

Tech PrEP: Seeding Technology Careers via Michigan Tech University's Enterprise Program

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Abstract

Since the fall of 2000, Michigan Technology University's undergraduate Enterprise Program (www.enterprise.mtu.edu) concept of cross-disciplinary problem solving and product generation has created active learning environments for undergraduate students across campus. Within the program, teams of students from a broad base of disciplines are provided an opportunity to work for several years in a business-like setting to solve real-world engineering problems supplied by industry. Through participation in the program, Enterprise students are able to develop not only technical competence, but also an understanding of the practical application of skills and knowledge in areas such as communication, relationships, conflict resolution, leadership, teamwork, global markets and competition, environmental and social issues, ethics, and business.

Michigan Tech strongly believes that in order to increase the numbers of minority and female students who select to enroll in technical programs, students must be introduced to engineering and science while they are in elementary and secondary school. For the last 30 years, Michigan Tech's Youth Programs (www.youthprograms.mtu.edu) have provided pre-college students opportunities to explore engineering and science-related fields through intensive summer workshops. In ten years of data tracking, approximately 35% of Youth Programs participants return for admission to the University after participation in the programs.

MTU is attempting to build upon the success of these two unique programs – Enterprise and Summer Youth – by extending the Enterprise educational concept to the summer youth participants through the introduction of a mini-enterprise experience. The mini-enterprise experience is designed to introduce and involve students in engineering and technology by using contextual learning experiences that will increase the technological capabilities of the future workforce. The intent is to provide a vehicle for increasing participation of minority and females, thus improving technology education and the technological capabilities of our future workforce. Furthermore, by building upon the belief that students grasp a better understanding of concepts when given an opportunity to teach them to others, the mini-enterprise experience provides undergraduate students an opportunity to help with the development and delivery of educational materials to the pre-college students, thereby strengthening their own level of understanding.

To date, this concept has been piloted with several of our enterprises ~ Aqua Terra Tech, Consumer Product Manufacturing and Wireless Communication, with great success. This paper will summarize the results of these pilot Enterprise-Summer Youth experiences, highlighting the

process used to develop the pre-college mini-enterprise curriculum, delivery of the curriculum by the enterprise students, and feedback from the pre-college participants.

I. Introduction

In the 2004 ASEE report entitled “Engineering in the K-12 Classroom: An Analysis of Current Practices & Guidelines for the Future”, the ASEE Engineering K-12 Center recommended six guidelines for improving engineering education and outreach¹. The guidelines include:

1. Use of *hands-on learning*, making K-12 science curricula less theory-based and more context-based by emphasizing the social good of engineering and demonstrating how it is relevant to the real world
2. Use of an *interdisciplinary approach* by adding a technological component to all subjects and lessons
3. Involvement of engineering in K-12 lessons that map to *state standards* for math and science
4. Engaging more K-12 teachers in outreach efforts and curriculum writing
5. *Making engineering “cool”* by outreaching to urban schools and females more aggressively
6. Creating better incentives for all *interested parties* to engage in K-12 outreach (especially higher education and industry)

Michigan Tech has combined two of its more successful educational models into one program which follows all six of the ASEE recommended guidelines thereby helping to infuse engineering education to middle and high school students, teachers, and administrators. This hybrid program, entitled Tech PrEP (Precollege Enterprise Program) merges the undergraduate Enterprise Program and the academic precollege Summer Youth Program. Both efforts are unique and successful initiatives in their own right. By combining these models, Michigan Tech is able to extend a wholly unique experience to precollege students underrepresented in STEM career fields, provide valuable curriculum modules to educators, offer undergraduate students a leadership skill building opportunity, and create dynamic partnerships between the three entities which have a stake in engineering education (K-12 schools, universities and industry).

II. Background

Michigan Tech is located in Houghton in Michigan’s remote, rural western Upper Peninsula along Lake Superior ~ approximately nine hours from downstate Detroit and four hours from Green Bay, Wisconsin. Michigan Tech has research, recruiting and development relationships with hundreds of corporations worldwide in a range of sectors (e.g. automotive, manufacturing, information technology, biomedicine, etc.). Founded in 1885, Michigan Tech offers associate, bachelor, master and doctoral degrees in the sciences, engineering, forestry, business, communication, and technology. A public university of the State of Michigan, Michigan Tech is designated as one of only four research universities in the State. Undergraduate education emphasizes study across disciplines, team learning and research. Graduate students receive intensive advanced instruction. Total enrollment is 6,300 students with engineering enrollment at 4,000, the 10th largest in the U.S. Michigan Tech has gained worldwide attention for innovative

education. Our faculty members strive to be mentors, our academic programs stress learning hand-in-hand with application, and our students learn to inquire and discover knowledge.

Michigan Tech's Enterprise Program is one example of the innovative approach to education the university is known for. The Enterprise Program combines education and experiential learning through interdisciplinary teams of undergraduate student working together to address real-world problems of significance to industry. The Enterprise curriculum is a 20-credit, 3-year experience which consists of 1) participation in the operation of a business (project work) and 2) completion of concentrated course material (instructional modules) designed to provide key information, processes and skills required for effective management of a viable business. There are presently 24 Enterprises on campus, involving over 550 students from 19 disciplines within the College of Engineering, College of Sciences and Arts, School of Business and Economics, and the School of Technology.

Participating undergraduates choose to join an enterprise of interest to them and through their project work are able to develop skills and connections with industry that make them desirable future hires. Each enterprise is required to address and complete at least one major project/product per year, although multiple projects are encouraged when appropriate and available. Consequently, each student participates in a minimum of three different projects during their tenure in the enterprise. Their tasks and responsibilities on each of the projects are many and varied, since over the three-year period they contribute to the projects in different ways due to changing levels of technical expertise, maturity, and seniority. Many project results are ultimately patented and targeted for future commercialization through the University's Intellectual Property Office.

The primary goal of the Enterprise Program (<http://www.enterprise.mtu.edu>) is to meet industry's need for graduates who not only have technical competence but also understand the practical application of skills and knowledge^{2,3}. The main objectives of the program are to help the students develop their skills and knowledge in the following key areas:

- communication, conflict resolution, teamwork and leadership
- an awareness of global markets/competition
- an appreciation of other cultures and outlooks
- a firm grounding in environmental, social, ethical and professional responsibility
- an ability to solve problems and think critically
- demonstrated business sense and management skills
- the ability to learn continuously and use information effectively throughout their careers

This active and collaborative learning environment is one in which women and minorities tend to thrive. In addition, the process of developing leaders through teamwork and hands-on exploration creates a climate for strong peer-peer mentoring. Exposure to all facets of engineering and business help students experience the more creative, exciting aspects of being an engineer and using technology. The MTU Enterprise Program, as well as science, technology, engineering, and math (STEM) undergraduate programs as a whole, has a smaller than desired percentage of female and minority students who participate (approximately 18% and 4% respectively for enterprise, 24% and 4% respectively for STEM related programs). To increase the numbers of female and minority students who select to enroll in these programs, MTU offers

precollege programs which expose underrepresented populations to academic and career pursuits at an early age.

Michigan Tech's award-winning Summer Youth Programs (SYP) (youthprograms.mtu.edu) established in 1973, are among the most established and best known U.S. pre-college explorations with 30% of participating youth age 13-17 ultimately matriculating as undergraduates at the University (African American youth rates are higher). Over 1,200 students spend at least 1 week on campus each summer to investigate careers and learn about engineering, science, mathematics, technology and business. SYP puts special emphasis on recruiting populations typically underrepresented in the STEM fields. Last year, 45% of the pre-college participants were from ethnic or racial groups underrepresented in engineering professions and over 60% were women.

The *primary goal* of SYP is to encourage participating students to become academically prepared so that college can be a viable option for their future. The main objectives of the programs are to:

- allow participants to explore post secondary education academic pursuit options in MEST
- offer career discovery in a hands-on/minds-on environment
- provide access to technology, laboratory resources, expertise, and academic experiences not normally available to middle and high school students
- help students feel comfortable in a university setting
- encourage student interactions with peers and role models (residence hall staff, all of whom are successful undergraduate or graduate students in a variety of disciplines; teaching assistants and faculty as well as minority and women professionals)
- facilitate information and resource exchange between Michigan Technological University, parents, and personnel from each participating school
- maintain students' focus on post-secondary education and future career opportunities, especially in the sciences and engineering with various follow-up activities
- regularly assess and change programs so that they meet the changing needs of students and parents

The Tech PrEP program described in the following sections blends the proven success of the above described Enterprise concept with the precollege programs' ability to present these academic and career pursuits to minority and female students. MTU believes that this program will begin to address the imbalance of females and minorities in engineering majors (a national problem) by introducing potential students to this exciting hands-on learning opportunity.

III. Tech PrEP Pilot

To date, the Tech PrEP concept has been successfully piloted with several of our enterprises including Aqua Terra Tech, Consumer Product Manufacturing and Wireless Communication Enterprise. We focus our attention here to the pilot offered during the summer of 2003 with one of the more established enterprise teams, the Wireless Communication Enterprise (WCE). The overarching goal of the program was to actively involve a group of diverse students and secondary school educators from both rural and urban areas throughout Michigan on the application of wireless technologies to create a greater understanding of the related studies and

careers. This pilot endeavor was supported with a grant from the SBC Foundation through their Excelerator Program. With the support from SBC, all parties with a stake in the programs outcome were thereby involved (K-12, university and industry), contributing to the overall success of the pilot.

During the 2002-03 academic year, a team of ten engineering students within MTU's Wireless Communication Enterprise (WCE) developed a comprehensive curriculum for secondary students in the areas of basic electrical engineering, wireless communication, and photonics. The curriculum was designed specifically for the intensive one-week summer workshop, but was also constructed for use in high schools during the coming academic year. The materials created by the WCE team comprised at least one semester of academic instruction, and were delivered on CD for ease of use and reproduction along with supporting materials such as experimental components and instrumentation for use in the high school classroom during the coming academic year. Selected elements of the overall curricula were chosen for use in the one-week summer workshop. Table I shows a list of topics included in the one-week mini-enterprise workshop experience. The workshop was conducted by three undergraduate student members of the Wireless Communication Enterprise. The elements shown below included short (10-minute) lectures followed by hands-on experiments. The workshop culminated in two major projects at the end of the week. High energy interaction among instructors and students was the norm throughout each day.

Table I – WCE Tech PrEP Pilot Workshop

Day 1	Day 2	Day 3	Day 4	Day 5
<ul style="list-style-type: none"> • Introduction • Ice-breakers • Lab Safety • Basic Electronics • Conductors • Ohm's Law • Alternating Current • Circuit Theory • Electronic Circuit Elements • Voltage and Current Sources • Light Bulbs in Series/Parallel • Circuit Analysis Techniques 	<ul style="list-style-type: none"> • Intro to Waves • Analog Signals • Oscilloscopes • Digital Signals • A/D Converters • Number Systems • Logic Gates • Memory Devices 	<ul style="list-style-type: none"> • Recap fundamentals of electronics • Wireless Technology • Modulation • Advanced Electronics Lab tour • GSM Networks • Electromagnetic Theory • Polarization of Waves • IC fabrication 	<ul style="list-style-type: none"> • Intro to Light • Light Sources • Electromagnetics • Photons • More Light Sources • Photovoltaics • Intro to Lasers • Lenses • Optical Systems • Fiber Optics • Relay Station 	<ul style="list-style-type: none"> • Build AM Receiver • Build Laser Communicator

The Wireless Communication Enterprise precollege exploration was offered to academically talented participants of diverse geographic and ethnic backgrounds. Being a pilot program,

distribution of applications was purposely limited to five areas, DAPCEP (Detroit Area PreCollege Engineering Programs), GRAPCEP (Grand Rapids Area PreCollege Engineering Programs), and the Wayne-Westland, Houghton-Portage Township, and Baraga/L'Anse area school systems. The average GPA of the students selected to participate was 3.49 on four point scale and the gender was balanced. Four African American students and one Hispanic student came from urban areas, four Caucasian students and one Hispanic student came from suburban areas, and one Native American student came from a rural area. Six of the eleven students were female (55%). Fourteen students were invited to participate in the program, however, due to last minute conflicts and emergencies, three of these participants were unable to attend.

During the workshop the students strengthened their understanding and application of mathematics skills and technology by:

- Exploring different areas of wireless and optical communication
- Investigating how electrical circuits work and learning how to analyze, build, and test them
- Building, testing, and assessing a laser communicator link
- Learning to interpret electrical schematics and build electrical components
- Designing and testing their own radio frequency communication link
- Touring MTU's high-tech electrical labs and measuring local radio and TV stations on our spectrum analyzer
- Learning practical electrical engineering design strategies
- "Solving the mystery" of electromagnetic wave propagation
- Being introduced to the world of digital electronics and its role in new technologies as well as optical physics and its new role in high-tech equipment
- Learning about the wide array of careers in wireless and optical communication
- Hearing how this career can directly impact the quality of people's lives
- Improving and practicing team skills and applying knowledge about wireless and optical communication during group projects
- Learning how to succeed in electrical, wireless, and optical communication undergraduate programs
- Becoming acquainted with college life and exploring extracurricular activities on campus
- Meeting other young people with diverse backgrounds and similar interests

In addition, educators or curriculum specialists from informal science education organizations participated in the workshop. These professional educators worked closely with the undergraduate students and the WCE faculty advisor. Armed with the precollege Wireless Communication Enterprise curriculum and full experimental sets of supplies and equipment they are now able to duplicate various components of the curriculum in classrooms throughout the region. In 2003 alone, the program had the potential to reach 6,100 students in the Grand Rapids school system. This particular aspect of the program is most valuable as the summer component creates a "living laboratory" for visiting educators. By participating and observing in the precollege summer program and then returning with the tools and supplies needed to replicate the experience in their classroom, educators are able to disseminate the material for the program.

IV. Lessons Learned

One of the most interesting results of the pilot program was that the educational experience for the undergraduate WCE students who participated in the curriculum development was as significant as that for the participating pre-college students. The WCE students were constrained to translate state-of-the-art technology and concepts into curriculum appropriate for the high school level while meeting the challenge of starting with basic concepts in electrical engineering leading up to the completion of successful hands-on projects in wireless and photonics technology. Additionally, it was clear from the day-to-day interaction of the Tech PrEP instructors (WCE students) with the SYP students, that energy and enthusiasm flows both ways. The MTU students involved throughout the program are richer because of the experience.

Students, instructors, and educators were asked to provide substantial evaluative feedback. Some of the highlights from the student participant evaluations from 2003 include:

- 100% of the students indicated they had many experiences (63.6%) or some experience (36.4%) learning about leading technologies during the program
- All but one student remarked that they learned about possible careers in this area.
- Almost 75% of the students were “very inspired” to learn more about this topic as a result of their participation
- All students remarked that the instructors (mentors) encouraged questions, were approachable and easy to talk to, and managed time well.

Written comments included:

- “I enjoyed learning about electronics, which I was previously unfamiliar with. It was good that I was able to put what I learned into practice with kits and activities.”
- “The most rewarding activities were the hands-on kits. However, they would have been worthless without the lectures.”
- “[The best part of the exploration was] building a radio because it took most of the day and it was hands-on.”

In addition, these students will be included in MTU’s Youth Programs on-going efficacy study of all students attending the programs since 1995. These mailed surveys seek to gauge the effectiveness and long-term impact in the Program Factors:

- Content: The extent to which the program(s) successfully transferred information and skills to students. Variables include: teacher abilities, facilities conducive to learning, difficulty of the curriculum, etc.
- Comfort: The extent to which the program provided students with a sense of awareness of, familiarity with, and comfort with college life (e.g., course material, peers, instructors, residential hall life, campus facilities).
- Career: The extent to which respondents perceived the program(s) as having an impact on their career choice.
- College: The effect of the program(s) on respondents’ decisions to attend college in general and, more specifically, to attend a specific college or university.
- MTU: An index of how much the program(s) introduced and familiarized participants with various attributes of Michigan Tech in particular.

MTU Youth Programs and the Engineering Enterprise organizers are already planning several other precollege Enterprise workshops for the summer of 2005. Successful program components from Tech PrEP are being documented (based on the results of the participant feedback from administrators/faculty/teachers/staff/counselors/students compiled by MTU staff). Based on the mailed surveys described above, we will enrich the “comfort” program factor. As the survey suggested it was this factor which was the most influential program component for the minority students attending the programs. We intend to augment this portion of the programming so that the students leave campus with a sense of awareness of what college life will be like, including increased interactions with undergraduate mentors, more introduction to course requirements, etc.

We are also enlarging the program to include other Enterprise teams, such as Robotic Systems and Pavement Design, Materials and Construction. Long term goals include developing four week experiences which combine the hand-on/minds-on model of the Enterprise with pre-calculus mathematics courses (for college credit) as well as communication and study skills enhancement. Funding is being sought from corporations, private and corporate foundations, as well as state and federal agencies.

The collaboration between MTU Youth Programs and the Wireless Communication Enterprise has been very successful. Both partners are very pleased with the relationship and plan to go forward with plans for future years. Partnerships with educational organizations which are intended to help recruit students are evaluated regularly. MTU will continue to work with school districts and informal science educators to monitor how the program curriculum and equipment initiative is progressing.

V. Conclusion

Michigan Technological University is pleased with the results of the initial Tech PrEP program experience and it's ability to successfully provide pre-college students the opportunity to meet and interact with University instructors, undergraduate and graduate students, and other students from diverse backgrounds. Precollege students are not only introduced to undergraduate role models who encourage and support their interests in continuing their education sciences and engineering at the University level, but many friendships are made that will last for years to come. We believe these students leave Michigan Tech better prepared to make educated decisions about their future curriculum and career paths. As always, our programs are continually evaluated as we strive to make improvements for the future. We look forward to continuing partnerships to introduce young people to a world of educational opportunities.

Bibliographic Information

¹ Engineering in the K-12 Classroom; An Analysis of Current Practices & Guidelines for the Future, Josh Douglas, Eric Iversen, and Chitra Kalyandurg *November, 2004* The American Society for Engineering Education.

²Summary of Reports for the past 5 years from Industrial Advisory Boards of the University, College of Engineering and each Engineering Department at MTU. Prepared Fall, 1999.

³*Manufacturing Education Plan: Industry Identifies Competency Gaps Among Newly Hired Engineering Graduates.* Published by the Society of Manufacturing Engineers and the SME Education Foundation (1997).

The Enterprise Program at Michigan Tech University: Results and Assessment to Date. Mark R. Plichta, Mary Raber. Proceedings of the 2003 ASEE Conference (2003).

Biographical Information

JOHN B. LEHMAN has served as the Director of Youth Programs since 1998. He holds a Bachelors of Arts from Adrian College and a Masters degree in writing pedagogy from Eastern Michigan University. His present duties also include resource development for minority and women's programming at the university.

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