Exciting girls, minorities and rural youth about engineering through 4-H

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Abstract – *A series of 4-H projects on engineering design are being developed to appeal especially to youth who are female, African-American, Hispanic, Native American or live in rural areas. These populations are under-represented in engineering professions and our goal is to get them interested in engineering design at a young age. We conducted focus groups with 4th and 8th grade students in these populations, and are using the results to identify specific strategies to recruit the target youth to the 4-H engineering design projects. Preliminary results show that girls and boys have similar interests, especially in 4th grade. Ethnic background seems to make little difference also at that age. Engineering design topics that appear to excite these youth, and have components that are age-appropriate, include: playgrounds, animal habitat (in a zoo, for example) and vehicles (robots; mouse-trap cars). Ideally, a young person with an aptitude and interest in things related to engineering would start a 4-H project at the "beginner level", and each year select a more challenging project from the series to continually build interest in a career in engineering. This program has the potential to reach a large number of youth. Nationally, 4-H has almost 7 million members, of which 3.4 million are female, 1.0 million are African-American, and 0.6 million are Latino. About 40% (2.7 million) live in rural areas. This series of engineering design projects may also attract more target youth into 4-H. Included are procedures and results that can apply to any effort to teach engineering design at a young age.*

Engineering, Focus Groups, Girls, Minorities, Rural Youth, 4-H, Science

INTRODUCTION

4-H is a national youth development organization that offers a wide range of projects for members in grades 3 - 12. Engineering-related projects, including bicycles, small engines, computers, electricity, welding and aerospace, can be taken by any member, and educational learning activities in these projects occur at the county, state, and nation levels. State and national 4-H data suggest that the percentage of girls taking engineering-related projects generally decreases as the participants increase in age. Females and minorities account for fewer than 10% of participants in the events associated with the National 4-H Engineering, Science and Leadership Event [1]. Likewise, the Oregon Museum of Science and Industry recently found that Latino Girls often rule out math, science, and technology by middle school [2]. Throughout the nation, there appears to be a significant drop in girls and minorities interested in math, science, and engineering somewhere around middle school. A national study by the National Center for Education Statistics found that less than half of all high school seniors were taking a science course in 2000 and even more alarming was the fact that the science scores for the National Assessment of Education Progress have been flat since 1992 [3].

Realizing the need of attracting and keeping these groups interested in engineering, our project focused on determining what attracts girls, minorities, and rural youth to math, science, and engineering, and the differences among these groups between the fourth and eighth grades. Identifying and then implementing the results will allow 4-H to develop a series of national engineering design projects to effectively attract these groups interested in engineering, and ultimately keep these groups interested in engineering to help supply the growing demand for engineers in the U.S.

According to the 2002 National Science Foundation's Science Engineering Indicators report, there have been 100,000 fewer engineering students in the past decade. In the same article Lynn Arts, recruiting manager for Johnson Controls, added that there is expected to be a 27% shortage of engineers by 2005. [4]

The computer industry and engineering organizations have started several efforts to attract girls into technical fields, specifically computer engineering. Often these programs are aimed at giving girls self-confidence, connecting them with mentors in industry, and showing them that engineering is a career where they can make a difference in society. They also want to show girls that engineering is "fun and cool, not weird or geeky". IBM has launched annual summer camps for seventh- and eighth-grade girls, where 1700 teens have received a hands-on introduction to technology and engineering by "tearing apart a PC and debunking the mysteries of a circuit board at IBM Labs." [5]

The proportion of female full professors in engineering, science and math at the top research institutions was less than 15% [6]. Improving these trends may begin with attracting more youth, especially minorities and girls, to engineering.

PROJECT GOALS

1. Identify and analyze existing formal and non-formal engineering and technology education programs that target girls, minorities, rural youth, and service to society.
2. Identify those engineering activities and programs that are of interest to youth with different ethnical and gender backgrounds
3. Create and develop a pilot set of engineering curriculum activities based on identification and analysis activities that meet the needs of specific ethnical and gender-based audiences.
4. Pilot test and evaluate the appropriateness of the engineering curriculum activities for the target audiences.

This paper focuses on project goals #1 and #2.

METHODS

To accomplish goal #2 focus groups were conducted with six groups of eight to ten students, 50% girls and 50% boys. Each group, either fourth graders or eighth graders, was asked 16 questions (see Appendix A) to determine their interests in a variety of engineering-related areas at each of these locations: Miami Trace School District in Fayette County, Ohio (rural); Baton Rouge, Louisiana (African American); and Mercedes, Texas (Hispanic). (A focus group with Native American youth at Cherokee Nation schools in Oklahoma is being planned but could not be scheduled in Spring 2004.)

To minimize any variability and reduce facilitator bias the same experienced facilitator (Dee Jepsen) conducted all six sessions. Ms. Jepsen revised and improved the proposed questions that had been prepared by project staff, and pilot tested them with 4-H youth of the appropriate age in Fairfield County, Ohio.

Also as an attempt to assure consistency, Randall Reeder attended all six sessions and took notes to assist the transcriber. Roger Tormoehlen was present for the Texas sessions, and Marybeth Lima assisted at Baton Rouge.

At the beginning of each focus group session, each student completed a one-page participant form (Appendix B) that asked for their grade, age, parent's profession(s), and favorite subject in school. The back of the form (Appendix C) provided space for the student to write answers to the final part of the questionnaire (Activity 17 in Appendix A). Topics covered in the questions included: favorite subjects, favorite store sections, favorite games, natural resources concerns, important parts of a new city, important parts of a new city on Mars, and preferred work opportunities in designing a playground, designing a swimming pool, designing a zoo, completing a mission to Mars, and cleaning up an oil spill.

The activities utilized to gather data on students' likes and dislikes pertaining to engineering employed a variety of educational methodologies. One activity used twenty photos to accommodate youth who are primarily visual learners. Students responded with lists of "favorite" and "least favorite" activities. This proved to be an excellent aid in selecting subject matter for development into "4-H engineering design activities".

The responses were recorded, coded, and organized in the QSR N6 computer program. This program allowed the qualitative data from the focus groups to be categorized in such a way that quantitative results could be acquired. This data was compiled into Excel charts for easy reading, and the results were sent to Advisory Committee members for review. Comparisons were made based on girls versus boys, ethnic groups, and grades (fourth grade versus eighth grade).

RESULTS

After compiling, comparing, and analyzing the data, several key points were observed. Comparisons included boys versus girls in both fourth grade and eighth grade (to determine any differences among genders), all of fourth grade versus all of eighth grade (to determine any differences among age groups), and Hispanic versus African American versus rural youth (to determine any differences among ethnic groups/backgrounds). There were very few differences among the ethnic groups. The key points identified based on analysis of the data include:

- The most significant difference between fourth and eighth grade students is that while boys and girls are both interested in machinery and equipment in fourth grade, the girls' interests significantly drop by the time they reach eighth grade (compare Figures 1, 2, and 3 to Figures 4, 5, and 6).
- Children like video games, sports, math, and science regardless of gender or ethnicity.
- All students prefer hands-on activities.
- Fourth and eighth grade girls and boys prefer the designing and layout portion of a project.
- Each ethnic group had a different natural resource concern: rural youth were primarily concerned with animals and air, Hispanics with plants, and African Americans with water.
- Girls and boys have an equal interest in sports.
- Boys prefer computer games, while girls prefer more "worthwhile" and helpful activities, such as math games.
- Girls like to read more than boys do.
- Girls prefer animals/wildlife, especially in an ecological sense, more than boys do.
- Girls' perceptions of what engineers do to develop a new city differ from that of boys in both fourth and eighth grades. Each gender brings a different viewpoint that is equally important to the group.

Responses to specific questions are shown in Figures 1 to 6. Figures 1 to 3 are for 4th graders, and Figures 4-6 are the identical questions asked to 8th graders. The responses listed on the x-axis are abbreviated versions of the complete multiple-choice answers to the question. See Appendix A for the exact, complete wording.

FIGURE 1

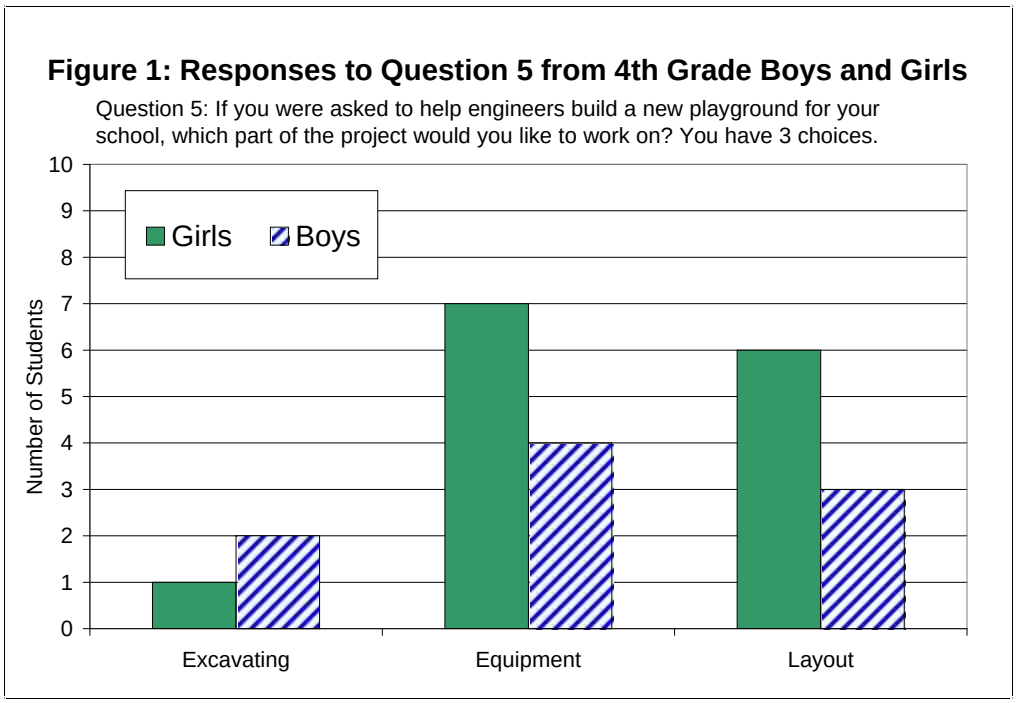


FIGURE 2

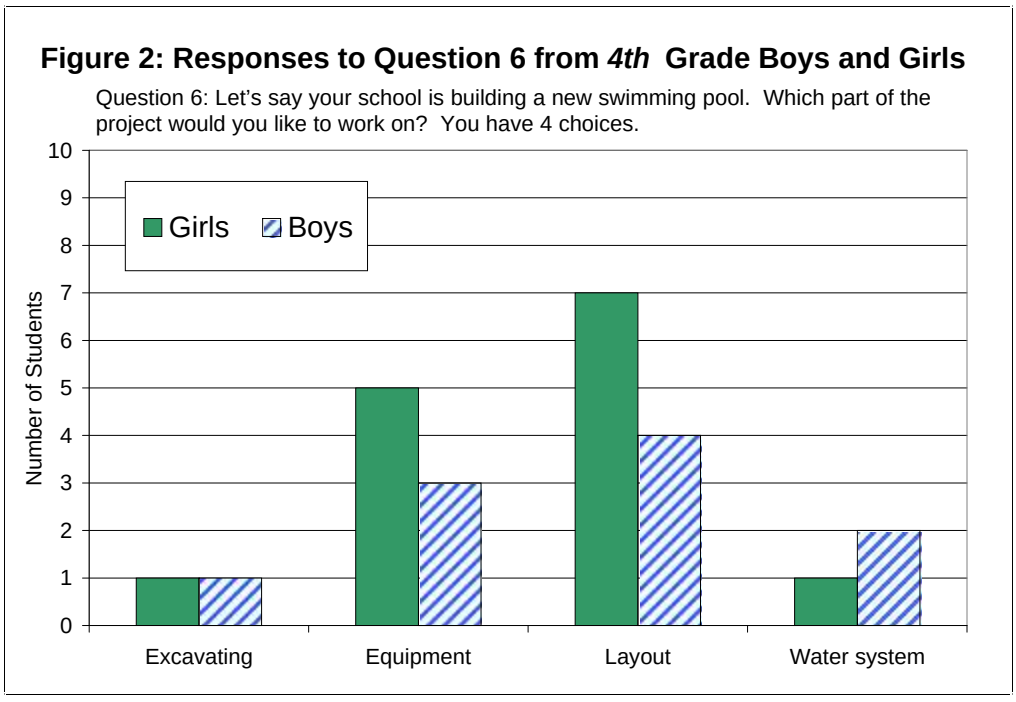


FIGURE 3

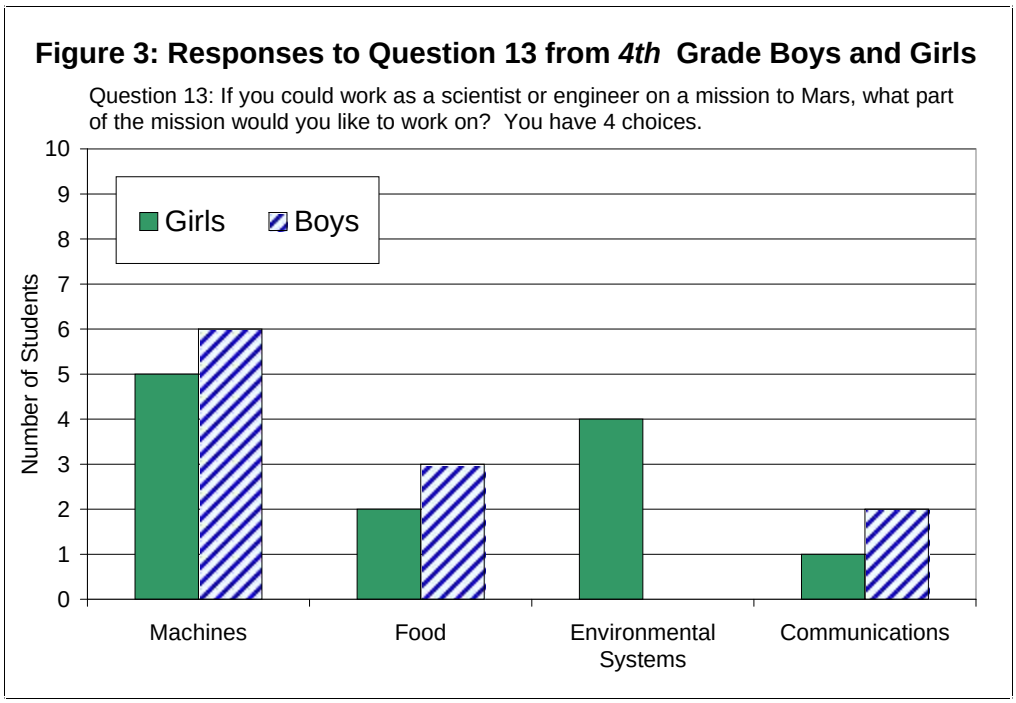


FIGURE 4

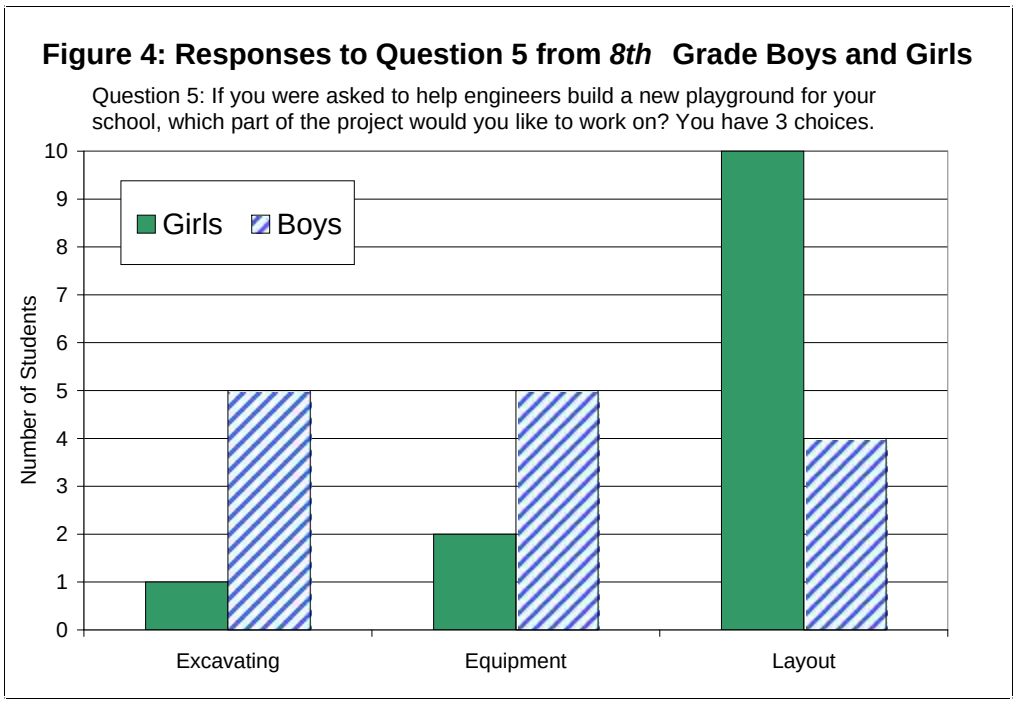


FIGURE 5

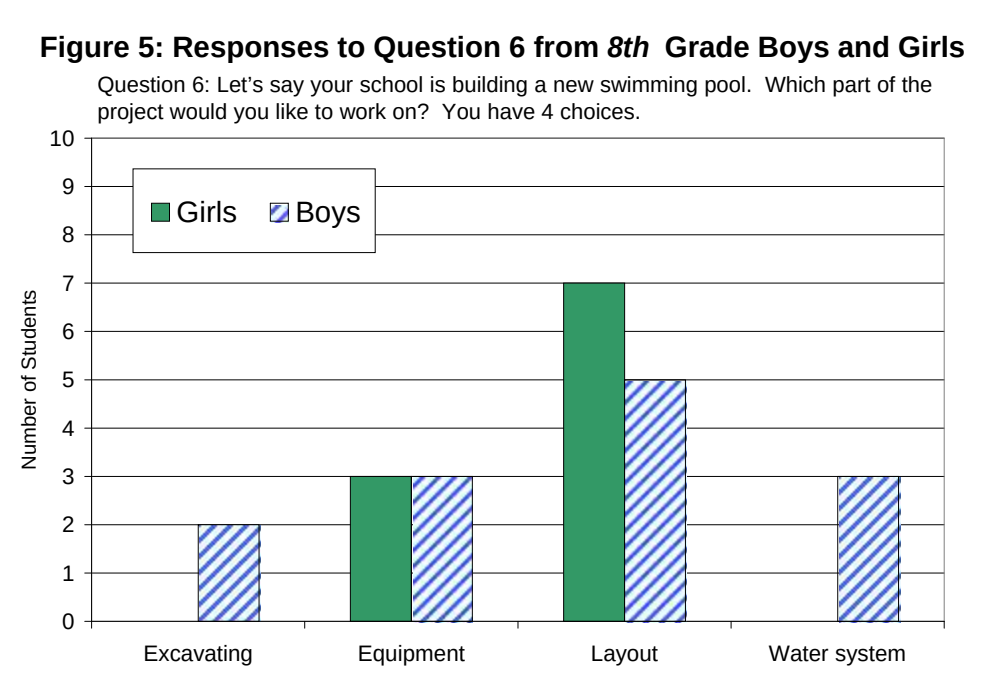
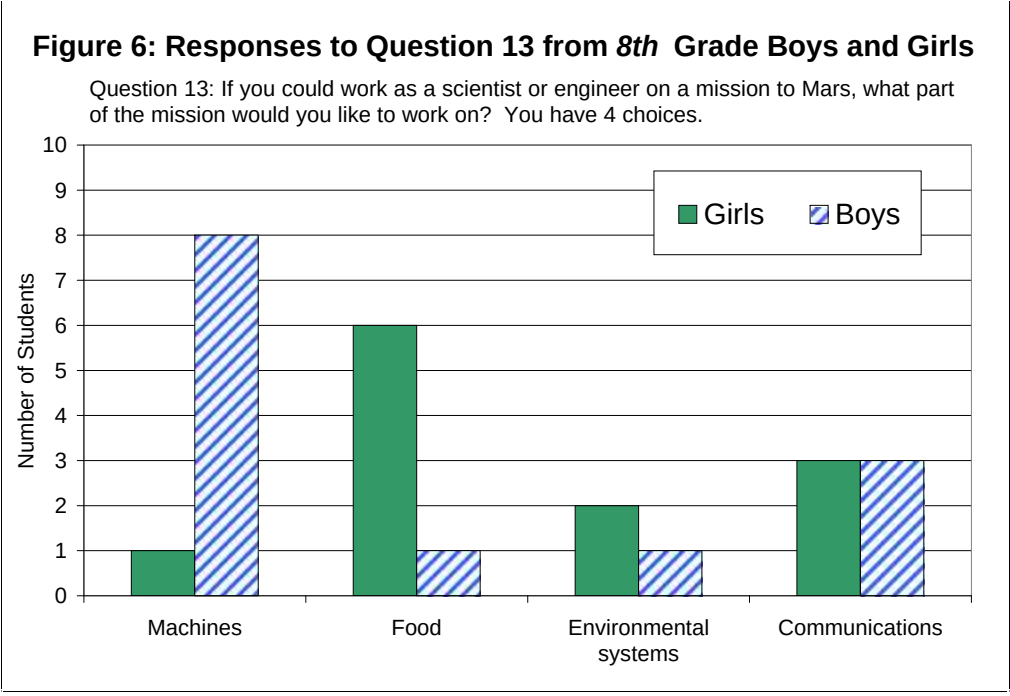


FIGURE 6



CONCLUSIONS

The most notable result was the sudden drop in girls' interest in machines and equipment from fourth grade to eighth grade. Some undetermined factor is causing girls to either lose their interest for these things or to feel like they have to hide their interest because these are not typical "girl" activities. Ideally, attracting these girls at a young age (fourth grade or younger) while their interests in machines and equipment are socially acceptable will keep them excited about engineering design. These 4-H projects that appeal to potential engineers when they are 9 to 11 years old can help increase the supply of young engineers, reversing the recent trend.

Since the goal of this work is to develop "activities" for a future series of 4-H project manuals on engineering design, four subjects/areas were selected for initial project development. This project's research indicates these will be equally popular among various ethnic groups. The four are:

- Playgrounds
- Zoo animal habitat
- Theme park (roller coasters)
- Mousetrap car

The activities will be written for slightly different age groups. The design and building of a little car powered by a standard mousetrap will focus on those about 9 to 12 years old. Playground design, with an emphasis on selection and testing of ground surfaces (soil, wood chips, concrete, etc) will also appeal to this age group. Zoo habitat and theme park design will be aimed at an intermediate age, and both topics offer excellent opportunities for additional activities for high school age youth. In fact all of these subjects have a natural progression toward more intensive design opportunities and are often used as design activities for college students.

The manuals will have many pictures and visual aids to appeal to youth oriented more to hands-on activities more than reading. Within each "topic", the youth will have a variety of optional specific activities allowing them to choose the area(s) that best suit their interests. The projects will provide interactive and "outside-the-box thinking" activities to broaden their views of engineering design.

ACKNOWLEDGEMENT

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APPENDIX A

Focus Group Discussion Guide
National Science Foundation Grant
Exciting Girls, Minorities and Rural Youth about Engineering through 4-H

Thank you for your time. Today's discussion will be about creating a new 4-H project book with engineering ideas that will be exciting for other students your age.

My name is Dee Jepsen and I work for Ohio State University. Assisting me today is Randall Reeder, from OSU, Roger Tormoehlen, from Purdue University, and Mary Beth Lima from Louisiana State University. We're attempting to gain some information about what types of engineering projects or activities that will excite young people your age.

Your school has been selected to participate in the information gathering session. It was either your principal or teacher that has selected you to take part.

Not all of you may have the same ideas about what I'm going to ask. Keep in mind there are no right or wrong answers, just different points of view. I want to encourage you to tell me about your point of view, even if it's different from what others may say. Keep in mind we are just as interested in activities you don't like, just as much as the ones you do like.

Before we begin, I want to review some of the ground rules. You probably have not been involved in this type of questioning. It is different from classroom questioning or other survey work where you would answer questions on paper. You're participating in what is called a Focus Group. That is where a group of people come together to discuss (or focus on) a certain topic.

Since we've gotten started, we won't stop until we finish the round of questions. I have about 16 questions to ask, and then we will conclude with an activity on the back table that involves looking at pictures. If at any time you need to get up and use the restroom, you may do so, and then come back in. I will not stop the questioning with the rest of the group. You will miss out on answering the questions that will be asked while you are out of the room.

The second ground rule is we are on a first name basis here. So please call me Dee, and that is Randall, Roger and Mary Beth. I will use your first name too.

We are taping the session; the wire you see on the table is a microphone that connects to the tape recorder. We do this because many times you will talk faster than we can write. And since your comments are very important to us, we don't want to miss anything you say. Anything you say will be confidential and not connected to your name. To us you are Student 1, 2, 3, and so on. I don't necessarily care what "Susie" has to say, just that Student 1 thinks this, or likes that type of activity. So there's not an issue of confidentiality that you may be concerned about. Don't worry about what your principal or teachers will find out.

We want to make sure everyone has a chance to offer their opinions on each question. So we will go around the table until each person has a chance to answer. I will start with a different person each time, so one person isn't always first or last to answer. I will read the question, and then I'll repeat it. I want you to have a chance to think about how you will respond. After we've been around the table and everyone has had a chance to answer, then I will open it up for any other ideas you may have thought about while the others were answering. At that time anyone can speak.

The only thing that I ask is that you don't talk while another person is talking. We'll have time to get to everyone's opinion before we move to the next question. We have about 1 hour scheduled, and we have about 16 questions. After our question session, Randall has an activity in the back of the room involving pictures. We will describe that activity when we get to it.

Do you have any questions before we begin?

QUESTION 1: What is your favorite subject in school? Tell me what you like about it, and what the teacher does to make it fun or exciting.

QUESTION 2: What is your favorite game you like to play? This includes all types of games:

- computer and video games
- board games
- dominoes
- Legos, tinker toys, Lincoln logs
- card games
- sport games (football, soccer, basketball, tennis)

When we go around the table, I would like for you to list all of your favorite games.

QUESTION 3: If you could go to a toy store, or the toy section of a Wal-Mart, and spend time in only one section, what section would you choose?

QUESTION 4: Have you ever heard of a contest called a pumpkin drop or egg drop? The idea is to design and build a container to protect the fragile egg/pumpkin, so that when it is dropped from a tall building, the product doesn't break. The winning team is the one who can successfully work together, hit a target, and keep their eggs from breaking. What would you think about this type of activity? Yes or no, does this activity sound interesting?

QUESTION 5: You may have never thought about it, but school and community playgrounds are great places to see "engineering designs." If you were asked to help engineers build a new playground for your school, which part of the project would you like to work on? You have 3 choices:

1. Digging and excavating the site; preparing the ground; and determining the surface that should be under the equipment
2. Designing and determining the type of equipment the playground should have (like swings, slides, climbing walls)
3. Determining the layout or design of the whole playground system: includes the materials you would use to build the playground (metal or wood), would it have cat walks, and the overall layout of the area.

QUESTION 6: Let's say your school is building a new swimming pool. Which part of the project would you like to work on? You have 4 choices:

1. Digging and excavating the site; preparing the ground; and pouring the concrete
2. Designing and determining the type of equipment the pool should have (like water slides and diving boards)
3. Determining the layout and design of the area surrounding the pool; some pools have volleyball courts, basketball courts, vending areas, and restrooms
4. Working on the pool's water system, which includes the pumps, filtration system, and other cleaning machines

QUESTION 7: Your school wants ideas on making its school buses safer. Give one idea as we go around the table, you can repeat the idea if it is one already mentioned.

QUESTION 8: Your community has decided to build a zoo. The engineers have invited you to help build the facility. Which area would you like to work on? You have 5 choices:

1. Building the animal shelters
2. Designing the layout, including the sidewalks, the food courts and other areas that humans need when they visit the animals
3. Developing a heating or cooling system for the types of animals you would have (like keeping the penguins cool, and the tropical animals and fish warm)

4. Landscaping the zoo with plants, trees, rocks and cliffs
5. Designing the waterways, pools and ponds at the zoo, this also includes the wastewater systems for both the animals and humans

QUESTION 9: (Leave out until the end for convenience. This is Activity 17, below, which requires the students to view 20 photos at the back of the room.)

QUESTION 10: Your art teacher asks you to draw a picture of your home or a home of the future. What things would you include on your drawing that makes your life easier, or helps you with household chores?

QUESTION 11: If you are building a new city, list all the area that you would see engineers involved in the designing or building of that city. We will go around the table and everyone can name one thing that engineers would be involved in. Then we'll go around the table again, and keep on going around until we think we've listed them all.

QUESTION 12: Now let's think about building this new city in a place like Antarctica or Mars. What kinds of things would you need to add or adjust in this city for humans to live there?

QUESTION 13: If you could work as a scientist or engineer on a mission to Mars, what part of the mission would you like to work on? You have 4 choices:

1. The machines: including the rocket, space vehicle, Mars landing vehicle, Mars driving vehicles
2. Producing the food for the astronauts, including growing the food and processing the food
3. Designing the environmental system and air supply
4. Creating the communication system: satellites, cell phone towers, and walkie-talkie helmets

QUESTION 14: If you were asked to make improvements to your environment here in the community, what areas would you focus on? Think of natural resources here in your community that needs improvement.

QUESTION 14A: Of those that were listed…… REPEAT ALL STUDENT RESPONSES…… which area is the most interesting to you?

QUESTION 15: How much do you know about the oil under the ocean's floor? Would you, YES or NO, be interested to learn how crude oil is changed into gasoline and diesel fuels for automobiles and trucks to use?

QUESTION 16: You've been hired to work on an oil spill that has occurred out in the Gulf. Which area would you be most interested in working on? You have 4 choices:

1. Fixing the leak on the ship itself, and re-designing the ship so it won't leak again
2. Cleaning the water, and working to get the oil to dissolve
3. Cleaning the animals, fish and wildlife exposed to the oil
4. Cleaning the soil and sand that had contact with the oil

Okay, that completes the questions I have. I want to thank you very much for your responses. I also want to take a moment and tell you about what just happened. You just participated in a focus group discussion, which is a way to collect information or research on a specific topic. You probably noticed that I was very business-like (unlike the friendly Dee you met when you first came into the room). I didn't do a lot of smiling or nodding of my head. Now this wasn't because your ideas weren't good, they were actually very good. I had to be very careful not to send any body language messages that would make you think you were answering correctly or incorrectly. Remember at the beginning I said there were no right or

wrong answers. If I nodded my head "yes" while one student was answering, then perhaps another student sitting there with an opposite view would think their idea was incorrect. So I had to be careful not to show much emotion towards your answers. In real life, I'm not really this way. Trust me, I'm a very friendly person.

ACTIVITY 17:
There are photos in the back of the room. We'd like to have you look at these 20 photos. You will have a worksheet to put your answers. We would like you to choose your 5 most interesting engineering projects you would like to work on. And then also, your 5 least liked activities, those 5 you wouldn't want to work on.

Then we will ask you to look at each group of photos. Out of the 6 groups, you must choose one photo you like the best from each group. You can only choose one. And even if you don't particularly like any from that group, you must force yourself to choose one.

APPENDIX B

Please answer the following questions:

Your Grade in School _____

Age _____

Zip Code _____

Are you a member, or were ever a member of:
(Circle all the apply)

4-H **Boy Scouts** **Girl Scouts**

Other (please explain)_____

Parent's (or guardian's) jobs or profession _____

_____

What is your favorite subject in school_____

_____

Optional information:

We want to send you a copy of a finished 4-H Engineering Design manual. If you give us your name and full address, we'll send you one.

Name _____

Address _____

_____

_____

Thank you for your information!

APPENDIX C

When instructed please complete each part:

Part 1: Look at all the pictures. In the blanks please write the letters that match your top five favorite activities.

In the next set of blanks please write the letters that match your bottom five least favorite activities.

Top Five (Favorite) activities:

_____

_____

_____

_____

_____

Bottom Five (Least Favorite) activities:

_____

_____

_____

_____

_____

Part 2: There are six groups of pictures. For each group please write the letter that matches your favorite activity in that group.

Group 1) _____

Group 2) _____

Group 3) _____

Group 4) _____

Group 5) _____

Group 6) _____