

The Pennsylvania State University “MTM Engineering Camp for Girls:” Generating Under-Represented Pathway Prospects Through A Diversity-Rich Pre-College Outreach Project

**Cheryl Knobloch
The Pennsylvania State University**

Abstract - *MTM Engineering Camp for Girls* started in 2001 as a residential pre-college outreach project targeting 11th and 12th grade high school girls. Three goals were initially the focal point of MTM: to provide high school girls with engineering career information, to recruit girls to engineering, and to enhance career development of undergraduate women engineers. Hands-on activities in interdisciplinary engineering fields, complemented by interaction with women engineer role models, were vehicles to these objectives.

After scrutinizing project assessment data, the project director determined that the camp served only twenty-five girls annually, 96% of whom were Caucasian. Significant modifications were made to the project in 2003 in a deliberate effort to enhance Latina and African American participant population, to maximize overall pre-college participation, and to optimize department resources.

As a result, a sleeker, more-effective outreach project emerged, successfully teaming 69 pre-college girls with 12 undergraduate women engineers in 2004. MTM '03 and '04 participant diversity was increased to 41% and 42% respectively. Thus, a fourth camp goal, exposing talented Latina and African American girls to the engineering profession, was implemented. Success was achieved through alliances with targeted urban school districts, and funding was secured to sponsor these students in entirety.

Modifying the camp structure to a day module experience proved valuable and captured almost three times more participants than the residential camp. Sponsored multicultural guests enjoyed two evening programs specifically tailored to higher education STEM opportunities and admission procedures. Women engineers of color served as vital role models and were an integral component to the success.

Penn State WEP MTM Project Goals

The Women in Engineering Program (WEP) “*MTM Engineering Camp for Girls*” outreach project successfully targets pivotal program objectives including diversity enhancement and recruitment challenges for the Penn State Women and Multicultural Engineering Programs. Girls with technical interest and intellectual promise unknowingly narrow their options because they have not received the necessary academic information, career exploration opportunity, role model interfaces, and/or vital encouragement. This problem is especially prevalent across multicultural boundaries including Latina and African American ethnic groups.

At a pivotal time in their academic lives, MTM provides students with hands-on engineering activities, career information, women engineering role models, and systemic support. These influences introduce, facilitate and reinforce girls’ interests in science and math, and encourage their continued participation in the courses necessary to pursue an engineering discipline in an institution of higher education. Women and students of color are historically under-represented groups in engineering disciplines at the undergraduate, graduate, and national professional levels. For this reason, these groups comprise targeted populations for diversity enhancement programming in both academia and in private industry.

The overarching principle of *MTM (Make the Machine) Engineering Camp for Girls* is to introduce girls to engineering and to positively impact career selection, thus addressing the under-representation of women in engineering. The week-long MTM project focuses on three distinct goals. The first goal is to provide technically capable girls entering ninth through twelfth grades with career information through hands-on engineering activities and active networking, and establish confidence in engineering and science-related careers. With the opportunity to engage in engineering activities, enhanced by interaction with women engineer role models, these girls will be more likely to continue math and science courses and to explore engineering as a career choice. Undergraduate and graduate women engineering students are selected as camp counselors and instructors, thus providing vital role models for camp participants.

The second goal is to expose talented Latina and African American girls to engineering as a broadly defined, engaging profession that is rewarding and satisfying for women. MTM hands-on camp activities and networking experiences positively influence multicultural participants’ desire to select math and science courses needed to be eligible for pursuit of an engineering degree in higher education. The third goal is to attract and to recruit junior and senior high school girls to the Penn State engineering program, thus addressing the under-representation of women in technology related careers.

The MTM project establishes participants of all ethnicities with technical opportunities and role models, and facilitates an exciting environment to explore engineering. Undergraduate women engineering students work with the participants and engage them in hands-on engineering activities and to recruit them to engineering, thus expanding the entry points on the engineering pathway.

WEP MTM Background and Description

MTM (Make the Machine) Engineering Camp for Girls is a week-long engineering day camp for girls entering ninth through twelfth grades. MTM focuses on broad interdisciplinary engineering fields with proven appeal for pre-college girls including bioengineering, environmental construction and design, product innovation, chemical engineering, and robotics. Each summer, new engineering modules are introduced to continue to attract participants from previous offerings. All activities are intensively team-oriented and feature collaborative learning experiences. Each MTM module engages students in hands-on activities related to the selected engineering discipline, complemented by a career development component; participants are further encouraged to interface with women engineers through participation in facility tours.

MTM camp was initiated in 2001 as a residential camp experience (*VEC-Tour Camp*) and was only able to serve twenty-five girls annually. The minority participation was very high in the initial offering (2001) due to targeted recruiting. In 2002, the participant ethnicity dropped significantly to only 4%. It was determined that the lack of targeted recruitment in 2002 had a direct relationship with the diversity of the project participants; therefore, targeted recruitment needed to be expanded upon and institutionalized in future MTM offerings (Bogue, 2004). It was not possible to attract a diverse audience without a targeted effort. Significant modifications were made to the project in a deliberate effort to enhance Latina and African American participant population, to maximize overall pre-college participation, and to optimize department resources.

In 2003, the project emerged with a new name and significant programmatic changes to augment the participation of multicultural students and to maximize departmental resources. *MTM (Make the Machine) Engineering Camp for Girls* featured concise day module programming offering camp participants the latitude to select any or all of the engineering disciplines to explore. This model was overwhelmingly successful; busy high school students were more likely to select two days of camp participation rather than dismissing the entire experience because they were unable to commit to a five-day resident camp. Furthermore, the day module format worked effectively with out-of-state participants. The camp structure allowed students to dovetail a weekend campus visit with one or two days of MTM Camp. As a result, MTM is designed to serve at least three times more participants than a resident camp over the course of a week.

An innovative day module structure enables program resources, both financial and workforce, to be appropriately focused on the camp content and program objectives rather than the “after-hours” camper entertainment. As supplement to this format, two evening programs are conducted for multicultural student guests traveling from targeted urban areas. MTM evening programs feature campus tours, interactive career discussions with women engineering role models of color, and college admission information.

Contact with participants continues beyond the camp experience. Through an email mentoring program, freshman and sophomore participants are mentored to select important math and science courses in high school, further enhancing their interest and confidence in technical opportunities. Junior and senior participants are invited to attend Women in Engineering Program outreach events and the College of Engineering Open House; seniors are encouraged to

apply to the Penn State College of Engineering. The effectiveness of these long-term action plans is measured utilizing multiple assessment instruments.

MTM offers five, eight-hour engineering modules to girls entering ninth through twelfth grades for one week in the summer. Each module highlights a different interdisciplinary engineering theme. Participants may choose to attend any number of modules; therefore, each day is populated by different participants. An important feature of this project is the leadership provided by undergraduate women engineering students. WEP students serve as counselors and engage participants in hands-on engineering activities, thus providing important role models. Counselor positions are competitive and selected students are rewarded with a small leadership scholarship of fifty dollars per day.

A nominal camp participation fee is an effective method to ensure MTM participant commitment; the \$25 per day participant fee, or \$100 for the entire week, provides participants with all camp materials, lunch, snacks, continental breakfast, and a t-shirt. This cost structure is complemented by full scholarships readily available to campers in need. A pre-determined number of potential daily scholarships are provided for sponsored multicultural student guests and others with demonstrated financial need. MTM project funding is largely provided by external sponsors.

WEP MTM Project Approach

MTM '03 and '04 proved to be diversity-rich pre-college outreach projects capturing an under-represented population of 41% and 42% respectively as compared to 4% in 2002. The significant upward shift in multicultural student participation was the result of networking and targeted recruitment to identify a partner school in key urban areas within the state of Pennsylvania. On-line searches of Philadelphia and Harrisburg schools included analysis of each institution's demographics. One such school documented a population base of 70% Latino, 27% African-American, and 3% Asian students. Dialogue with the school guidance department was initiated and the MTM math and science enrichment opportunity proved to be of significant interest; the school science coordinator became the long-term liaison.

The science coordinator enthusiastically agreed to identify and accompany 12 Latina girls selected for their interest and ability in math and science. The faculty member determined that an optimal duration for the initial MTM Camp experience was two days. As a result, the twelve multicultural student guests arrived at Penn State the day before their first day of MTM Camp. All transportation, meals, lodging, and fees were sponsored by Penn State WEP; this sponsorship directly facilitated the ability to attract talented Latina students to the event.

Details of the multicultural student sponsorship were captured in proposals to entirely fund the project's diversity enrichment goal. In all, twelve Latina students and two chaperones were sponsored for the trip to Penn State; students were accompanied by their female science coordinator and Spanish teacher. Similarly, an African American student group in Harrisburg was identified for the opportunity to participate in MTM. Students in the Black Achievers mirrored the excitement of Latina guests from the Philadelphia. As a result, twelve African

American girls and two chaperones were selected for sponsorship in MTM. In all, recruits from Black Achievers and NEA comprised twelve spaces per day, for three of the five MTM modules.

Multicultural girls interested in science and math were selected for the opportunity to participate in *MTM Engineering Camp for Girls* with faculty chaperones from the two institutions. Meetings were conducted with parties at both locations to encourage participation and to answer related parent questions, thus maximizing the opportunity for success. A pivotal component to success was the faculty liaison at both locations to champion students and to reassure families. Most of the prospective participants had never left the boundaries of the area. Trusted faculty chaperones from each organization were key selling points to parents and families.

Twelve Latina students participated in the first two days of MTM '03. External funding enabled these students to arrive the evening preceding the first day and to participate in two engineering days: bioengineering and acoustics. The students enjoyed a supplemental evening career program, and Latina women engineers were actively engaged as role models for the girls.

Similarly, twelve African American students from Black Achievers participated in the last day of MTM; the group self-selected participation in one day of MTM although offered two days. External funding enabled the students to arrive the preceding evening and to participate in the *Product Innovation* module the following day. The twelve enjoyed a supplemental career program upon their arrival and women engineers of color were on hand throughout their visit as role models for the girls. External funding for transportation, lodging, and meals facilitated the participation of these students.

The MTM diversity enhancement initiative launched in 2003 proved to be an overwhelming success. Funding was awarded for the initiative to repeat in 2004, and opportunities for partnership were given to the same two organizations. In 2004, twelve Latina students participated in the first two days of MTM, and twelve students from the Black Achievers participated in a third MTM day.

Recruitment of women instructors and engineering student counselors of color was integral to optimize the potential for success for the Latina and African American participants.

Modules and Hands-on Design Activities

MTM activities are designed to introduce girls to each interdisciplinary engineering topic in a hands-on fashion. Moreover, projects are intentionally designed to be successful, and able to be understood by participants. Overly complex activities can frustrate and discourage both participants and volunteers; selected activities should be pre-tested to ensure success and to promote the exploration of engineering in a supportive, team-based environment.

Networking with women faculty and graduate students at the host institution provides a lucrative pool of expertise. Once the topic and the hands-on design project have been developed, facility tours and women engineering role models are complementary components important to the module. Facility tours at the institution are obvious resources; however, external businesses are

viable options. Significant planning is important to the success of site visits. In some circumstances, special permissions are needed. Further, the value of having women engineers present at each facility cannot be overstated.

As an example, a dynamic MTM module agenda is illustrated in Table I. Bioengineering women faculty engaged students in a two-faceted design project. The first facet introduces participants to bioengineering by constructing their own Electrocardiogram circuit (EKG) device; students consequently work in teams to use the device to test and to synthesize data produced by the EKG. The second facet introduces participants to bioengineering by building an optical microscope.

The MTM bioengineering agenda was further enhanced by site visits to an Artificial Heart and Cardiovascular Fluids lab. Furthermore, students visited a mechanical engineering laboratory and each tried her hand at a cutting edge surgical simulator. A number of women bioengineering and mechanical engineering faculty and graduate students were highly visible throughout the day. One hundred percent of the participants successfully completed their EKG and optics design projects and, consequently, module assessments reflected their excitement and bolstered confidence. Not surprisingly, undergraduate women students enthusiastically engage in module projects as well. Their enthusiasm and interest entices pathways students and the mentoring cycle is fueled from within. In 2004, this module served 48 pre-college girls and featured 12 women engineer volunteers.

TABLE I
Bioengineering Module Agenda

Time	Activity
8:00 a.m.	Registration & Welcome
8:30 a.m.	Chalk Talk: “Introduction to Bioengineering”
9:00 a.m.	SPLIT into Concurrent Sessions
Group I	* Electrocardiogram Circuit Design & Testing * Mechanical Engineering Surgical Simulator Demonstration * Optics Design Challenge “Chalk Talk”
Group II	* Mechanical Engineering Surgical Simulator Demonstration * Optics Design Challenge “Chalk Talk” * Electrocardiogram Circuit Design & Testing
Noon	Picnic Lunch - ALL
1:00 p.m.	SPLIT into Concurrent Sessions
Group I	* Microscopy & Optics Design Project * Artificial Heart/Cardiovascular Fluid Lab Tour
Group II	* Artificial Heart/Cardiovascular Fluid Lab Tour * Microscopy & Optics Design Project
4:00 p.m.	Assessments and Module Conclusion

Table II depicts an engaging MTM “Robotics” module agenda at the opposite end of the technical innovation spectrum. Activities are notably broad and allow for creativity, thus artistically appealing to the girls. In 2004, this module served 36 girls working in design teams, and utilized 10 women engineer volunteers.

After learning about gears and mechanical movement, participants worked in teams to design a mechanical robot to satisfy a number of pre-determined parameters. Student teams selected music and programmed robots to perform a dance of pre-determined length satisfying specific mechanical requirements. The design project culminated in a robot dance contest judged by women engineering faculty and guests. The music selection allowed girls to be individually expressive complemented by the team experience building the robot and programming the unique movements. An interactive tour of a mechatronic campus research laboratory rounded out students’ experiences; the lab tour and women engineers on site provided a conceptual understanding of how robots and mechanical engineering are used in everyday life.

TABLE II
Robotics Module Agenda

Time	Activity
8:00 a.m.	Registration & Welcome
8:30 a.m.	“Introduction to Mechanical Engineering” <i>Overview of gears and robotics</i>
9:15 a.m.	Robotics Team Design Challenge: Design and Build a Dancing Robot
11:00 a.m.	<i>SPLIT into Concurrent Sessions</i>
Group I	* Tour Mechatronic Robot Laboratory
Group II	* Programming LEGO Robots
12:30 p.m.	Picnic Lunch - ALL
1:30 p.m.	<i>SPLIT into Concurrent Sessions</i>
Group I	* Programming LEGO Robots
Group II	* Tour Mechatronic Robot Laboratory
3:00 p.m.	LEGO Robots Dance Competition
4:00 p.m.	Assessments and Module Conclusion

Every moment of each MTM module is utilized in an effort to interface pathway students with engineering professionals. Lunchtime picnics are orchestrated and include women faculty and graduate students of color in all circumstances. These informal mentoring opportunities are highly effective and encourage participants to engage in career-related discussions. In many circumstances, invited engineering guests will generate a panel discussion to discuss career experiences related to the interdisciplinary daily topic.

Parents and chaperones of MTM students are a targeted group for engineering education. Parents have the opportunity to participate in a Parent Information Workshop; a typical agenda is illustrated in Table III. Parent feedback confirms that this initiative is of significant value.

Information sessions include topics that introduce parents to the engineering profession and help them prepare their daughters for a STEM career opportunity. This is an effective measure providing students with an informed support system when they complete their MTM camp experiences. Parents learn what high school courses benefit their daughters, the requirements for admission and admission process, academic requirements for engineering, and STEM opportunities that lie in wait of their talented daughters. Parent sessions are well attended and more than 60% of MTM students have a parent or chaperone elect to participate in her behalf.

TABLE III
Parent Workshop Agenda (*Optional Activity*)

Time	Activity
8:00 a.m.	Registration & Welcome <i>Information handouts & review</i>
8:30 a.m.	PSU Undergraduate Admissions Presentation
9:30 a.m.	Women in Engineering Program Presentation <i>“Engineering as a Career Path for Women”</i>
10:30 a.m.	Engineering Academic Advising Presentation
11:00 a.m.	Parent Program concludes
4:00 p.m.	Tour of Campus with Lion Ambassadors <i>Participants and Parents welcome</i>

WEP MTM Project Assessment

MTM Engineering Camp for Girls uses a combination of quantitative and qualitative data to measure the program success including pre- and post-assessments, retention tracking, and formative event evaluations. Both formative and summative instruments enlist the expertise of NSF-funded, *AWE (Assessing Women in Engineering)* project directors (Bogue, Marra, 2004).

Pre-camp surveys are mailed to participants one month prior to the event to determine whether participants currently entertain engineering as a viable career option, what stereotypes about women’s career choices campers may bring to camp, existing confidence levels in math and science, and their perception of engineering. Immediately following participation, participants complete a post-survey and a formative camp evaluation.

Six months after the camp, a supplemental post-camp survey instrument is mailed to participants to determine whether participant confidence levels in math and science were augmented, whether existing stereotypes about women’s career choices shifted, and whether MTM introduced engineering as a viable career option. This survey also measures the extent to which MTM had an impact on math and science course scheduling in high school.

MTM participant assessment results highlight the success of the project. As expected, the women engineering student role models held a significant role in the participant consideration and understanding of engineering. The data show that as the week ensued, MTM participants were directly and positively influenced by their women engineer role models. Using a Likert scale, 100% of the participants had full or partial agreement with the statement, *“The women engineering student counselors helped me understand engineering more”* during the last three days of camp. An average 82% full agreement with the statement further illustrates the value women engineering student counselors bring to MTM program activities.

Assessment results indicate that hands-on engineering activities, complemented by career site visits and role models, effectively and positively present engineering as a dynamic career choice for young women. When asked for agreement to the statement, *“After today’s activities I feel I have a better understanding of what engineering is,”* 95% of the overall participants indicated full or partial agreement.

Assessment data measured a shift in career interests as a direct result of participation in the MTM project. Participants were asked to rank order their top three career choices on pre-camp instruments. That data showed that engineering was the number one career choice for 36% of the overall pre-camp participants, and in the top three career choices for 57% of the overall participants. Extracting data for the multicultural students, 0% of the students had engineering as the number one career choice and only 15% selected it in the top three careers before MTM. Immediate post-event instruments show a shift in career choice for the overall participant pool, and a significant impact on the multicultural student response. Post-event data show that engineering was the number one career choice for 41% of the overall pre-camp participants, and in the top three career choices for 71% of the overall participants. Post-event data for the multicultural students show that engineering was the number one career choice for 22% of the overall pre-camp participants, and in the top three career choices for 62%.

Conclusions

The MTM project effectively serves a number of important WEP program objectives including both recruitment and diversity initiatives. Since the project inception as a residential experience in 2001, the shift to a day camp experience has optimized departmental resources and pathway participation. Utilizing an innovative partnership with urban schools and organizations complemented by a shift in programming, MTM serves an average of 68 pre-college girls annually with 42% of the participants being multicultural.

MTM is now well institutionalized and continues to attract girls of all ethnicities from across the country. As a result of the enhanced diversity initiative, MTM has made a measurable impact introducing pre-college multicultural girls to engineering as a viable career for women. Anecdotally, three of the MTM '03 pre-college participants from the Latina-based high school returned to MTM '04 and are now applying for university admission. The three rising seniors approached school science faculty to request the opportunity to return and explore engineering for the entire week. As a result, the three participated for the entire week on full scholarships,

and are at the threshold of an engineering career path. MTM has cultivated a sense of “ownership” for the pre-college students of color, and resulted in applications to Penn State.

The Penn State MTM project generates a positive response from undergraduate women who are eager to serve as counselors, a valuable effect on pathway participants, and a significant endorsement from parents and pre-college STEM faculty. Consequently, the MTM project has evolved to become a significant pre-college activity teaming pathway prospects with undergraduate women engineering students in a dynamic, diversity-rich environment.

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CHERYL KNOBLOCH (cknobloch@engr.psu.edu) is a ceramic engineer and associate director of Women in Engineering Program at The Pennsylvania State University. Her WEP initiatives include recruitment and retention of women in engineering. She is also co-instructor of two first-year mechanical engineering courses at Penn State.