AC 2009-1642: USING HANDS-ON LEARNING IN AN AFTER-SCHOOL ENGINEERING PROGRAM TO PROMOTE STEM CAREERS TO HIGH-SCHOOL STUDENTS

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Using Hands-On Learning in an After-School Engineering Program to Promote STEM Careers to High School Students

Abstract

Pre-college exposure to Science Technology Engineering and Math (STEM) concepts can generate enthusiasm and encourage students to pursue careers in these fields. This work describes an approach to teach STEM concepts to minority high school students via hands on activities and seminars in an after-school program at Tri-Cities High School located in East Point, Georgia. The primary objective of this after-school program is to use hands on activities and seminars to stimulate interest in STEM fields and invoke college pursuits. This paper discusses the activities and seminars conducted during the 6th programmatic year. The weekly activities and seminars promote skills in four key areas: academic excellence, leadership, technical/professional development, and teamwork.

Academic excellence was promoted by beginning each meeting with a Scholastic Aptitude Test (SAT) math question and participation in a math and science quiz bowl with high school teams from six different states. Leadership skills were gained through constructing and implementing Rocket Building workshops targeted to middle school students at a regional engineering conference. Technical skill development was fostered via hands-on STEM activities that included, constructing alarm systems, designing biodiesel devices, egg drop design competitions, and miniature boat building. Professional development was promoted through a public speaking seminar, and a college tour which included an admissions seminar, college engineering club seminar, and engineering and science research lab presentations. All activities were established to encourage collaboration and enhance teamwork skills.

Details on the procedures used to implement each activity and seminar are included in this work. Suggestions on pre and post program assessment methods to measure student confidence and interest in STEM related careers are discussed. Projected assessment techniques seek to track the effectiveness of the four key areas: academic excellence, leadership, technical/professional development and teamwork in the promotion of STEM career interest and pursuits amongst minority pre-college student participants.
Introduction

This study was implemented in collaboration with the Student Teacher Enhancement Partnership (STEP) program, hosted at the Georgia Institute of Technology (GaTech), which partners advanced undergraduate and graduate students, STEP fellows, with metro-Atlanta area high schools. STEP is funded by a National Science Foundation (NSF) grant that aims to improve STEP fellows teaching-related communication and leadership skills by providing teaching and leadership training via a one-year teaching assistantship in a metro-Atlanta area high school. This study was conducted by a current STEP fellow (2008-2009), a STEP fellow alumni (2005-2006), and a GaTech staff member.

Structure of After-School Engineering Club

The after-school engineering club is a sub-program, Pre-College Initiative (PCI), within a larger international engineering organization. The goal of the PCI program is to encourage students in grades K–12 to attend college and pursue technical degrees. The PCI program was designed to stimulate high school student interest in science, technology, engineering, and mathematics (STEM). The program encourages the utilization of hands-on activities to expose students to engineering and technology in order to relate STEM concepts to the world around them. By experiencing the latter students discover the excitement of academic excellence, leadership, technical development and teamwork.

Currently twenty students participate in the after-school engineering club. The racial and gender demographics of total student enrollment at the high school and after-school engineering club enrollment are displayed below in Table 1. Program logistics such as meeting room reservations and field trip form requests were handled by the high school teacher advisor. Organization and facilitation of weekly meetings and correspondence with the international engineering organization were handled by the STEP fellow.
Table 1. Race and gender demographics represented per percentage of total student enrollment at the high school and in the after-school engineering club.

<table>
<thead>
<tr>
<th>Race</th>
<th>High School</th>
<th>After-School Engineering Club</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>82%</td>
<td>85%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>13%</td>
<td>5%</td>
</tr>
<tr>
<td>Asian</td>
<td>2%</td>
<td>10%</td>
</tr>
<tr>
<td>White</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Multiracial</td>
<td>1%</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>High School</th>
<th>After-School Engineering Club</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>47%</td>
<td>45%</td>
</tr>
<tr>
<td>Female</td>
<td>53%</td>
<td>55%</td>
</tr>
</tbody>
</table>

*Hands-On Activity and Seminar Logistics*

Field trips were conducted to participate in the math and science quiz bowl, Rocket Building workshop, and college tour. Weekly engineering club meetings were held after school for one-hour time durations to conduct the hands-on activities and the public speaking seminar. Each weekly meeting began with the review of a SAT math question facilitated by the high school students. This activity promoted academic excellence, one of the four key areas addressed in this work, by encouraging students to grasp concepts tested on the pre-college entrance examination.
Motivation

The four key areas of: academic excellence, leadership, technical/professional development and teamwork, were selected as important focus areas based off of a general review of the literature and primarily adopted from the U.S. Accreditation Board for Engineering and Technology (ABET) Engineering Accreditation Commission Criterion #3 on Program Outcomes. ABET being recognized as the accrediting body for college and university programs in applied science, computing, engineering, and technology, states the importance of pre-college student development in the four key areas to ensure success in pursuing STEM fields in college. The “Criterion #3” lists from (a) to (k) the required outcomes for accredited engineering programs, Table 2 shows the four focus areas associated with specific desired criterion outcomes.

<table>
<thead>
<tr>
<th>Key Skill Area</th>
<th>Related ABET Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Academic Excellence</strong></td>
<td>(a) ability to apply knowledge in mathematics, science, and engineering</td>
</tr>
<tr>
<td><strong>Leadership</strong></td>
<td>(e) ability to identify, formulate, and solve engineering problems</td>
</tr>
<tr>
<td><strong>Technical/Professional</strong></td>
<td>(f) an understanding of professional and ethical responsibility, (g) ability to communicate effectively, (k) ability to design and conduct experiments, as well as organize and interpret data,</td>
</tr>
<tr>
<td><strong>Development</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Teamwork</strong></td>
<td>(d) ability to function on multidisciplinary teams</td>
</tr>
</tbody>
</table>

It has also been shown that early exposure of pre-college students to STEM principles through hands-on activities can lead to increased interest in and preparation for STEM fields pursued in college. Jeffers et al. states, “Two primary factors why today’s K-12 students are shying away from engineering are a limited understanding of the engineering profession and the loss of interest in science and mathematics”. It is with these two factors in mind that this after-school outreach program has been maintained and the work in this paper compiled. The goal of this work was to educate and excite pre-college students about pursuing STEM fields through hands-on activities and professional development seminars.
Hands on Activities

Alarm System Design

The alarm system design activity was conducted in a single one hour session. The aims of this activity were to expose students to electrical physics concepts, enhance team work skills, and promote real world problem solving techniques. Promotion of these aims aligns with two of the four key skill areas addressed in this work which include technical/professional development and teamwork.

Prior to beginning the activity students were provided with a brief ten minute lecture/discussion on electricity and basic circuit design by the graduate student sponsor. At this time students were allowed to ask questions about electrical properties and obtain clarification on how to relate the information to the alarm design activity. During the activity students were assigned to groups and each group was provided with materials and documentation to complete the activity. The documents supplied to the students to complete the alarm system design activity are located in Appendix A.1 of this study.

Students were given the opportunity to be creative in this assignment via role-playing in the activity scenario. The activity scenario stated that an object was missing from the student’s bedroom and they were to use their knowledge from the electricity and basic circuit design lecture/discussion to create an alarm system to catch the culprit. This scenario allowed the students to personalize the activity by defining what object was missing from their room and by taking on the role of technical expert to create an alarm to catch the culprit. Students’ problem solving techniques were explored in the design of the switch to activate the alarm system. Each group had to decide on the best approach to create a switch that would activate an audio buzzer when tripped. Students were provided with questions regarding their switch design in the documentation materials. These questions were posed to initiate reflection on their own problem solving methods and promote the investigation of strengths and flaws within their design approaches.

At the completion of the assignment students were provided with solutions on how to create the switch and asked to compare their own switch design with the solutions. This questioning process provided the students with an opportunity to view various methods to solve the problem. The finished alarm systems were given to the students to take home at the completion of the activity. This activity provided the students with a chance to obtain technical/professional development in the application of electrical physics concepts to real world problems and enhance their teamwork skills through the hands-on group design of an alarm system.

Bio-Diesel Device Design

The bio-diesel device design activity was implemented as a long term project which was aimed at the fostering of team work skills and the development of the students’ technical skills in mechanical physics, and chemical and environmental science concepts. To have a better impact on their environment high school student participants were inspired to investigate methods to convert waste into usable energy resources. At the completion of
their investigative process students decided to implement a cost effective environmentally friendly bio-diesel device. From their research students determined how to convert waste vegetable oil, obtained from the school cafeteria, into bio-diesel fuel for fuel utilization in auxiliary high school buses.

This experiment was conducted in small working groups to produce 0.3 gallon batch bio-diesel conversion processors. The structure of this project included an in lab experiment that used mason jars to complete the chemical process. Three different types of oil were utilized, one batch of waste vegetable oil from the school cafeteria, one batch of waste vegetable oil from a local restaurant and one batch from that is un-used vegetable oil. The students’ bio-diesel converter design included an old water heater, a pump, piping and fittings for the mechanical aspect of the device. The chemical processes were studied and it was found that adding methanol and potassium hydroxide to vegetable oil produced a bio-diesel fuel with a by-product of glycerin. The students first completed a small scale experiment in the chemistry classroom, where they mixed the vegetable oil and chemicals in a jar. Initially the students tested the vegetable oil to determine the amount of chemicals to add to the vegetable oil to produce the bio-diesel fuel. After washing the solution with water and allowing it to settle, the bio-diesel fuel and the glycerin were separated completing the production of the bio-diesel fuel.

Since the bio-diesel project was established as a long term project this activity will be continued beyond the completion of this paper. The final portion of this long term project will require the entire engineering club to work together on building a bio-diesel processor that can convert 50 gallons of vegetable oil per batch. This will be used as the source of bio-diesel fuel for the auxiliary buses.

The engineering club through designing and building this device was able to turn a waste product from the school’s cafeteria into a re-usable environmentally friendly product. Incorporation of this waste-to-fuel conversion procedure also has provided cost savings for the schools extracurricular bus fuel expenses. To promote the usage of these techniques students, upon successful completion of this project, will share their bio-diesel device design with other high schools in the metro-Atlanta area. Lastly, this hands-on activity has provided the students with the opportunity to expand their knowledge base in basic mechanical, chemical and environmental science concepts and to utilize the information learned to directly improve their high school environment.

**Egg-Drop Design Competition**

The purpose of this activity was to foster teamwork skills and technical development in basic mechanical physics properties which included gravity, force, impact and collision. Activity instructions were provided to the students via the graduate student facilitator. The documents supplied to the students to complete the egg-drop design competition are located in Appendix A.2 of this study.

In this group activity, students were required to conduct a cost analysis, which required them to establish a successful egg-drop design utilizing a $5.00 budget. A successful egg-drop design required the construction of an egg holding device that prevented the egg
from cracking when dropped from a height of 10 feet. Each student group was provided 10 minutes to conduct a cost analysis. The price list of materials supplied to the students for the cost analysis may be found in Appendix A.2.

Upon completion of the cost analysis student groups were supplied with materials based on their $5.00 budget and given 20 minutes to construct their egg drop designs. The group that successfully protected the egg and had the lowest cost analysis were declared the competition winner.

Following design testing, the graduate facilitator directed a discussion about the relationship between basic physics properties which included gravity, force, impact and collision to the design techniques utilized by each group. This information was then related to the consumer packaging industry and the importance of design packaging in protecting consumer products from damage. From this activity students were allowed the opportunity to enhance their knowledge base in basic physics principles and develop their ability to work in teams.

*Miniature Boat Building*

In this exercise, the students worked in teams to further develop technical skills in basic material science concepts and teamwork skills. The graduate student facilitator started the exercise by discussing material science concepts essential to the successful completion of the exercise. Concepts discussed included a brief introduction on buoyancy and density. Students were separated into groups of two, to encourage teamwork, and directed to design and build a device that floated in water and could support a specified weight load. Students were allotted 20 minutes to design and build their “boats”. Material efficiency was deemed important, therefore students were informed that every excess square inch of material would result in a 5 point addition. The material dimensions and types utilized in this activity may be found in Appendix A.3.

The boat load testing began following the boat building process. A tub of water was used to test the boats. Pennies were utilized as the testing weight load for the boats. Groups received 1 point for each penny the boat could hold with the maximum load being 100 pennies. Pennies were placed in the boat one at a time until it was submerged. The team with the highest point total was selected as the winner.

After the activity was complete, the facilitator discussed the design thought process utilized by each group to select a material. During this discussion students expressed how they determined the amount of material to save in order to obtain additional points for material minimization. This process displayed to the students the real-world material design issue of minimizing material usage and maximizing load capacity. Through this activity students were given the opportunity to familiarizing themselves with basic material science concepts and improve their teamwork skills.
Math and Science Quiz Bowl

The math and science quiz bowl was aimed at developing a positive student attitude towards academic excellence. The quiz bowl aided in grooming the team members for success in STEM courses and prepare them for standardized testing. It fostered good study habits, helped prepare for standardized test exams, and promoted good sportsmanship skills. Good study habits were fostered by weekly study sessions led by an engineering graduate student volunteer. The study group focused on learning methods for new material and techniques to improve memory and recall previously learned material. The math section study materials consisted of questions that were likely to appear on standardized tests/college entrance exams. The latter provided the students the opportunity to obtain preparation for both the math and science quiz bowl and standardized testing. By competing at a regional conference with other high school students in a friendly but competitive environment the students practiced good competition and good sportsmanship.

Seminars

Public Speaking Seminar

The public speaking seminar was given by the local university staff member, previously mentioned in the “Introduction” section of this work. The purpose of this seminar was to develop the students’ clarity of speech, confidence in delivery, and ability to focus on the speech topic. In addition to developing their strengths in these areas, the goal of this seminar was to prepare them for facilitation of a workshop at a regional engineering conference. The targeted public speaking skills address the key areas of professional development and leadership.

During this activity, students were given a presentation on public speaking skills and strategies in the areas of delivery, performance, content, and the use of visual aids by the facilitator. The slides presented to the students during the public speaking presentation are located in Appendix B.1 this study.

After the presentation, students were asked to engage in an extemporaneous speaking activity. A student was selected to give a 2-3 minute speech on a topic chosen by the remaining students in the audience. The documents supplied to the students to conduct the impromptu speech activity are located in Appendix B.2 of this study. The amount of ‘ums’ and ‘ahs’ were counted during the impromptu speech to assist in the improvement of speaking delivery and performance techniques. Also, if the student spoke beyond the three minute time limit they were politely interrupted by the facilitator, this technique was utilized to prevent excessive speech content. After the impromptu speech activity, the audience consisting of the student speaker’s peers was asked to provide constructive comments regarding the quality of the speech. At the completion of the activity, a winner was chosen by audience voting with respect to delivery, performance, content, and the use of visual aids. The speaker with the optimal performance regarding the latter was awarded a prize from the facilitator.
Immediately following the public speaking activity, students were asked to discuss if and how participation in the impromptu speech assignment changed their level of confidence in public speaking. They were also asked if they considered the activity a helpful preparation aid for their own facilitation of an upcoming engineering regional workshop sponsored by the international engineering organization mentioned in the “Structure of After-School Engineering Club” section of this work.

The public speaking seminar aimed at professional development, provided the students with the opportunity to learn and apply successful public speaking skills first hand. The interactive nature of the activity also allowed the students to build their confidence and gain leadership skills, one of the four key areas addressed in this work.

*Rocket Building Workshop*

The students in the engineering club developed and presented a workshop to middle school students at a regional meeting of the organization. Firstly, the students studied about rocket history in order to clearly present the information to the middle school students. Next, the students had to learn the schematics behind building rockets that were powered by rubber bands. During the workshop the students were able to use the skills they learned from the earlier public speaking seminar. The presentation and skit facilitated by the students maybe found in Appendix B.3. The engineering club students were able to successfully lead the workshop and engage the middle school students with the science concepts behind building a rocket. This greatly enhanced their leadership skills by giving them the experience of managing a mini-project and working through the project with individuals outside of their group.

*College Tour, Admissions Seminar and Research Presentations*

Student participation in the college tour aligned with two of the four key skill areas addressed in this work which included academic excellence and professional development. During this activity students learned first hand the academic requirements needed to attend an accredited four year technical university by participating in a one day campus visit which included a campus tour, admissions seminar, and research presentations.

In the campus visit students attended an admissions session facilitated by an admissions advisor in which requirements for acceptance into the university’s engineering program where discussed. Students also participated in a collegiate engineering society’s general body meeting. This meeting gave the high school students the opportunity to directly interact with the collegiate students and learn about specific engineering disciplines. The program also included a campus tour lead by university students followed by presentations by select university engineering and science research labs. At the conclusion of the visitation day, students were asked what they learned from the experience and were encouraged to share key points that resonated with them from the day’s activities.
The campus visit was important in that it directly exposed the high school students to the requirements for attending a four year technical university and informed them about the skills needed to successfully pursue a STEM career path. High school student interaction with current college students allowed for the evaluation of college preparation techniques needed to successfully transition from the high school to college environment.

Students were also given the opportunity to reflect upon how decisions they make during their high school experience might affect their college pursuits. This activity contributed to the promotion of academic excellence and professional development through college-preparation and exposure to higher education, respectively.
Conclusions and Recommendations

It has been shown that students exposed to pre-college engineering programs and hands-on science and math curriculums are more interested in pursuing STEM fields in college. The purpose of this work is to provide an overview of an after-school program aimed at promoting STEM fields to minority students using hands-on activities and seminars.

The activities and seminars in this work were created to address skill development in four key focus areas: academic excellence, leadership, technical/professional development, and teamwork. Table 3 below summarizes activities and seminars conducted in this study with the corresponding key focus areas. This table is provided as an activity selection guide for other after-school engineering clubs wishing to promote, in their programs, any of the four key focus areas via utilizing activities and/or seminars addressed in this paper. Table 4 displays the relationship between the study activities and seminars to STEM fields of study. This table is presented to provide the reader with an activity selection guide to promote specific STEM fields in their own after-school engineering clubs.

This study has been presented as a guide to implementing hand-on activities and seminars to promote STEM careers to minority high school students in after-school engineering programs. Hopefully the work presented in this study will aid other after-school engineering programs in the formulation of their curriculum.
Table 3. Summary of Key Skill Areas and Corresponding Activities and Seminars

<table>
<thead>
<tr>
<th>Key Skill Area</th>
<th>Activity or Seminar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Excellence</td>
<td>SAT Question Review, Math and Science Quiz Bowl, College Tour</td>
</tr>
<tr>
<td>Leadership</td>
<td>Regional Conference Workshop Facilitation, Public Speaking Seminar</td>
</tr>
<tr>
<td>Technical/Professional</td>
<td>Alarm System Design, Bio-Diesel Device Design, Egg Drop Competition, Miniature Boat Building, Public Speaking Seminar, Research Presentations, College Admissions Seminar, College Tour</td>
</tr>
<tr>
<td>Development</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Summary of Activities and Seminars and Corresponding STEM field Relationships

<table>
<thead>
<tr>
<th>STEM Field</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Physics</td>
<td>SAT Question, Math and Science Quiz Bowl, Bio-Diesel Device Design</td>
</tr>
<tr>
<td>Chemical Science</td>
<td>Bio-Diesel Device Design</td>
</tr>
<tr>
<td>Electrical Physics</td>
<td>Alarm System Design</td>
</tr>
<tr>
<td>Environmental Science</td>
<td>Bio-Diesel Device Design</td>
</tr>
<tr>
<td>Material Science</td>
<td>Miniature Boat Building</td>
</tr>
<tr>
<td>Mathematics</td>
<td>SAT Question Review, Math and Science Quiz Bowl</td>
</tr>
</tbody>
</table>
Future Works

Future works for this study include the formulation and distribution of assessment tools to measure the value of the after-school engineering program in promoting STEM fields to minority students. Projected metrics to conduct the latter include survey assessments, personal interviews, and student tracking.

Survey assessments will include formulating, distributing, and analyzing surveys of student’s STEM confidence pre and post exposure to the after-school engineering program. Also, survey assessment will be conducted for each hands-on activity and seminar. Feedback given in the surveys will guide the hands-on activity and seminar selection and modification process for subsequent after-school program years. Additionally, the data collected from these surveys will aid in identifying the strengths and weaknesses of the after-school program in developing student skills in the four key areas.

Personal interviews will require the graduate student fellows to conduct one-on-one interviews with each student in the after-school program. Pre and post after-school program exposure interviews will be conducted to establish individual student STEM learning goals and conduct student self evaluation of STEM interest, strengths and weaknesses. Information obtained during these interviews will assist in the high school student’s self evaluation of learning STEM concepts and assist in selecting and modifying the hands-on activities and seminars to best suite individual student needs.

Lastly, student tracking will involve follow-up of after-school engineering program participants upon completing their high school experience. Student follow-up will consist of tracking student matriculation to institutions of higher education and their enrollment in STEM fields of study. This information will provide a metric to determine the efficiency of the after-school engineering program in promoting STEM career pursuits to the student participants.

All previously mentioned after-school program assessment tools are significant in that they provide insight into the effectiveness of using hands-on activities and seminars to stimulate student interest and career pursuits in STEM fields.

Acknowledgements

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Bibliography


Appendix A: Hands on Activities Resources

A.1 Alarm System Design

*It’s Alarming!

Scenario:

You notice that your __________ always come up missing from your room when three of your family members visit your house. After learning basic circuit theory in your after-school engineering club you decide it would be a great idea to build a door alarm to catch the culprit in the act.

Your have the following items at your disposal:

1. **Insulated** Wire
   - Hint: In order to make this alarm, you will need to peel off the rubber/plastic insulation from two of the wires.
2. 1.5-**volt** battery.
3. Yarn
4. Scissors
5. Electrical tape
6. 1.5-volt mini-buzzer
7. Spring-type wooden clothes pin
8. A scrap piece of cardboard
9. Glue

You have also decided to use some human resources and you invite your friends from the engineering club to help you build your alarm. Do your best to recall your knowledge on circuit theory and use your team working skills to catch the culprit and regain your belongings!

Happy Securing!
Alarms System Design

Questions to Ponder

1) How many designs did you implement before you obtained a working alarm?

2) What methods did you use in your design process? (i.e., placement of the battery, buzzer, yarn, clothes pin)

3) If you could use any materials in re-designing your alarm what item(s) would you substitute for your materials of choice?

4) Do you see any flaws in your design that would possibly allow the culprit to go undetected? If so, what are they?
A.1 Alarm System Design

*It’s Alarming (Solutions)*

1. Disconnect one battery wire from the buzzer.

2. To make things easier, put the battery and the buzzer on the wood, as shown in diagram 2.

3. Use a piece of electrical tape to tape the battery to the cardboard so that it does not move.

4. Get the buzzer and put it at the other corner of the cardboard and tape it to down, just as in diagram 2.

Now that you have taped the battery and the buzzer to the wood, we will work on the most important part of the burglar alarm, the switch. The burglar alarm switch is a little different from the buzzer switch that you made by disconnecting and connecting the wire at the beginning of this lesson.

Now you want a switch that works easily and more quickly, without you having to make and break the connection with your hands. You need a switch that turns on and off the buzzer depending on a door opening or closing. Making a switch that does this will result in a Burglar Alarm Switch.

*This exercise was adapted from the following website:
http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/burglar.html*
A.1 Alarm System Design

The Burglar Alarm Switch

1. First, you will need to wrap the ends of the clothes pin with the non-insulated wire or the insulated wire that you have peeled. Look at [diagram 3].

2. Make sure that the wires touch when the clothes pin closes, as in [diagram 4]. If the wires don’t touch, then there will be no connection and the alarm will not work.

*This exercise was adapted from the following website: http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/burglar.html
A.1 Alarm System Design

3. After wrapping the wires, connect one of the free ends of the wire to one of the wires coming from the battery.

4. Connect the other wire from the pin to the buzzer.

5. Connect the remaining free wire from the battery to the buzzer (if you have not yet done so when making the buzzer switch, above).
   - Note: If you are confused by now, just look at diagram 5 and connect the wires as shown in the picture.

6. Test the switch by opening and closing the pin. When the clothes pin is closed, the alarm should sound. If it doesn’t, make sure all the wires are connected and that the clothes pin’s non-insulated wires on the end are touching. If it still does not work, look at diagram 5 and check all the wires again. It should work.

7. When it is working, you may want to turn it off by placing a small piece of cardboard in between the ends of the pin so as to open the switch and turn off the buzzer. It is annoying to continue working with the buzzer on. (See diagram 6.)

*This exercise was adapted from the following website: *http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/burglar.html*
**A.1 Alarm System Design**

8. With the buzzer off, attach the clothes pin to a corner of the cardboard using tape (see diagram 7).

9. Finally, attach the string to the cardboard that you already put between the ends of the pin. When this string is pulled away, the wires in the pin will make contact and the alarm will sound.

10. You are done!

Now you have a burglar alarm. Just tie the string to a door tightly, so that when the door is opened, the cardboard is pulled out and the alarm sounds.

*This exercise was adapted from the following website: http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/burglar.html*
A.2 Egg-Drop Design Competition

Egg Drop Challenge

Challenge: You have been asked to build a device which can safely protect an egg when it is dropped from 10 feet.

Materials Product Prices: The materials that can be used are as follows:

Table A.2.1: Price list of materials for egg-drop design competition

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost per Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper plate</td>
<td>$1.00</td>
</tr>
<tr>
<td>Styrofoam cup</td>
<td>$3.00</td>
</tr>
<tr>
<td>Cotton ball</td>
<td>$0.10</td>
</tr>
<tr>
<td>Packing peanut</td>
<td>$0.20</td>
</tr>
<tr>
<td>1 foot scotch tape</td>
<td>$1.00</td>
</tr>
<tr>
<td>6 inch masking tape</td>
<td>$1.00</td>
</tr>
<tr>
<td>1 foot yarn</td>
<td>$0.50</td>
</tr>
<tr>
<td>5 minute scissors rental</td>
<td>$0.50</td>
</tr>
<tr>
<td>1 sheet toilet paper</td>
<td>$0.10</td>
</tr>
</tbody>
</table>

Rules of the Competition: You may only use materials brought from the above list. You will be judged upon how well your device performs, the cost used to make it and the feasibility of your design.

A.3 Miniature Boat Building

Table A.3.1: Materials list for miniature boat building activity

<table>
<thead>
<tr>
<th>Material</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printing Paper</td>
<td>8.5”x11”</td>
</tr>
<tr>
<td>Aluminum Foil</td>
<td>8.5”x5.5”</td>
</tr>
<tr>
<td>Printing Paper</td>
<td>8.5”x5.5”</td>
</tr>
<tr>
<td>Aluminum Foil</td>
<td>8.5”x11”</td>
</tr>
</tbody>
</table>
Appendix B: Seminar Resources

B.1 Public Speaking Seminar Visual Slides

The Art of Public Speaking

Overview

• Hindrances
• Success Strategies
• Speaking Tips
• Use of Visual Aids
• Resources
• Activity
Things That Hinder Success

- Lack of preparation
- Fear
- Nervousness
- Anxiety
- Lack of motivation
- Rambling
- Poor delivery

Key Success Strategies

- Preparation
  - Know your material
  - Know your audience
  - Know your area
- Practice and rehearse
- Visualization
- Breathing
- Do not call attention to your nervousness
- The audience wants you to succeed
Performance

- Confident
- Pleasant
- Enthusiastic (if appropriate)
- Knowledgeable
- Engaging
- Calm
- Relaxed

Delivery

- Speak slowly and clearly
- Eliminate crutch words
- Vary vocal tone
- Use well-placed pauses
- Use appropriate gestures and be aware of body movement
- Make good eye contact
- Engage the Audience
Content

• Overview
• Introduction, body, and conclusion
• Keep it interesting and relevant
• Quotes
• Give of yourself - anecdotes
• Remain within your allotted time

Visual Aids

• Know your AV presentation
  – Do not read the slides
  – Use bullets as speaking points
  – Smooth slide transition
• No need for unrelated graphics, animation or sounds
• Use readable font
• Make use of “white space”
• Have backup slides if necessary
Activity: Table Topics

• Extemporaneous speaking – ‘off the cuff’
  – 2-3 minutes to speak on a random topic
  – Constructive feedback will be given
  – Counting uhs, ums, ands, etc.
B.3 Rocket Building Workshop

Script for Rocket Building Workshop

Rykia: Good morning and welcome to the launch of a great adventure into space. My name is Vanna Black and I will be your guide today. Each of you received a rocket. Make sure you are sitting at the correct launch site based on the color of your rocket. Please move to the correct launch site now. Thank you.

Today we are going to learn some techniques on effective team building.

(Slide of Launch Site)

You are about to go on a long journey with your teamates. At this time, introduce yourself to the other members of your group. It’s very important that you know each other before departing (allow a minute or two)

May I have your attention please? As we prepare for our adventure today, each group will receive points along the way. At the end of our adventure, the group with the most points will receive an award.

I need total silence from each group, as we prepare for departure. You received a rocket as your entered. At this time, write your name on the rocket. Now, turn the rocket over and write down the names of the members in your group. You cannot communicate with them in any manner now. If you talk, your group will lose points. It is imperative that you remember each member of your group. You have one minute to complete this task. You may begin. No Talking (allow 1 minute). Stop. Pass all papers to the end of your table at this time (take them up).

If you did not know all of your members, now is the time to make sure you know everyone’s name. It is important that you remember the names of your group members. Also, you must select one teammate as your leader. All leaders should sit on the end of your launch site. Leaders, if your team is ready, raise your hand (only allow a minute for this). We are now ready to launch the first group of middle school students into the great beyond to explore the universe. Buckle up! I will see you later.

(Sound of rocket taking off and the slide of the rocket taking off)

Jenae Enters: Wow this is great we are actually in space. I can’t wait to go back to Georgia and tell my friends about my experience.

(Sound of rocket crashing)
(Next Slide)

Jenae: What’s happening? We’re crashing!!! (Janae acts like there has been a crash)
Jenae: Wow this is a strange planet. I wonder where we are. Look at that strange sign.

(Enter the Bulldogs)

Jenae: Hello, my name is Jenae. These are my friends. We are from Earth. We were placed on a rocket and launched into space to explore the universe, but our rocket crashed on your planet. Do you speak English?

Butch: Woof, Woof, Woof

Princess: Stop clowning around Butch, yes we speak English. You have landed on Bulldogia, the great planet of Bulldogs. Welcome, my name is Princess.

Butch: Why are you welcoming these strange creatures? They have invaded our world. Give them a bone and get rid of them.

Janae: Our rocket crashed and we have no means of transportation back home. Can’t you help us Mr. Bulldog, Mr. Butch?

Butch: Growls

Princess: Be quiet Butch. We will help you build a rocket to go home.

Butch: Ok, so what do you know about rockets?

Janae: Well, it’s a big piece of metal and needs a lot of fuel to get it up into the atmosphere.

Butch: And what do you know (ask another student in the room and wait on response) I knew it, I knew it. They don’t have a clue.

Princess: Well Butch let’s help them with a few facts about rockets. Let me introduce to you some of our engineers. This is Dr. Queenie, Dr. Flex and Dr. Penny. (Each one barks as their name is called). They will give you a very brief history of the rocket and principles related to rockets. Take notes on the major points.

Butch: Be sure you pay attention, because you are going to have to pass a test before we can help you build a rocket.

Princess: Don’t pay him any attention. There is a note sheet for your use. Take good notes.

Three Scientists: Rocket Facts, Rocket Facts - We Have Got Rocket Facts

Queenie: The first rocket like engine came from the Greeks along time ago, Studies show that it was developed by a man named Hero.

Flex: Rockets have been around for centuries you know
The Chinese used gun powder to make fire arrows that glow. Solid materials when ignited provided the thrust. But the rockets went haywire and control was a must.

**Penny:** Many scientists have contributed to the rocket's legacy. Like Bacon increased the range, Froissart increased the accuracy. Then came Newton who laid the scientific foundation for modern rocketry. For the laws of motion put everything for rockets in perspective you see.

**Queenie:** With the Laws of Motion and all the other rocket stuff. Goddard put it all together and made the rocket tough. He is called the Father of Modern Rocketry, that's right. By using liquid fuel to produce a controlled flight.

**Three Scientists:** Rocket Facts, Rocket Facts-Do you know your rocket facts? Woof, Woof, Woof

**Butch:** That was a waste of time, 'cause these humans can’t remember anything.

**Princess:** I bark to differ. Watch. Leaders, Dr. Queenie please pass out the quiz sheet to each group. Groups as the questions come up, collaboratively come up with one answer and write your answer on the paper provided for your group. I will read each question to make sure Butch has not marked his territory.

**Butch:** Growls

Go through the question slides quickly. Butch, take up the paper from each group and briefly look over the results. Then he growls.

**Penny:** From Butch’s expression, it looks like you know your rocket facts. Now it is time for you to design your own rocket. Butch and Dr. Flex, please pass out the materials needed to build their rocket. We decided for you to build a Goddard Rocket. It’s very sturdy, easy to control and will carry you home.

**Princess:** Look at the material in your bag. Use the paper provided to design your rocket using all the material in your bag. You must design quickly because you only have a short period of time to build your rocket and escape from Bulldogia. So work quickly, you have 3 minutes to come up with a design. Leaders be prepared to share the design with Dr. Flex when you are finished.

**Flex:** Butch, help me review the designs (both look at them quickly and start barking like something is funny as you look at the designs). These are horrible.

**Queenie:** Don’t worry. We will help you (pass out the directions and help them put it together).
Butch and Flex sit back with their legs crossed as they put the rocket together. After all groups are finished, Butch speaks.

Everyone else should help each group get their rockets put together. Each leader should indicate by standing up when their rocket is finished.

**Butch:** So you put a rocket together. Well let’s see if you can launch it. Your rocket must have enough thrust to escape the atmosphere of Bulldogia. In other words, it has to go this far.

**Princess:** Don’t worry. They will escape our atmosphere. I need the leader of each group to launch your rocket. If you escape the atmosphere, we hope you have a safe trip home. If you do not escape, you will have to listen to Butch until the next launch time comes around.

**Butch:** Flex let’s help them with the launch, because I am not sharing my bones or my dog house with any humans.

**Rykia:** Thank you for participating in our workshop today. We hope that by working you learned some valuable points about working as a team. The members of the Bulldog team are: _____________________________. The winning team is _______________.

As you leave today you will receive a certificate of participation and a care package so that you can make your own rocket later. Good luck!
Lost In Space
Rocket Facts

Aeolipile

An aeolipile, a rocket-like jet engine invented in the first century by Hero of Alexandria, is considered to be the first recorded steam engine or reaction steam.
Rocket Facts

Early Chinese Rocket

“Fire Arrows”, as the Chinese called them, were made of solid material and gun powder. Once ignited the “Fire Arrows” were uncontrollable.

Rocket Facts

- Roger Bacon (English) increased the range
- Jean Froissart (French) improved the accuracy
- There were many other contributors to the rockets development
Rocket Facts

- Sir Isaac Newton
- Three Laws of Motion
- Laid scientific foundation for modern rocketry

Rocket Facts

Robert Goddard (American)
“Father of Modern Rocketry”
• First explored mathematically the practicality of using rocket propulsion to reach high altitudes and even the moon (1912);
• First proved, by actual static test, that a rocket will work in a vacuum, that it needs no air to push against;
• First developed and shot a liquid fuel rocket, March 16, 1926;
• First shot a scientific payload (barometer and camera) in a rocket flight (1929, Auburn, Massachusetts);
• First used vanes in the rocket motor blast for guidance (1932, New Mexico);
• First developed gyro control apparatus for rocket flight (1932, New Mexico);
• First received U.S. patent in idea of multi-stage rocket (1914);
• First developed pumps suitable for rocket fuels;
• First launched successfully a rocket with a motor pivoted on gimbals under the influence of a gyro mechanism (1937).
Rocket Facts-Group Quiz

1. What did Newton's Laws deal with?
2. Who developed the first rocket like engine?
3. What was the problem with the Chinese rocket?
4. What type of fuel did Goddard use in his rocket?

Rocket Facts-Quiz

5. What did the Chinese use to make their "fire arrows"?
6. Name one of the two scientist that contributed to the rocket's range and accuracy.
7. What is Goddard referred to as?
8. What was so significant about Goddard's rocket?
Rocket Facts-Quiz Answers

1. Motion
2. Greek named Hero
3. Uncontrollable
4. Liquid Fuel
5. Gunpowder
6. Bacon (range) and Froissart (accuracy)

Rocket Facts-Quiz Answers

7. The Father of Modern Rocketry
8. It was controllable
Effective Team Building

• Know your team members
• Choose a leader
• Collaborate
Rocket Design Credit

Civil Air Patrol
Model Rocketry
published by the
Leadership Development and Membership Services
Directorate,
National Headquarters,
Civil Air Patrol and the United States Air Force,
Maxwell AFB, Alabama 36112