further, the lack of role models plays a big role in young girls not choosing to pursue STEM fields. This importance of needing appropriate role models has been continually cited as being one of the main factors which encourage young female students to enter the field of science and engineering[16,17]. To date, in many families and cultures, women of all ages are seen in traditionally-perceived roles of being home-makers, while young males are encouraged to pursue engineering and other technically intensive fields. Many successful females in the fields of math and science have had one or both parents in associated technical fields[16]. Further, many studies also suggest that boys are more confident about their science skills compared to girls of the same age[18], while girls tend to receive less encouragement from their school teachers[19].

In order to overcome the gender gap prevalent in the field, it is essential to understand what drives women away from a career in STEM, and what steps can be taken to develop interest of young girls towards the field. Research has shown that choice of careers is an ongoing process which starts when children are in middle school. Hence, targeting this age group is essential to develop interest and enthusiasm in STEM, and to encourage them to break the barriers of the conventional roles of males and females in society.

Outreach Workshop Activities and Schedule

The WE IDEAS summer camp, sponsored by the Women in Engineering (WE) program in the Dwight Look College of Engineering (COE) at Texas A&M University, invited junior and senior level female high school students to attend a residential camp and participate in a number of activities intended to introduce them to engineering and engineering technology. A faculty member in the MMET program in the COE offered a workshop session introducing welding and manufacturing and showing the students to make a star from sheet steel using the resistance welding process. The star project was adapted from a lab activity developed by Dr. Wayne Hung in the MMET program for the MMET Introduction to Manufacturing Processes course. Triangle shapes with edge tabs are stamped from 22 gauge carbon steel, then a ridge is bent down the center of the triangle. Tabs are bent and welded to adjacent triangles to make the star points using the resistance welding process. The components are bead blasted to smooth any rough edges. Five triangles are joined to make a star. Due to time constraints for the outreach activities, a portion of the star points were formed and welded together for the students; they finished bending and welding together the remainder of the star points.

In preparation for this camp, the participants were provided handouts for each of the activities they would experience. A welding presentation was prepared for inclusion, which provided a basic overview and definition of welding. A safety overview was included. Before arriving at the laboratory for the activity, participants were asked to wear jeans and closed shoes. Safety glasses and leather shoe covers with steel toes were provided to the students when they arrived at the lab.

Five sessions over two days were offered with 16 students per session. The students were introduced to the welding process and then shown how to make the bends and the welds. In line with previous work showing the advantage of a female role model in these outreach activities, a female student majoring in MMET gave the campers an overview of her major, demonstrated the process and helped to supervise the campers as they made their stars. An MMET student demonstrated the submerged arc welder for students who were waiting for the equipment, as a faculty member watched over the group and answered questions for campers. The timeframe allowed ample time for the campers to see the lab, learn about manufacturing, and see how the welding process fit into the overall scheme.

In a second camp, the timeframe and number of students was different and much more demanding. The ENGAGE camp was directed toward junior and senior level high school students, both male and female, from underrepresented groups. This camp was sponsored by the Access and Inclusion program at the COE. The star activity was incorporated as part of a larger view of manufacturing. There were approximately 90 students to accommodate in roughly 3.5 hours. Constraints were the number of students who could work in the welding lab reasonably at one time and the number of support staff and faculty available for the session. In order to facilitate a good experience the students were broken into six groups of 15, and scheduled for various activities, as shown in Table 1. Each group had two TAMU students escorting them to the different sessions. Half of the students were sent to a classroom to watch an episode of the television show "Modern Marvels" entitled "Welding". This gave the campers a chance to observe various welding processes and their applications.

Table 1. Schedule for the ENGAGE Summer camp Manufacturing activity

Group	11:35 - 12:05	12:10-12:40	12:45-1:15	1:20 - 1:50	1:55 - 2:25	2:30-3:00
1	welding	Computer Lab	HAAS	Movie -	Movie -	Movie
2	HAAS	welding	Computer Lab	Movie -	Movie -	Movie
3	Computer Lab	HAAS	welding	Movie -	Movie	Movie
4	Movie	Movie	Movie -	Computer Lab	welding	HAAS
5	Movie	Movie -	Movie -	HAAS	Computer Lab	welding
6	Movie	Movie -	Movie -	welding	HAAS	Computer Lab

The welding session had the students making the stars as explained previously, but with only two points to weld for the completed star. During the HAAS session, an MMET laboratory supervisor demonstrated a HAAS multi axis machine and explained the concept of material removal. During the computer lab session, a faculty member introduced the concept of resource management using the computer game "Royal Envoy" by Playrix. The lower levels of this game can be played for free without any registration at bigfishgames.com. The departmental student computer lab was reserved for the outreach event, and the game was opened on each computer. Students were given a brief overview of resource management concepts and how they apply to engineering, then were asked to play the game. As the participants progressed through levels, they were encouraged to think about how they could improve their time by adding resources or changing the order of their actions on the assigned tasks. At the end of the session, participants were reminded again how this game can model decisions that must be made during manufacturing.

Feedback and Conclusions

The feedback from the participants was overwhelmingly positive. In particular, attendees who reviewed the welding lab session component noted again and again that they liked having the star to take home. Comments included “it was fun to make our own stars and get to keep them”, “I loved welding so much”, and “It was fun and interactive. It made me excited to come into engineering.” Regarding the MMET student who worked with the welding lab, participants said she “very passionate about her work” and “was excited and we could tell she was interested in her field of study”.

These comments from participants follow with published recommendations for outreach. The star activity was just one example of hand-on manufacturing experiences that can be used in events like this. The challenging part is accommodating large numbers of students in a limited time frame. The first round for the WE camp provided an easier introduction to the time management for the presenters. The second round for the ENGAGE camp using the star activity as part of a larger experience for more students worked well for the constraints given.

Future Changes and Assessment

For future outreach activities, more hand-on activities using multiple processes will be developed, making sure that the students have something to take home and can use more processes as part of an overall system. Having the game first would have been helpful to put the coordination of the manufacturing process components into perspective for the students. Having additional female students to help with the activities would be beneficial in the context of role models. In the end, showing how all of the individual activities come together as a whole of manufacturing is extremely important and will have a greater impact.

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