Tech X Ploration: A Summer Institute for High School Girls
or
What We Did on Our Summer Vacation

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Abstract

New Jersey Center for Advanced Technological Education, NJCATE, has a National Science Foundation Grant to host a summer academy for rising high school sophomore girls with the goal of interesting them in pursuing science, technology, engineering or math as academic and career choices. The first session was held in July, 2006, for 25 young women from central New Jersey.

The goal of the academy was for the girls to design and build a working scale model of an amusement park ride. We started the academy with a day at Six Flags Great Adventure and concluded with presentations of five working scale model, computer controlled amusement park rides to a panel of judges. Everyone was a winner in this competition.

This paper will discuss:

- Format and structure of the academy
- Recruitment, selection process and target demographic for participants
- Mentoring process with college women majoring in engineering or technology, and professional female engineers
- Designing and building amusement park rides
- Hands on, trial and error approach.
- What we learned and what we will do differently

Background:

To address the need to inspire more young women to enter engineering and technology fields, NJCATE, A National Center for Advanced Technological Education at Middlesex County College initiated a project entitled TechXploration, A Technology Adventure for Teen Girls. Supported by the National Science Foundation, TechXploration is a three year project composed of a four week summer academy, two full day follow up activities, and an ongoing mentoring program designed to empower the young women with knowledge, skills, confidence and academic preparation and to support them to aspire to engineering or technology careers. The academy was limited to rising high school sophomores who had completed Algebra 1.

U.S. Department of Labor statistics show that of the 450,000 engineering technicians in the U.S. labor force, only 83,000, or 18% are female. The Center for Work and Women at Rutgers University reports that although women are approximately 46% of the American workforce, women fill only 29% of SET (science, engineering and technology) jobs. Statistics show that until middle school, girls and boys show equal interest in science, math and technology. So, how do girls get lost along their path to an education in technology and what can be done to retain them?

According to Introducing the Trilogy of Success: Examining the Role of Engagement , Capacity, and Continuity in Women's STEM Choices, "It is clear that women's STEM under-representation is more complex than earlier imagined and that focus on any one factor, no matter how necessary, will not lead to success." Successful continuation appears to be related not to one, but to three interrelated factors:

1. Engagement: Having an approach to STEM that includes such qualities as awareness, interest, and motivation.
2. Capacity: Possessing the knowledge and skills required to advance to increasingly rigorous STEM capacity.
3. Continuity: Having institutional and programmatic opportunities that support advancement to increasingly rigorous content.

NJCATE's Adventure Ride Learning Module served as a guide for TechXploration. The program integrates problem solving, teaming, mathematics, physics and communication skills with technical components. The core of the module is the hands-on activity of designing and building a scale model of an amusement park thrill ride.

TechXploration was designed to increase the participants' interest in and knowledge of technical careers and to build confidence to pursue them. TechXploration is also designed to work with the parents, teachers and guidance counselors to increase their awareness of the viability of technical careers for females.

Physical empowerment supplements the intellectual components with karate instruction integrated as part of the summer camp. Through karate the young women gain strength, discipline and a sense of confidence.

TechXploration sought to target a diverse population of students, not limited to the elite students who would normally gravitate to a program of this sort. The center actively recruited students from minority and/or economically disadvantaged school districts.

Recruitment and selection of students

The program targets rising sophomore girls who have successfully completed Algebra I. NJCATE has worked with high schools throughout the state with programs such as Building for Tomorrow and the RoboRocks robotics competition. The center did mailings to their network of high school teachers and guidance counselors. The center took advantage of listserves and government agencies with web links to advertise TechXploration. Information about TechXploration was available at the summer camp open house held at Middlesex County College.

Because the program is designed to engage students with a wide variety of backgrounds and abilities it was critical to reach out to student with a range of grade point averages. It was spelled out in the literature, web site and brochures that a grade point of A, B or high C was appropriate. Programs like this will tend to attract only the highest achieving students, so it was made clear that the program was open to an academically diverse population.

The application process:

- Online student application was completed with information about interests, academic background and eligibility for the program.
- Online teacher recommendation. One objective of the teacher recommendation was to assure that the student has or will have completed Algebra I.
- Online health waiver forms and other logistical documentation.
- Interview which gave the staff a chance to meet the student and a parent and to evaluate the level of motivation the student had for attending the academy. The academy is held on the Middlesex County College campus and parents are responsible for transportation. The interviews were conducted with student and parent together. For 2007 the interviews will be done separately so that the student can be more candid and without parental influence.

Technical Counselors

The technical counselors are female college students majoring in a technical field who can act as role models for the students in their charge. Each counselor had a team of five students. Ideally the counselor would have experience with hands-on projects and the use of hand and power tools.

The search for counselors began with the Engineering Technology Department at Middlesex County College but finding students who meet the criteria was not easy. Two counselors were recruited from MCC. The center reached out to other schools and faculty members to find students who were available to work for one month in the summer. Counselors were recruited from Union County College, New Jersey Institute of Technology and Cornell University. The majors included Chemical Engineering, Electrical Engineering Technology, Architecture and Civil Engineering.

Partnerships

NJCATE partnered with different organizations who share the mission of attracting women to the fields of engineering and technology. The Society of Women Engineers based at a local engineering firm, The Nielsen-Wurster Group, provided speakers for a Friday Women in Engineering Careers series, as well as a generous donation of gifts. The National Society of Professional Engineers donated gifts, books and magazines. Middlesex County Vocational Technical High School, located on the MCC campus provided facilities for camp activities.

At the fall follow up day activity, three young women from Engineers Without Borders did a presentation and slide show about their work in Kenya, the mission of their organization, and talked about their own careers as engineers.

Summer Academy and Follow Up Activities

The four week summer camp was structured with 2 hours of activity based core instruction, 2:75 hours for the hands on project activity of designing and constructing the "adventure ride" and 1 hour of karate. The core instruction included computer aided drafting, physics, math and communication skills. The hands on project activity included instruction in the use of tools, manufacturing techniques, materials, safety and troubleshooting. The students were divided into teams of five students and one technical counselor. When students came from one school they were divided into separate teams.

The first Friday of the summer academy was dedicated to the first hand observation of the functioning of amusement park rides with a trip to Six Flags Great Adventure. At Great Adventure we discussed the physics and the engineering of the various rides.

On three Fridays the Society of Women Engineers provided lunch time speakers who talked about their careers and experiences as women practicing engineering. On the fourth Friday, the five counselors moderated a panel discussion with the students. They shared their experiences as engineering school students and why they made the personal choices of engineering or technology

During the following school year, two full day workshops (one in fall and one in late winter) were held for the students. The workshops were structured like the camp day with a guest speaker and a hands-on activity done in teams. The students were asked to invite friends to participate. The turn out for the two follow up activities days was excellent with over 90% of the academy participants attending and bringing friends.

Designing and building amusement park rides

The goal of the "technology" module of TechXploration was to make the design and build activity fun (and in the best case, exciting) so that these young women would be comfortable in the pursuit of an engineering or engineering technology academic track.

Engineering design is tough. There are no "right" answers. The process can be intellectualized and the minutia can be engineered to many significant figures, but ultimately it takes bold leaps

of faith to create good design. Unfortunately, the bold leaps of faith produce many failures along the way and failures are discouraging. How do you do this with 15 year old girls? How do you make it fun? How do you assure success?

The underlying assumption with this group was that they had little or no skills using tools and little or no knowledge of materials, hardware and mechanisms. This assumption was valid with TechXploration 2006. The assumption was, unfortunately, also valid for the counselors who were responsible for the students. When asked, almost universally, any experience in this area was credited to the fathers.

The curriculum was laid out in a logical fashion that introduced tools (cutting, gripping, measuring), materials and processes. The curriculum was done at a pace that would introduce new subjects as they were needed to fabricate the amusement park rides. The last subject was computer controls of motor circuits. The neat and orderly curriculum melted into CHAOS within two days! As the design ideas took shape the needs for materials, hardware and processes (drilling, cutting, shaping, tapping, bending, etc.) became apparent and were not in synch with the neatly laid out curriculum. The process became a creative environment that produced an endless stream of Teachable Moments.

In hind sight, the curriculum was taught. It was not taught in the traditional lecture, exercise format. It was taught as Teachable Moments. It was taught one-on-one. This takes a lot of time and far more time then was budgeted for the process. The building activity was scheduled for 2:45 hours per day. By the end of week one the building activity had almost doubled in time. It happened with individual requests to work on the projects instead of doing some other activity. We adjusted to our market.

Design and fabrication of an engineering project involves risk. Success is never assured. At the risk of generalizing and stereotyping, young women are less prone to take risks then their male peers. Women want to be successful and they do not want to make mistakes. They will read and follow the directions. Our activity had no directions. Failure loomed around every corner. Fasteners failed. Circuits burned. Mechanisms did not function. How were we to measure success in the face of failures?

We used every failure as a learning experience, praising the failure for what we could learn from it and teaching about what causes the failure. **The goal was to make failures safe,** and to make the students comfortable with accepting the failure of their design and using that failure to create a larger success. This was design as an iterative process.

Nuts and bolt issues

The student teams were given a box of tools. The tools anticipated the processes that they would need to fabricate their projects. The tools included a variety of cutting tools (saws, knives, pliers, etc.), a variety of gripping tools (adjustable wrenches, pliers, etc.) and a variety of measuring tools. The area was equipped with a bench milling machine, miter saw and two drill presses. We had, at our disposal a CNC milling machine, lathes, grinders and sanders.

The suggested building materials were plywood, ¼" phenolic (scrap contributed by a local manufacturer), and 2 x 3 metal building studs. Other materials were available and, within limits,

we were able to supplement the stores. A variety of standard hardware was available (sheetmetal screws, machine screws, nuts & bolts, pop rivets, etc.). The hardware available was a combination of laboratory supplies from MCC and the stock of hardware loaned to TechXploration by a local high school FIRST Robotics team.

For controls we chose Parallax Basic Stamps and had designed a relay interface board that was suitable for small 12 VDC motors. We chose to use 12 Vdc lead-acid batteries (motor cycle size) as the power source. The choice was a good example of an engineering failure. Two of the designs used direct coupled motors that would stall during the motion of the ride. These motors were large enough that the stall current easily exceeded the rating of the relays, fuses and wires that we provided. In other words, prone to electrical fires. Each failure provided solid teachable moments and ultimately better designs and understanding of some complex engineering issues. It also provided treasured mementos of burned relays and charred wires.

We set only two safety rules. Rule 1: 60 working eyeballs at the end of the camp. Rule 2: 300 attached (scared was acceptable) fingers at the end of camp. The only power tool that was not entrusted to the students was the miter saw. We suffered a few cuts but nothing worse.

Design

The constraints on the design were to limit the size to 4' x 4' with no water rides. The model was Six Flags Great Adventure where water rides are popular. One group prevailed and fabricated a 4' x 8' water flume that took 6 maintenance men to move it to another building for the final presentation. Another group fabricated a 4' x 8' roller coaster. If the inspiration was going to be Six Flags Great Adventure we have to expect them to think BIG and disregard constraints! Lesson learned!

Final Presentation and Awards

The concept of the academy was to have the students make a final presentation of their projects to a panel of judges and display their projects to parents and guests. The judges ultimately selected a "winner" with a rating system and numeric scores. The teams' designs satisfied their own criteria and none were designed to be "better" then another. Each team measured their success against their own specifications and these specifications evolved significantly over the four week period. We are reevaluating the criteria to be used to evaluate the completed projects for the next summer academy.

Conclusion

TechXploration was a genuine learning experience. It was a learning experience for the students who participated, the technical counselors, and the faculty and NJCATE personnel who were responsible for implementing the summer academy. The objective was to give 25 young women the confidence to pursue an education in science, technology, engineering or mathematics.

The five teams produced working models that were creative and inventive with every working model far exceeding what was anticipated by the organizers. While the NJCATE Adventure Ride Learning Module served as a model for TechXploration, the final results, driven by the students, took the learning module on its own adventure ride.

The success of TechXploration will not be known for many years. How many of the 25 participants will pursue an academic track that leads to a career in science, technology, engineering or math? The anecdotal success, however, is the number of requests that the center received from participants who want to come back. To address the requests, TechXploration will most likely have Technical Counselors In Training for each team in July 2007. That is a success!

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