Promoting STEM Education Through The Ford High School Science & Technology Program

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ABSTRACT

The fields of Science, Technology, Engineering, and Mathematics (STEM) have been critical for the U.S. workforce in order to maintain its competitiveness and leadership worldwide, and to stand at the forefront of innovation in the U.S. economy. It is anticipated that STEM related jobs will continue to grow faster than average for all occupations from 2010 to 2020. However, it has been noted that only sixty percent of the new jobs which will be created in the U.S. and available in the 21st century will require skills possessed by only twenty percent of the current workforce (National Commission on Mathematics and Science for the Twenty-first Century , 2000).

For the past three decades, Ford Motor Company has been a pioneer and a leading force in promoting STEM education amongst high school students in southeast Michigan, inspiring generations of scientists and engineers, demonstrating the wonders of science and technology thru a unique initiative: the *Ford High School Science and Technology Program* (HSSTP). The intent of the program is to increase student's interest in engineering, science, mathematics, and related careers. In this paper, we will review the motivation behind the Ford HSSTP program, discuss lessons learned, and provide some suggestions to others who are interested in developing similar programs.

Keywords: STEM, Conference Proceedings, K-12 Outreach, Hands-on Learning

INTRODUCTION AND OVERVIEW

The lack of STEM education is a critical issue not only nationally, but also for the state of Michigan and local industries, especially the automotive industry. Reports and studies have shown that the State's failure to prepare, attract, and retain college graduates did prevent it from increasing prosperity. For the past twelve years, Michigan continued to struggle economically due in part to its failure to adopt and adjust to a knowledge-based economy that is focused on the role of information, technology, and learning in economic performance (Michigan Future, 2012). The bottom line is that what made Michigan prosperous in the past is no longer a path to prosperity. The world has changed fundamentally, we either adjust to the changes or we will continue to struggle compared to the rest of the country.

National and state educational policymakers renewed efforts begun in 2006 to improve the overall mathematics, science and technology literacy of U.S. students.

These efforts became known as the Science, Technology, Engineering and Mathematics, or STEM, initiative. The goal of STEM education is to integrate technology into daily classroom teaching methodologies, focus on applied science, mathematics and engineering curricula, provide ongoing advanced training for teachers and develop core knowledge assessment approaches (STEM School, 2012).

For almost three decades, volunteers from the Research and Innovation Center (RIC) at Ford Motor Company, in Dearborn, Michigan, have provided educational enrichment opportunities for area high school students and teachers. The Ford "High School Science and Technology Program" (HSSTP) is a prime example of the type of "leading corporate citizenship" that has become an explicit company goal to support STEM education in the state of Michigan. The HSSTP has evolved and grown over the years into an important community resource that also provides both tangible and intangible benefits to the company. Over the years and since its inception, the program has directly impacted over 10, 000 students and teachers, and involved hundreds of employee volunteers. In 1993, the program was selected by the Industry Research Institute as one of 11 "wining" pre-college education programs nationwide (Piehl, Mihm,& Ruckley, 1995; Hass, Lucchetti, Winkler, & Woestman, 1997).

The Program was founded in the fall of 1984 with the intent to increase student awareness about technical careers and demonstrate the importance of science and mathematics in industry. This was achieved through a variety of programs designed to relate the "classroom" science and math learned in school to the different kinds of experiments, operations, and technologies used within industry in general and specifically those at Ford. The sessions create enthusiasm among many students and can often spark an interest in a field. Students often carry this newly found interest with them to college.

Table 1 provides a chronological listing of some major HSSTP milestones. From the program commencement, its cornerstone has been a series of Saturday sessions for students and teachers in grades 9-12th. These sessions began entirely in lecture format, but now generally include some combinations of lab tours, demonstrations, and hands-on activities as well. Summer Internship opportunities for selected juniors and seniors were initiated in 1996 as a second major component of the HSSTP. In 1987, the HSSTP Saturday sessions began to be offered as an official "course" of the Detroit Area Pre-College Education Program (DAPCEP); this connection has greatly increased participation by minority students from the city of Detroit. Another HSSTP initiative, summer Fellowships for high school teachers, began in 1989, but since then has been administrated separately.

The target audience for the program is self-selected high school students who live in or near southeast Michigan. Within this set, the participants could be classified into two groups. For students hesitant about science and math or uncertain about whether they would find an engineering career appealing, we provide an applied, "hands-on" view of what it means to use math and science in an engineering, math, or science career. For students who already excel in

Table 1: Program Milestones

Year	Event
1984, Fall	First Saturday session
1986, Summer	First summer student internships
1987, Fall	Formal connection to DAPCEP established First Saturday session held outside RIC
1989, Summer	First summer teacher fellowships First student intern placed outside of RIC
1992, Winter	First Saturday "Career Workshop"
1993, Fall	Recognition as IRI "wining" pre-college education program

science and math, we provide additional enrichment about how the material mastered in school is applied within research and product development environments. For both groups, the program is most appropriate for students in grades 11 and 12, since these students have typically learned more math and science in school. The program is also interesting to students in grades 9 and 10. One challenge to the program is satisfying both groups and grade levels simultaneously. The program is also open to high school teachers, who attend with their students, and take ideas from the program back to their classrooms, where they can be used as examples of "real-life" applications.

The formal objective of the HSSTP is to increase awareness of technical careers and the importance of science and mathematics industry. The objective emerged in part from assessments of the varied needs of students and teacher participants and of the strengths of what the program has to offer. These strengths include exposure to: (1) a diverse, multi-disciplinary group of professional scientists, engineers, and technicians, (2) state-of-the –art laboratories and manufacturing facilities, (3) recent advances in science and engineering and their applications, and (4) emerging technologies and the factors that drive them. By emphasizing "exposure" to these areas, the HSSTP recognizes that it can do little to circumvent ingrained deficiencies in K-12 science and math education, but it can serve to inspire students, to provide examples of the relevance of high school science and math curricula, to provide role models of successful technical professionals, and to open eyes to technical advances and careers that many participants would not encounter otherwise. From the beginning of the HSSTP, efforts were made to encourage strong teacher participation and thereby potentially leverage Ford's efforts by having teacher share what they had seen or learned with present and future classes.

The HSSTP has also constantly striven for continuous improvement. Short questionnaires after each session and additional advice from teachers have provided important feedback on the

quality of the program, and have been responsible for most of the improvements. Such feedback has also resulted in a general trend toward more hands-on activities, an increasing emphasis on career information, and improvements in summer internship experiences, from the perspectives of students, mentors, and supervisors. The responsiveness of the HSSTP to such feedback has helped to build trust and credibility with local educators and to establish a true spirit of partnership, which is a desirable goal for any outreach effort.

SATURDAY MORNING SESSIONS

The main component of the HSSTP is our Saturday morning sessions. Six Saturday sessions are held during each school year, between October and March. Five of these sessions are devoted to specific topics that relate to work practices within Ford and especially within the Ford Research and Innovation Center (RIC). The remaining session is a more broadly focused Career Day. On average, between 125 and 175 students and teachers attend each session.

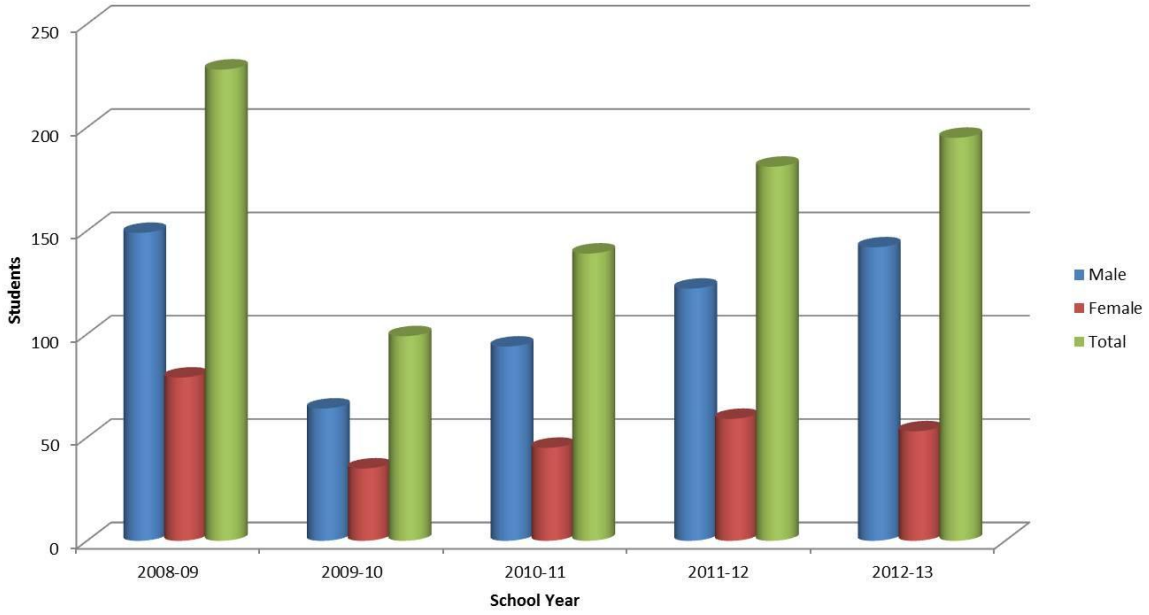

Figure 1: High School Students Participating in the HSSTP

The Saturday session topics from the last three years are listed in Table 2. Members of the sponsoring department, topical area, or remote facility act as a session coordinator and helps identifying people to host the different parts of the session. Session topics are rotated over at least a four-year cycle in order to prevent repetition from both the viewpoint of students who attend for multiple years and volunteers who conduct the program. Each session consists of two main parts. The first is a 20-minute lecture, which is designed to provide an overview of that day's topic and to relate different aspects of the topic to one another. The second part of the session consists of a series of "tour stops". These form the heart of the program and distinguish it from the experience of a scientist/engineer visiting a school or from a typical plant tour. The students are divided into smaller groups, and volunteer tour guides escort each group to a series

of laboratories and/or conference rooms. At each location, the group spends approximately 20 minutes learning more details about one subtopic of the day's subject.

Tour stops also demonstrate research tools that have been developed within RIC, such as a Driving Simulator, which tracks driver response to a computer-generated driving situation in the safe environment of a lab, or a Vehicle Vibration Simulator (CAE session), which reproduces previously measured vehicle vibrations on an isolated driver seat in order to allow assessment of vibration harshness and discomfort in an environment isolated from any preconceived impressions associated with particular vehicle types. The tour stops are what really excite the students. They can crowd around an interesting piece of equipment or a unique computer simulation tool and see "live" how it functions and how that relates to an industrial application.

Table 2**:** HSSTP Session Topics

Session Topic
Tribology
Automatic Transmissions
Career Day Workshop
Which Come First, Science or Technology?
Vehicle Electronics
Chemistry
Polymers
Advanced Manufacturing Technology
Phase Transitions
Powertrain Research
Computer-Aided Engineering
Engine Design/EcoBoost Engine
Electrification
Vehicle Safety
Climate Control Systems

The Career Day workshop has an Open House format and is thus somewhat different. Volunteers are solicited from across the Ford RIC, Engineering, and Manufacturing organizations in southeast Michigan. On the day of the event, each volunteer brings some props that help to promote conversations about how they use their engineering, math, and science training in their daily jobs. For example, in past years people have brought prototype engines, catalyst honeycombs, PC-based computer models, and entire vehicles to show the kinds of engineering work undertaken in their part of Ford. These displays are set up throughout the atrium of the RIC. During the Career Day event, the student attendees roam throughout the atrium from display to display in a somewhat random fashion, meeting the engineers and scientists and discussing career paths, engineering and science fields, colleges, and all their interconnections in one-on-one conversations. Simultaneously, a career panel discussion is held in the auditorium, with four or five employees sharing their experiences and answering student

questions in a "Town Hall" format. Many students appreciate the chance for extended conversations that Career Day provides. They also like being able to design their own program by picking and choosing which people they talk with. Other students enjoy listening to others' questions during the panel discussion (Greenfield, Cooper, & Ciechanowski, 2000).

We publicize the Saturday morning sessions (including Career Day) in three ways. First, at the beginning of the year we send a letter (e-mail) to the Science Department Head at all high schools in southeast Michigan. This letter describes the program, lists tentative dates and topics, and asks that an HSSTP co-director be contacted for additional information. Second, a distribution list (e-mail) of interested teachers is maintained, and 1½ weeks before each session we mail a flyer that describes the session in detail and provides a map. We ask teachers to distribute the information to students who are interested in the fields of science and engineering. Third, we offer the HSSTP as an enrichment class with the Detroit Area Pre-College Engineering Program (DAPCEP). Students enrolled through DAPCEP are invited to participate in the program and receive a DAPCEP certificate if they attend at least five of the six sessions.

An important closer to each Saturday session is the evaluation / feedback questionnaire filled in by many of the students. While the questions are not complicated — What did you like? What didn't you like? What do you wish was different? — The feedback received is useful for identifying stronger and weaker aspects of each session. Based on this immediate post-session feedback, we conclude that students who attend each session are generally very excited to see, hear, and touch these "real-life" applications of science and technology. Many students attend sessions throughout their high school education, and some have said that one topic or another at one of the sessions has helped them decide what they want to study in college.

SUMMER INTERNSHIPS

HSSTP summer internships provide the opportunity for outstanding high school students who have attended the Saturday sessions to gain practical engineering and research experience at Ford. The intern selection process is extremely competitive. Applicants must attend a minimum number of Saturday sessions (usually five out of six), personal statement, submit a teacher recommendation and a grade transcript, and fill out the internship application form which solicits information relating to their motivation and desire. Applying students must be in their junior or senior year of high school. Intern selection and placements are made by the HSSTP directors. Students are limited to a single internship, and many successful interns have continued working at Ford in later summers as supplemental employees or college interns.

Each student offered an internship is matched with a mentor/supervisor in an area in which the student has indicated an interest. Mentors are charged in guiding the intern’s engineering and research efforts. From the beginning, it is stressed to mentors that interns must participate in real programs and not just busy work. Interns typically design experiments, collect data, and assist in data analysis. Internships last four weeks (minimum), but could be extended up to eight weeks, starting and ending at a mutually agreed upon time.

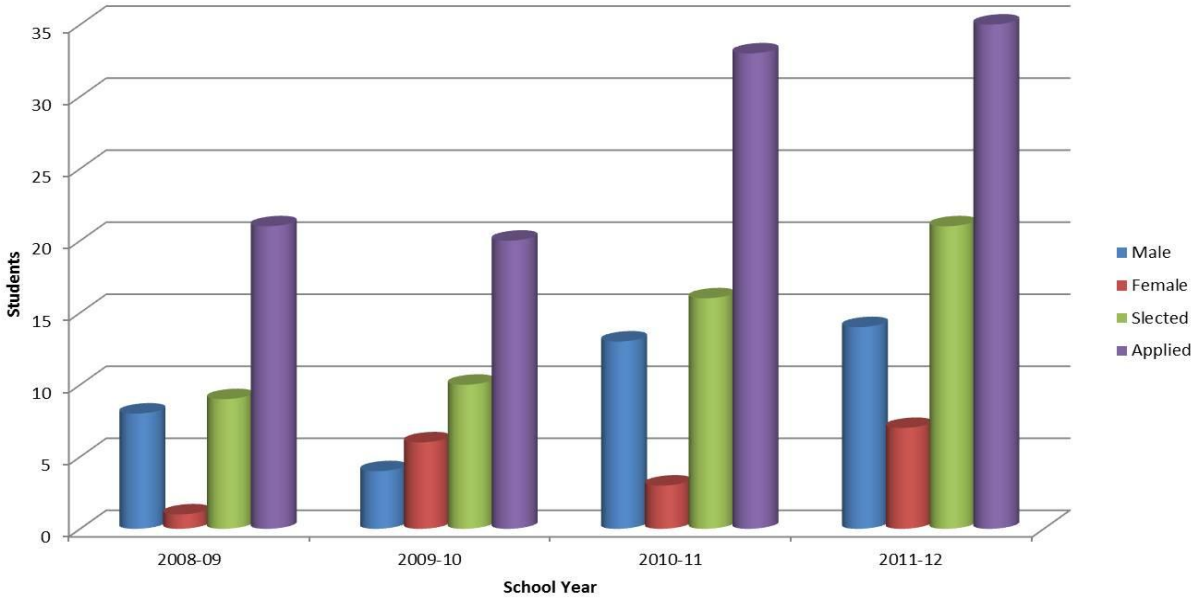

Figure 2: Total Number of High School Summer Interns

Each year's students and mentors are extensively questioned about their experiences and ways to improve the program. One thing learned is that most participants end the summer well satisfied. Students have been unanimously thankful for the opportunity to participate in the program and many have indicated an interest in continuing to work at Ford. A common student comment is that they would have loved to do even more if only they had been assigned more work. This willingness to both learn and work hard is certainly one of the characteristics of most interns. Mentors have been uniformly amazed with student maturity as well as the amount of work interns have been able to accomplish. Many mentors accept students year after year and have found that these students have provided them an opportunity to get work done that wouldn't get done any other way. In the vast majority of cases, mentors have recommended that interns continue to be tracked by Ford for possible future employments.

PROGRAM IMPACT AND BENEFITS

The HSSTP is a valuable community resource that provides important exposure to aspects of science and engineering not traditionally encountered in high school. Perhaps the greatest quantitative measures of success are the continued high numbers of Saturday morning sessions attendees, applicants for summer internships and Ford employees willing to volunteer their time and energy. A further quantitative assessment has not been attempted, both because of the limited resources available for tracking program alumni and because of the intangible nature of the anticipated benefits to participants. Given that most participants are already interested in science and engineering, it would be difficult to determining precisely how much influence the HSSTP has on such matters as career goals and success in college. Nevertheless, the overwhelmingly positive feedback received is consistent with the memorable and reinforcing

nature of similar extracurricular activities experienced by most technical professionals before beginning their own careers.

Summer interns clearly have the most intense experiences within the HSSTP, and drive the greatest benefits. The individual mentoring they receive from professional scientists and engineers, and the first-hand exposure they gain to the technical workplace, provide valuable sources of inspiration and confidence that can give them a significant boost over classmates in their early years in college.

FUTURE ISSUES

After almost 30 years, the greatest threats to the future of the HSSTP are complacency and dampened enthusiasm. Rotating leadership begun in 1992 has done much to ensure continuity and freshness, but future co-directors will continually need to find creative ways to recruit and retain volunteers, seek and justify management support, improve the quality of and prevent overcrowding at Saturday session, and allow the program to adapt to the ever-changing work environment and organizational structure at Ford.

Main issues and concerns likely to warrant special attention:

Managing growth - The HSSTP is already close to its saturation point, but pressure to allow more students to attend Saturday sessions and provide more summer internships are not likely to go away. Fear of overcrowding is a perennial problem that has prevented the HSSTP from seeking greater publicity for its activities with the local community.

Teacher involvement - Teacher participation in general is such an important aspect of the HSSTP that co-directors have to work hard to maintain or increase the percentage of teacher participants. It is especially important to attract new faces each year, perhaps younger teachers just starting out in their careers.

Increasing use of the internet - Create a HSSTP website for advertising, preregistration, and documenting successful demonstrations and hands on activities, are just a few ideas that come to mind. Perhaps use social media to allow teachers and students to share ideas and get answers to technical questions they might have.

Proof of effectiveness - There are really two challenges here: the first being a continuous self-assessment to ensure that the HSSTP continues to justify the effort expended to the satisfaction of both Management and HSSTP volunteers, and the second being the more difficult question of whether small-scale programs of this kind have any measurable impact overall, or whether they merely "random acts of kindness."

As difficult as it is to demonstrate the impact of the HSSTP quantitatively, continued documentation along the lines of the present report is extremely valuable, both as a reminder of its degree of acceptance within Ford Motor Company and the local community, and as source of ideas for how the program might improve further. A more formal tracking of previous and future HSSTP interns might be especially useful for justifying the value of such internships,

which do require a noon-trivial investment form Ford, and competed to some extend with the college internships.

The larger issue of the overall impact of programs like the HSSTP is clearly beyond the scope of our expertise; as both the company and the country in general begin to pay more attention to K-12 STEM education, however, new insights may well emerge into the most effective roles for industry, and technical professionals, and the HSSTP should be prepared to adapt accordingly.

SUMMARY

The HSSTP would not be possible without the many Ford employees who volunteer their time to make it a success. Three co-directors share the leadership responsibilities, with a new co-director chosen each year to replace the senior co-director. This position is a serious time commitment since co-directors wind up addressing many questions during business hours. The co-directors handle most logistical matters, choose the session topics, solicit volunteers, and help with planning each session.

In total, we are proud that the HSSTP is now beginning its 29th consecutive year. After beginning with a small group of students on a few Saturdays, the program has demonstrated industrial applications of science, math, and engineering to so many high school students and school teachers. With a strong volunteer base, strong management support, and overwhelming interest, we expect that the program will continue to prosper for many more years.

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