FAMILY ENGINEERING: INTRODUCING ENGINEERING TO PARENTS & CHILDREN

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Abstract: The goal of Family Engineering is to engage, inspire, and encourage elementary and middle school students to consider careers in engineering and science through hands-on activities with their parents at Family Engineering Nights. This program is designed to address the United States' need for an increased number, and greater diversity, of students skilled in math, science, technology and engineering. A *Family Engineering Activity Guide* and *Family Engineering* program for 5-12 year-olds and their parents is being developed, modeled after the popular *Family Science* and *Family Math* programs. Family Engineering will increase public understanding and appreciation of the role engineering plays in everyday life, as well as encourage parents and children to consider engineering as a career. Student chapters of professional engineering organizations on college campuses, elementary classroom teachers, engineering professionals, and informal educators at museums, will be encouraged to host Family Engineering events. A compendium of family engineering activities is under development. Program partners include Michigan Technological University, Foundation for Family Science and the American Society for Engineering Education.

Key words: STEM, education, engineering, elementary school, parents, family, technical literacy.

Introduction

Enrollment in many engineering fields is static or declining and the number of science and engineering graduate students in the U.S. has continued to fall since 1993. However, demand for scientists and engineers is growing steadily, but the US is unable to meet that demand. The resulting shortage of technically skilled employees threatens national economic and technological competitiveness

Efforts must be made to educate and inspire students to pursue STEM careers. A recent National Academy of Engineering plan, "*Taking Action Together: Developing a National Action Plan to Address the 'T&E' of STEM,"* proposes specific actions to build and strengthen the Technology and Engineering pipeline in the U.S. A first step is the goal: "all students will have a basic understanding of T&E and be able to make educated decisions about careers in these areas." The report favors "early career exploration among students... beginning in middle school *if not before*".[1]

Parents play an important role in developing their children's career interests by providing support, guidance, career and educational suggestions, and experiences that support career development.[2] Therefore, a child's elementary years are an ideal time for engaging parents in informal science and engineering education programs. Because parental influence plays a key role in children's educational achievements, parent/family involvement is an essential part of the solution to the looming STEM crisis. Studies have found that student achievement increased directly with parental engagement.[3] Laying the groundwork for success in challenging high school STEM courses requires

that students have a solid grasp of math and science concepts in the early grades, as well as enthusiasm and comfort with learning math and science. When parents participate in their children's education, students' achievement and attitude increase.[4] Other benefits include higher aspirations for school and career development.[5]

Many if not most parents are not technologically literate. Technological literacy is confined mostly to those people who are directly working in engineering, manufacturing, science, or mathematics. A recent report, *Technically Speaking: Why All Americans Need to Know More About Technology* summarizes research showing that children and adults know shockingly little about technology and engineering: the vast majority of our citizens have a very narrow conception of technology, believing that the term refers only to computers and electronics, and that engineering and science "are basically the same thing."[6] Larry G. Richards, chair of the Educational Research and Methods Division of the American Society for Engineering Education (ASEE) states, "Although technology permeates our everyday lives, few Americans understand how that technology works.[7] "The vast majority of American citizens have little or no comprehension of basic concepts upon which technology is based."[8] Traditional pre-college education in the U.S. has largely ignored engineering and technology as a core subject, except as it relates to computers. Students rarely, if ever, take courses where they are exposed to the engineering design process or learn how engineers use math and science in the solution of society's problems.[9,10] Engineering- oriented applications naturally incorporate authentic learning experiences, which are of demonstrated importance in the educational process.[11,12]

In an effort to combat technological illiteracy, the International Technology Education Association (ITEA) published *Standards for Technology Education for the K-12 Curriculum* in 2000.[13] The 20 standards for technology education are grouped in the following topical areas: 1) Nature of Technology, 2) Technology and Society, 3) Design, 4) Abilities for a Technological World, and 5) The Designed World. Each of the technology literacy standards has benchmarks for grades K-2, 3-5, 6-8, and 9-12. It is widely understood that achieving the goal of technological literacy for K-12 children will require input from all stakeholders—parents, teachers, students, and university faculty.

Family Engineering

The *Family Engineering Program* will engage public audiences in self-directed learning in informal settings. The primary target audience for this project are: (1) children, ages 5-12 years, and (2) their parents/care-givers, from urban, suburban, rural, and ethnically and economically diverse areas of the U.S.; while the secondary target audience are the program facilitators: (3) university STEM majors, STEM formal and informal educators and STEM professionals who will deliver and disseminate the program.

The "family unit" and elementary-aged children are the focus of this project for a number of reasons: 1) family involvement is critical for elementary-school age children's learning and development and future success in STEM courses at the high school level; 2) most STEM education programs focus directly on students in classroom or after- school settings, failing to recognize or target parents as communicators of informal science

education; 3) few STEM education programs have been tested for widespread use among diverse populations; 4) elementary-aged children are at an ideal age for initiating career exploration;[14,15,16] and 5) elementary-aged students are much more likely than older children to enjoy spending time with their parents doing educational activities. To assess the interest of parents in attending a Family Engineering event and to better understand the long-term impact that family science night events have had on participating children and their parents between 1997-2007, Chadde conducted a survey during March-April 2007. Of 40 parents who responded from five elementary schools, 100% found Family Science Nights to be a 'good' or 'very good' use of their time, and 100% believed that the Family Science Night program increased their child's interest in science "somewhat" or "a great deal." At least 50% said they would be interested in a resource containing science and engineering activities to do with their children, as well as information on how they can best support their child's interest in STEM topics and careers. A majority of parents were most interested in attending community events that involved parents and children in learning about science and engineering; as compared to simply receiving educational materials on the topic. One parent wrote, "Family Science night is a worthwhile activity for my family because it combines learning with family and makes it fun. It also allows the college students an opportunity to share their expertise with younger students. It is well-organized and we enjoy it every year."

University STEM majors, STEM educators, and STEM professionals are a secondary audience because of their potential to reach new audiences and serve as important role models for elementary-aged children – especially under-served populations and young girls. In May-June 2007, the project team surveyed student chapters of more than 48 professional engineering societies in the U.S. to determine the level of interest among STEM majors and STEM university faculty to participate in *Family Engineering*. Our survey found that while half of the respondents currently provide outreach to K-12 students, most focus on grades 6-12, and none reach out to parents. Furthermore, 80% of respondents are moderately to very interested in initiating or expanding their outreach efforts to K-5 children and families.

The primary goal of this project is to increase interest and understanding of engineering and engineering career opportunities among parents/caregivers and their children A secondary goal is to increase the capacity of the informal education field to offer meaningful engineering education resources to the public by enhancing the ability of STEM majors, informal and formal STEM educators, and engineering professionals to teach children and their parents about engineering and engineering careers.

The project is designed to have the following measurable impacts:

Impacts on parents of children ages 5-12: 1) increased interest in and understanding of engineering and engineering careers, 2) improved ability to support and encourage their children to pursue STEM coursework and STEM careers, and 3) enhanced parental ability to engage in hands-on informal STEM learning with their children using the *Family Engineering Activity Guide*.

Impacts on children ages 5-12: 1) increased interest in and understanding of engineering and engineering careers, 2) improved confidence about their abilities in STEM-related subject areas, and 3) increased interest in pursuing STEM courses in middle and high school in order to prepare for STEM-related careers.

Impacts on STEM majors, informal science educators, and engineering professionals: 1) increased interest in and ability to facilitate informal STEM learning experiences for parents and children ages 5-12; and 2) confidence in using the *Family Engineering Activity Guide* to conduct a *Family Engineering event*.

The project will measure impact on a local, regional, and national level. For example, in the western Upper Peninsula of Michigan where Family Science Nights have been conducted at many elementary schools annually since 1997, the results of the Michigan Education Assessment Program (MEAP) for science have steadily increased for grade four. This may be due, in part, to greater interest and awareness of science resulting from science programs that engage the parents of elementary-aged children, such as Family Science Nights and science fairs.

Pathways to Higher Education: Narrowing Pipeline some of the barriers to getting more female and minority students to pursue higher education and STEM careers.[17] They found that low-income, minority, and rural parents generally have less access to information regarding higher education opportunities for their children, and the courses children need to take to qualify for college. Often cultural and family pressures encourage them to work, rather than seek higher education. Children from neighborhoods with high percentages of low-income and historically underrepresented populations have fewer successful role models to emulate, and they frequently lack parental encouragement to set high aspirations. The *Family Engineering* program will provide much needed information about engineering careers to parents, and give children inspiration, motivation and role models in the engineering field.

Evaluation

The purpose of the external evaluation will be to 1) assess the nature, extent, and appropriateness of the pilot- and field-testing of the materials, 2) evaluate the effectiveness of training and dissemination, and 3) conduct a study of the impact of the materials on parent and student users. Audiences for the evaluation will include PIs, partners, expert review committee, National Advisory Committee (NAC), contractors, participants, and event facilitators. The focus of the external evaluation will be on the effectiveness of the Family Engineering materials, their delivery system, and impact on targeted audiences. The evaluation will be guided by the following evaluation questions:

- Do the Family Engineering materials effectively address their intended goals and objectives?
- What has been the impact of the materials on parents and students? What has been the impact of the materials and support resources on STEM Family Engineering program facilitators?
- What has been the nature and extent of the materials development and dissemination processes and who has participated in them?

Quantitative and qualitative data will be gathered using surveys, awareness checklists, subject-matter assessments, observation of activities, interviews of participants and facilitators, review of materials, and documentation of participation and activities. Data collection instruments and procedures will be developed so that data relevant to intended outcomes (and associated measures) and implementation activities are gathered. To determine impact of the materials on parents and students, focused studies with a sample of participants will be conducted to include pre/post program assessments, follow-up surveys, interviews, and review of parent-student projects. Surveys, interviews, and observation of a sample of actual workshops will be used to determine effects on dissemination facilitators. Evaluators will also advise project staff during planning and implementation of pilot- and field-testing.

The evaluation will be informed by the work of Dierking and Falk (Dierking, *et. al.*, 2003; Rennie, *et. al.*, 2003; Dierking and Falk, 1993). Evaluators will adhere to pertinent national evaluation standards (Joint Committee on Standards for Educational Evaluation, 1994).

Evaluation data from parent-student participants will be collected at three levels: 1) end-of-Family Night surveys of ALL participants; 2) a pre/post Family Night assessment among at least 50% of participants in up to 6 of the dissemination sites; and 3) follow-up interviews with a sub-sample of those completing assessments. Additionally, up to three mini-studies will be done of parent-student groups at one site to gather more in-depth, long term evidence of program effects. Assessment, survey, and interview instruments and procedures will be developed and piloted during the field test phase (as Family Engineering materials subject-matter and activities are identified and readied for field testing) in preparation for more intensive studies during the dissemination phases in the final two years. Assessments and surveys will be reviewed by appropriate experts to establish validity and piloted to establish reliability using standard test development procedures. Standard quantitative data analysis methods will be used for appropriate survey data, assessments, standardized observations, and participation levels. Categorical qualitative data analysis methods will be used for pertinent open-ended survey data, interviews, and site visits. Rubrics for assessing parent-student products will be developed consistent with standard procedures for preparing assessment rubrics.

The external evaluation is being conducted, in cooperation with project partner staff and developers, by Science and Mathematics Program Improvement (SAMPI), a unit of the Mallinson Institute for Science Education at Western Michigan University in Kalamazoo. Dr. Mark Jenness, SAMPI Director, is serving as the lead evaluator on this project. SAMPI has extensive experience in evaluating materials development programs, engineering and science education projects, as well as informal science education programming. Evaluators will prepare instruments and procedures for data collection and analysis, conduct interviews and observations, compile and analyze data, and prepare reports. Staff will be expected to provide entrée to parent-student participants and family night facilitators, assist with administration of assessments and surveys, maintain all participation records, provide program materials for review, share

internal evaluation data as available, and communicate regularly with external evaluators over the course of the project.

The Project

This project will create and disseminate the following youth and community program deliverables:

a. ***Family Engineering*** **Event Model**

A national model for delivering *Family Engineering* using STEM majors, engineering professionals, and informal and formal K-5 educators to increase parents' and children's interest and understanding of engineering and potential engineering careers

b. ***Family Engineering Activity Guide***

A fun filled book with at least 60 hands-on engineering activities designed for use in planning and delivering *Family Engineering* events or by parents wishing to encourage their own children to explore engineering at home.

c. **A *Family Engineering* Facilitator Training Workshop**

Designed to be delivered as a stand-alone training or as a half- or full-day seminar at selected conferences and conventions of professional engineering societies, national education associations, national museum associations, home school groups, and other settings where potential *Family Engineering* facilitators can be assembled.

d. ***Family Engineering Website***

Designed collaboratively between MTU and the Foundation for Family Science, this website will be an important additional resource for those familiar with the *Family Engineering* program and a valuable first point of contact for parents, educators, and engineers looking for teaching and learning resources for engineering education.[18] Activity postings, helpful hints for planning and delivering your own *Family Engineering* events, event highlights, additional engineering education resources and materials, and resources for parents to encourage their children to explore engineering careers will all be available.

This project will model the format of *Family Math* and *Family Science* programs, with the innovation of engaging STEM majors and engineering professionals nationwide to organize *Family Engineering* events.[19,20] One of ASEE's key contributions will be to help recruit engineering professionals and students chapters to present *Family Engineering* nights.

The project team is experimenting with various graphic designs for the *Family Engineering Activity Guide* which will contain descriptions for at least 60 hands-on engineering activities. Our goal is to provide materials that are easy to use by lay educators and attractive to STEM college majors, engineering professionals, and parents of elementary-aged children who likely have little or no elementary education expertise.

It is the experience of the *Family Science* and *Family Math* programs nationwide, as well as at Michigan Tech, that parents and children are eager to attend. Recruitment can be as easy as sending a flyer home with the students several days before the event, followed by a reminder a few days before. One time, the school principal forgot to send home the flyer for a family science night coordinated by Joann Chadde, until the

day before the scheduled family science night. While a smaller crowd was expected, a surprising 200 parents and children attended!

This project is intended to fill a void in engineering education by directly engaging parents and their children in learning about engineering and engineering careers. An informal survey of many nationally-connected informal science educators in the U.S. confirms the need for a *Family Engineering Program* and the lack of any similar existing program available nationwide. Phone conversations with several professional engineering societies, including Tau Beta Pi Engineering Honor Society, Society of Women Engineers, and the American Indian Science & Engineering Society confirms their interest in having student chapters participate in the delivery of a *Family Engineering Program*. Likewise the survey of student chapters of engineering societies conducted by the project team in May-June 2007 found that 80% of respondents were moderately to very interested in conducting outreach activities with K-5 students and families, and 2/3 of respondents were willing to serve as field test sites for the new Family Engineering program.

Michigan Tech has had considerable experience linking university STEM students with elementary students and their parents through a unique approach to conducting *Family Science* programs. Family Science Nights programs are presented in the evening to parents and their children, by Michigan Technological University undergraduate and graduate STEM majors who are trained to present engaging hands-on activities as part of an upper-level "Communicating Science" course taught by co-PI Chadde at Michigan Tech University.

While much attention is focused on creating highly-qualified teachers, it is essential that parents are on board when it comes to supporting their child's choice to pursue math and science in secondary school and, ultimately, STEM fields as a college major. Numerous studies have found that college students and young adults cite parents as an important influence on their choice of career. STEM college majors will be excellent role models bringing their enthusiasm and knowledge of engineering to their work with both students and parents. In addition, much evidence shows that role modeling can have a positive impact on student career choice. For female, minority, and economically-disadvantaged students, it is important to have a diverse group of role models providing these opportunities.

In a final report to NSF, Weissbaum states that many parents noted positive changes in their children's attitudes toward mathematics and in their child's approach to tackling math problems.[21] Furthermore, the EQUAL S program demonstrated the ability of community agencies to successfully deliver Family Math programs to a diversity of female and minority populations, and found that many parents continue to use the materials at home.[22]

The *Family Engineering Activity Guide* will be promoted to math/science centers, universities, and colleges. ASEE will assist in disseminating the *Family Engineering Activity Guide* and *Family Engineering Event* model by reaching out to engineering professionals and professional societies, by conference presentations, and by facilitator

training workshops. Materials will be shared with Departments of Education and Engineering at universities and colleges throughout the U.S. National dissemination to formal K-5 STEM educators will be facilitated by National Science Teachers Association through conference presentations and journal articles and partnerships established with the LHS EQUALS program at University of California-Berkeley.

Current Activities and Next Steps

Twenty five engineers, educators, and outreach specialists joined the Project Team and five of the NAC members for a two-day writing workshop held October 22-24, 2008 in Houghton, MI. The breakdown in expertise of all of the workshop participants was 7 engineering educators, 9 practicing engineers, 10 education specialists, and 9 outreach specialists.

After an introduction to the Project, the workshop participants went into various brainstorming sessions to develop ideas for family engineering activities. First, the entire group developed a list of engineering disciplines/fields coming up with almost 50 different topical fields. Topics were consolidated into eight groups and teams of 4 participants develop ideas for activities that might demonstrate what engineers do. Time was spent time listing the things that children need to know about engineering and trying to list the things that children could relate to. The small groups came up with almost 200 ideas for activities – both short and long.

These activities were reduced to a smaller number for pilot testing. Prior to pilot testing, some additional activities were developed to ensure adequate field coverage and the desired mix of short and long activities. The candidate activities were field tested at locations in Michigan's Upper Peninsula, Detroit, Michigan, Portland, Oregon, and the North Carolina Area. Activities were also presented at the ASEE K-12 Teachers Workshop in Austin, Texas.

Following the pilot testing, the activities were further refined in preparation for field testing. At this point there are approximately 20 short activities and 25-28 long activities. The team is in the process of selecting the activities to be actually used in field testing.

The Project Team is also in the process of determining how many field test sites and developing a request for proposals. Those interested in hosting a field test will submit proposals by the end of October. The next step will then be training for the field test teams and selection of activities by the teams. Field testing will place during calendar year 2010.

Summary

Family Engineering is building on the very successful Family Science and Family Math programs to involve young children and their parents in experiencing and learning about engineering. The expected outcomes are increased interest in engineering and improved technical literacy for all. The project team hopes that these materials will be used by

colleges and student groups in their efforts to reach out to this important audience – young children and their parents.

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