13th Annual National Engineering and Science Academy

Introduction

This National Engineering and Science Academy develops the awareness of career choices in Engineering & Science fields. It is for young men and women who are entering the 8th Grade Fall of 2015 or older. Our program provides an opportunity for them to be aware of different technology career opportunities, insight into the excitement and challenges in these careers, and guidance on planning through high school and beyond to achieve this goal.

Committee Members

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Ms. Sandy Martin	Program Specialist, Learning for Life
Mr. Jack Waite	Director, Learning for Life
Mr. Martin Barbie	Scout Executive, Westmoreland-Fayette Council
Dr. Theodore Davi, F-SAME	Fellow, Society of American Military Engineers
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National Engineering and Science Academy General History

During the 1990's, a national committee was formed in Washington, D.C., named the National Engineering & Technology Exploring Committee, a part of the Learning for Life program of the Boy Scouts of America. The mission of this committee was to assist youth, boys and girls between the ages of 14-20, in helping them to find and develop a technical career path for their future development.

The first Academy was held at Marshall University in Huntingdon, WV, and in the following years, under a separate program held at the Westmoreland-Fayette Council's Learning for Life Council. Since its inception within the Ohio Valley Region and in other parts of the United States, over 2,500 students joined the program. A high percentage of these students have gone on to technical careers after graduating from colleges or universities. Students have also been introduced to technical career opportunities available through trade schools.

2015 Theme: Advanced Manufacturing and Automation

The 2015 National Engineering and Science Academy (NE&SA) was attended by 31 students, including five women and one African-American. Students were also from a wide range of economic backgrounds. Camperships were made available to qualifying students.

The theme of the 2015 program was Advanced Manufacturing and Automation. Students were introduced to these concepts through hands-on activities as well as site visits to Alcoa Technical Center, Saint Vincent College, and the Central Westmoreland Career and Technology Center.

Day 1: Stored Energy

The students participated in two different activities involving storing and releasing energy; Nerf™ guns and catapults. They examined how these devices use stored energy and the technology behind the design and construction of these devices.

The Nerf™ Experiment

The students were challenged to assemble and fire a Nerf™ gun. This activity had two goals:

- Understand how the spring mechanism was used to store energy to fire the foam projectile
- Examine the individual pieces and assembled product and consider how this is accomplished with automated equipment.

The students were given disassembled Nerf™ Guns and challenged to determine a sequence for assembly and then reassemble the toy. During the process, they were encouraged to think about what had to be considered when designing the toy, how different disciplines worked as a team to make the final product, and what challenges they may have encountered. They were asked questions such as:

- How do you think this part was made?
- Why do you think the designer put the screw here?
- What features were built-in to make assembly easier?
- How would a machine put this together? Would a robot be used?
- What decisions did a mechanical engineer make? How about a chemical engineer?

Students were encouraged to assist one another during the assembly process. We considered the team-building aspects as important as the assembly challenge. Students were also asked to think about ways the design could be improved; modify the toy to shoot the foam projectile further or more accurately.

After the students assembled their Nerf's, they had a marksmanship competition

The Science of Catapults

Students built a catapult from a kit. They examined how the energy is stored and released, and they experimented with the adjustments to the catapult to see the effect on energy release and the subsequent distances they could achieve with their jellybean projectiles.

Day 2: Alcoa Technical Center

The second day of NE&SA was spent at the Alcoa Technical Center, Alcoa's research and development facility. Students met with metallurgists, designers, mechanical engineers, electrical engineers, chemists, computer scientists, machinists, and other disciplines. The goal was to show how diverse teams, with different technical backgrounds come together to solve a challenging engineering problem. Two different projects with very different technical requirements were highlighted, the Ford F-150, and Additive Manufacturing. These were chosen to show how technologists must be ready to solve a wide variety of problems. In addition to seeing how project teams work, the students were paired with young professionals

Ford F-150

Students met with metallurgists, mechanical engineers, designers, machinists, and mechanical test technicians who worked on developing materials, designs, and forming processes for the all aluminum Ford F-150. The interactive discussion included research questions such as:

- What is formability, and how alloy design is used to achieve formability necessary to make the various panels;
- The use of mechanical testing to understand final properties, and how the project team uses designed experiments to develop the manufacturing plan to achieve these properties;
- Choice of processing such as hot rolling and cold rolling to achieve target dimensions, mechanical properties, and desired surface appearance;
- The role of heat treating and other post-processing to achieve the necessary mechanical properties that cannot be accomplished simply from rolling;
- The role of process control in operations such as rolling and heat treating;
- How design and functionality decisions affected the choice of fasteners, spot welding, or arc welding for final assembly;

Additive Manufacturing

Students met with the research team working on additive manufacturing (AM) / 3D printing for metals. Many of the students were familiar with 3D printing used for plastic parts, but did not realize the special challenges associated with applying this technology to metals. They learned how the team relies on many areas of expertise:

- Designers work with mechanical engineers to integrate 3D CAD designs with FEM models;
- Electrical engineers work with machine operators to understand how to get better measurements and improve part quality;
- Metallurgists, mechanical engineers, and electrical engineers develop first principles models to understand the physics at work during part manufacture.

Students had an opportunity to see industrial scale 3D printing systems at work. This gave them a peak into the future of manufacturing in the United States.

Mentoring

Another feature of the visit to Alcoa Technical Center was pairing students with young professionals. This provided each student an opportunity to talk with someone, very close in age to themselves, about the choices they need to make over the next couple of years. Typical questions included:

- How did you know you wanted to be an engineer?
- What kind of classes did you take in high school? Is it worth taking AP classes?
- How did you pick a college?
- Do I have to go to college?

Day 3: Paths to a Technical Career

The third day provided the students a first-hand look at different paths to a technical career. The first half of the day was spent at Saint Vincent College and the second half at the Central Westmoreland Career and Technology Center. This is important because choosing college is an expensive proposition. For students who want a technical career, but are not sure if college is right for them, there are many opportunities. For those students considering college, this is an opportunity to experience the classroom setting and help solidify that decision.

Saint Vincent College

Students met faculty and students affiliated with the Herbert W. Boyer School of Natural Sciences, Mathematics, and Computing. One part of the visit was an in-depth tour of the school's planetarium. Students learned about the system used to display stars, and track the paths of planets and comets in the solar system. The second activity was participating in a bridge design competition.

Central Westmoreland Career and Technology Center

The vision of the Central Westmoreland Career and Technology Center is to provide industry-based technical programs to meet the need of an evolving workforce. Students of the NE&SA had the opportunity to learn about and have a hands-on experience operating a simulator for metal fabricating and welding, a thermal process control system, and electrical technology.

Day 4: Controlling Flight

The final day of the academy focused on flight, and control of flight. Two different vehicles were examined; rockets and airplanes.

Rocketry

Students were given an introduction to the theory of rocket flight, and what is important for a stable, controlled flight. Students learned hands-on by assembling and launching their own single-stage rocket. Topics covered included:

- Safely building and launching model rockets;
- The importance of center of gravity and fins for stable flight;
- Use of parachutes and streamers for safe recovery of your rocket;
- The structure of the rocket motor and how it propels the rocket and the reason for the ejection charge;
- How to size the rocket motor to your rocket;
- How rocket motor ignition works;
- Setting up a safe launch site;
- The importance of a stable launch device;
- Rules to be observed for launch safety.

Aerolab

Aerolab is an activity developed by the Academy of Model Aeronautics (AMA) where students learn the principles and physics of flight. Detailed information can be found at http://www.modelaircraft.org/education/aerolabs.aspx. Students use a JetStream balsa airplane, powered by a rubber motor, and tethered to a central pylon. This allows the students to run controlled experiments on the airplane and develop simple models of plane behavior. This is a group activity with the following roles:

- Winder
- Launcher
- Lap Counter
- Timer

Students practiced the activity and decided who would take each role. This is a key part of team building; use the strengths of each member.

Activities focused on students measuring plane behavior, creating models, and predicting results. Activities were designed such that students made specific changes to their plane, hypothesize a result, measure and quantify, and then assess their hypothesis. Activities were:

1. Calculate average speed by measuring time aloft and distance flown. Perform replicates and determine spread of results and reason for outliers;
2. Put different amounts of power into the rubber motor (600, 800, and 1000 turns), and measure average speed and time aloft. Use linear regression to develop a model relating turns to speed and time aloft. Identify and explain potential data outliers.
3. Add drag to the airplane and repeat Experiment 2. Compare results, and the model to the one developed for Experiment 2.
4. Add weight to the airplane and repeat Experiment 2. Compare the results to Experiments 2 and 3. Suggest a hypothesis to explain the difference.
5. Given a target speed and time aloft, use models developed in 2, 3, and 4 to adjust drag, weight, and number of motor turns to achieve the target. Run the experiment and evaluate the results.

This provided a very hands-on approach to the experimental method, design of experiments, empirical model building and system identification, and application of statistics. Students were also encouraged to evaluate their experimental methods and revise as necessary to improve the accuracy and repeatability of their experiments.

Summary

The overall goal for the National Engineering and Science Academy is to introduce late middle and high school students to the challenges and rewards of a technical career. This was done through hands-on activities, allowing the students experience to the decision making made by engineers and scientists. They were also given an opportunity to see engineers and scientists in action and learn about what makes a technical career exciting. Finally, they were given guidance on how to plan their career path and access to people to answer questions when making this decision.