

Outreach to Prospective Engineering Students: Assessing Michigan Technological University's YES! Expo*

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According to the National Science Board, we must increase interest in STEM education and careers to maintain our position as a global scientific and technical leader. The number of students indicating interest in engineering, engineering related, and computer related fields on their ACT exams has plummeted. Ethnic and gender diversity in engineering continues to be low. In a response to this declining enrollment and interest, Michigan Technological University annually brings together industry, institutions of higher education, governments, and the K-12 education system to offer the annual YES! (Youth Engineering and Science) Expo, a career awareness event at Ford Field in Detroit, Michigan for 15,000 students and 1,500 teachers. Using pre- and post-event surveys to assess the impact of the event, results indicate that the YES! Expo has a significant positive effect on students' educational and career goals.

Keywords: engineering education; self-efficacy; diversity; career goals

INTRODUCTION

OUR NATION faces a serious crisis of youth losing interest in Science, Technology, Engineering, and Math (STEM). Michigan and other technology and manufacturing centers have already suffered significantly from this decline. Additionally, women and minorities are vastly under-represented in STEM fields. Until these trends are reversed, the nation will struggle to develop a highly skilled and knowledgeable workforce for the 21st century who are able to sustain the nation's position as a global leader in science and engineering. The Youth Engineering and Science (YES!) Expo was designed by Michigan Technological University to address this problem. YES! Expo aims to generate interest and enthusiasm in engineering, science and technology among Michigan's youth, and to encourage these youth to attend engineering and science programs at institutions of higher education and ultimately pursue employment with Michigan corporations.

PRESENTATION OF PROBLEM

Without a skilled technical workforce and the innovations and new products they create, our nation's economy will be in jeopardy, leading to a lower standard of living. The scientific and technical foundations of our nation are eroding at a time when many other countries report growth in these areas. The low-wage culture in many of these countries adds to the problem by creating a competitive advantage over the United States. As a nation we must urgently realize that in order to maintain our position as a global scientific and technical leader, we must increase interest in STEM education and careers [1].

As we entered the first decade of a new century, the state of Michigan mirrored national trends, seeing the number of students entering STEM related post-secondary education plummet. Over an eight year period, students indicating interest in engineering, engineering related, and computer related fields on their ACT exams fell by about 52% percent (see Fig. 1).

Ethnic diversity in engineering continues to be low even though the overall number of minorities in the general workforce is increasing. White males

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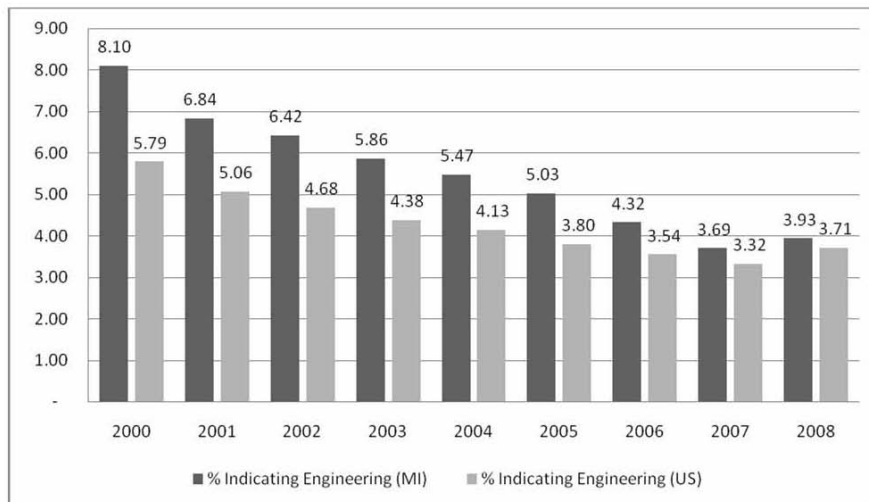


Fig. 1. Michigan vs. nation in percentage ACT test takers indicating interest in engineering.

make up nearly two-thirds of all U.S. undergraduate and graduate engineering students, while minorities earn only about 12% of the engineering degrees awarded in the U.S. [3]. Females are also underrepresented in university engineering programs (20%) and in the high-tech workplace (10%) [4]. So why aren't females entering, and remaining in, the science and technology workforce? Several possible answers may include family considerations and workplace locations that are not attractive to women, business climate issues, or academic preparation. Others have suggested a lack of female role models and mentors. Despite this bleak picture, workplace diversity is critical in order for engineers to find solutions to societal problems as the minority population in the U.S. increases. If our ever-increasing diverse population is represented only by a traditional white male perspective, and they can't find solutions to problems facing our society, our nation will indeed lose its technical leadership in the global economy.

SOLUTION

In a response to this declining enrollment and interest, Michigan Technological University brought together industry, institutions of higher education, governments, and the K-12 education system to offer the first annual YES! (Youth Engineering and Science) Expo, a career awareness event at Ford Field in Detroit for 15,000 students and 1,500 teachers annually. From the outset, the mission of the YES! Expo was to inspire middle and high school students to pursue education and careers in engineering and science. The immediate goal of the event is that students leave having experienced that 'Ah Ha!' or 'Gee Whiz' eureka-type moment that initiates career inquiry.

YES! Expo tackles these issues head-on by

promoting and encouraging students in grades six through twelve, primarily attending Detroit and southeastern Michigan schools, to choose exciting and rewarding careers in engineering and science. The YES! Expo contributes to Michigan's higher educational system, which supplies companies with productive, innovative engineers and scientists. The ability to fill engineering and science jobs contributes to the success of Michigan's economy and the many major manufacturing companies that choose to be headquartered here.

YES! Expo was first held in 2004 at Crisler Arena at the University of Michigan in Ann Arbor, attracting 5,000 students. In 2005, the event was moved to Ford Field in Detroit in order to facilitate attendance by Detroit area schools. The large venue of Ford Field allowed YES! Expo to grow sufficiently to host 13,000 students in 2005, and 15,000 students in 2006 and 2007. We estimate that one teacher was present for every 10 students. Of approximately 25 non-sporting events held annually at Ford Field, the YES! Expo is the largest.

YES! Expo consists of two elements: (1) a tradeshow-style format where corporations, universities and other organizations provide and staff exhibits that are intended to expose students to exciting technology-based careers and educational programs; and (2) provides a live/multimedia educational program highlighting technology, education, and careers in a fun and entertaining way. The show lets students know there's lots of 'cool' in technology and the people behind technology, and that not long ago those engineers and scientists were just like them. A Teacher Resource Center was also introduced in 2006 to provide teachers with resources for their own professional development as well as activities related to engineering and science that they could take back to their classrooms.

YES! Expo is a unique collaboration of more than 60 companies, 25 universities/colleges, the State of Michigan, professional societies, youth and community organizations. To our knowledge, an event involving so many corporations and universities—all directed at addressing serious future shortfalls in the state's high-tech job base—has never before been presented.

Sponsoring companies have the opportunity to secure exhibit space at YES! Expo so that students can become familiar with the technology/science careers that they offer. Corporate sponsorships and grants allow students to attend free. On entering Ford Field, students experience a stadium full of exciting engineering and science exhibits from corporations and they have the opportunity to talk with real engineers and scientists. Other display space is hosted by universities, professional societies, youth organizations, state organizations and business development organizations from throughout Michigan. Universities provide exhibits showing unique and dynamic educational pathways that lead to technology-based careers and demonstrate to students what they will be doing in college as they study engineering and science. Special exhibits such as the New Detroit Science Center, NASA, and FIRST Robotics provide hands-on experiences and demonstrations that create excitement and wonder about the world of science and engineering.

The cornerstone of YES! Expo is a high-energy, professionally produced educational show. This live/multimedia theatre-in-the-round program, held on the playing field, strives to make engineering and science relevant and appealing to students by highlighting the people behind the technologies that students appreciate. It demonstrates that these people were once just like them, and that Michigan youth too can be part of the technologies that create the future. It has historically been our goal to secure a keynote speaker or performer with a proven track record of relating science to youth; in the past, guests have included Paul Zaloom, star of HBO's *Beakman's World*; National Public Radio personality Bill Hammack, known as the Engineering Guy; retired NASA astronaut Dr. Jerry Linenger, Bill Nye, the Science Guy, and Steve Squires, principal scientist of the Mars Rover project.

Entering its fifth year, the YES! Expo uses the entirety of Ford Field (home of the Detroit Lions). Students venture through the concourses, in the stands, and on the field itself, talking, doing, and learning with role model engineers, scientists, mathematicians, and technologists. It is, more or less, a one day museum of STEM related career discovery. Since 2004, over 48,000 high school and middle school students and over 5,000 secondary educators have attended, all free of charge.

Coordinating such a large event is no small task, particularly for Michigan Tech, the initiating, organizing, and sponsoring institution, which is located 550 miles (or a 10 hour drive) from down-

town Detroit. To help with the day to day logistics in Detroit, we partner with Innovation Emporium, Inc. an educational event planning firm based in Detroit. Innovation Emporium, Inc. has led the marketing and communications with school systems, individual educators, and the Boy Scouts and Girl Scouts. With their assistance, in collaboration with Michigan Tech's Admissions, academic departments, and educational outreach departments, the YES! Expo is able to recruit and register teachers and students for the event.

Michigan Tech considers its hosting of the Michigan YES! Expo to be an important public service. However, this is definitely not a Michigan Tech-only event; rather, Michigan Tech invites participation from all the universities and colleges throughout the state that offer educational programs in science, engineering and technology fields.

Funding for the event is also a collaborative effort. Corporations participate financially by securing their exhibit space through a donation. Other support comes from donations from the Herbert H. and Grace A. Dow Foundation, as well as many other private foundations, corporations and organizations. Most of these are contributing to the event on an annual basis, and other new organizations continue to step forward with their support. We realize that the future of the event is dependent on our receiving a broader base of funding from private foundations. The DeVlieg Foundation has been a YES! Expo supporter for the last two years, and The Carls Foundation has joined us this year with a significant contribution. In light of the enthusiasm for supporting YES! Expo, we do not foresee a problem in meeting this challenge; we plan on hosting the event on an annual basis. In fact, many of our 2007 sponsors have committed to 2008 funding as well.

In addition to corporate and university displays, professional societies, youth outreach service foundations, state entities, and business development organizations from throughout the state participate as exhibitors. Special representation comes from the New Detroit Science Center and the Cranbrook Institute of Science, who provide interactive experiences and demonstrations that create excitement and wonder about the world of science and engineering. FIRST Robotics and Habitat for Humanity lead experiential programming during YES! Expo. These exhibitors are not required to donate to the event to participate.

For the Michigan Tech exhibit, a team of ten staff, faculty, department chairs, and students work together for six months prior to each year's event to design and plan our representation at YES! Expo. This year, the Michigan Tech exhibit showcased sixteen different aspects of the University, all hosted primarily by students. It is the philosophy of this planning team that our best outreach is done by our experts, our students. Previous Michigan Tech interactive exhibits included:

- a physics related cardiovascular interactive display where plasma screens displayed biometric feedback of hearty Michigan Tech students putting their bodies through all sorts of physical challenges on a stationary bike;
- a student run organization displayed a recently built nano-satellite that was evaluated by NASA. Participants were able to manipulate the satellite seeing how thrusters and gyroscopes keep the device positioned in orbit;
- a discovery-based participatory exercise in ground water remediation was hosted by the Engineers Without Borders group, civil and environmental engineering students who travel to third world countries helping to improve clean water availability to various towns and villages.

All of the Michigan Tech exhibits involve students, faculty, and university researchers in the planning, building, and hosting. Exhibits are also advised by faculty members of our Department of Education for appropriateness of information for middle and high school students.

ASSESSMENT

To determine the effects of YES! Expo attendance on educational and career goals, student attendees were encouraged to complete an online survey before and after the 2007 YES! Expo. The online survey was a follow-up to paper and pencil surveys given to a smaller sample of attendees of the 2006 YES! Expo. The findings reported below, from the 2007 assessment, both supported and clarified findings associated with the smaller 2006 survey.

Surveys were designed to assess student educational and career attitudes, perceptions of the impact of YES! Expo on their career goals, and educational preparedness of students for STEM-related higher education. Students were informed of the surveys through their teachers, who were sent emails and mailed flyers encouraging them to announce the survey to their students. In true spirit of the collaborative efforts of many industries in sponsoring the student's tickets for the show, the assessment was a collaborative effort of the Dow Corning Foundation and Michigan Tech's Department of Cognitive and Learning Sciences. The assessment results presented below focus on the impact of the event on students' reported educational and career goals, although we also examined K-12 teachers' needs and experiences in providing quality educational experiences for students in sciences, math and engineering to meet the goals of Dow Corning Foundation's education initiative.

POST EVENT SURVEY RESPONSES

Results presented below were from the students ($n = 565$) who attended the event, completed the

post-event survey, and reported Caucasian or African American ethnicity. While a larger sample of post-event survey respondents exists ($n = 773$), the main focus of this paper is to examine: (1) differential reactions across gender and ethnicity to the YES! Expo, and (2) differential impacts of event attendance across gender or ethnicity. While students of other ethnic backgrounds participated in the Expo, and completed the survey, their small numbers warranted exclusion from this analysis due to concerns regarding generalizability (over 85% of total respondents reported African American or Caucasian ethnicity; the next largest ethnic group, Pacific or Asian American, accounted for fewer than 3% of all respondents). The resulting sample consisted of 45.8% female respondents ($n = 259$) and 51.1% of respondents who reported African American ethnicity ($n = 275$).

The sample size, which is approximately 5% of all attendees (773 of approximately 15,000 attendees), is lower than would be expected from a traditional survey invitation that is targeted directly at potential respondents (response rates vary, but 20% is considered good). It is likely that our method of solicitation, which was indirect, negatively impacted our response rate. Our invitations to participate were not directly targeted at potential respondents, as the only contact information we had prior to the event was from teachers who ordered tickets for their students to attend. While the small response rate may lead to questionable generalization, the fact that the 2007 survey replicated findings from a similar 2006 survey suggests that the results are reliable. Furthermore, respondents represented a wide variety of schools from communities with varying demographics.

Using 4-point agreement scales (1 = strongly disagree, 4 = strongly agree), students responded to a series of statements designed to gauge their opinions about the impact of their participation in the YES! Expo. Table 1 lists the statements, followed by the percent of students endorsing each level of agreement. A majority of attendees reported positive effects of attendance as measured by these agreement scales. The statement receiving the highest endorsement, with over 90% of students agreeing or strongly agreeing, was that participation in the YES! Expo made them think more about continuing their education after high school.

A multivariate ANOVA, treating gender and ethnicity as independent variables, was conducted for each of the participation items reported in Table 1. A main effect of ethnicity existed [$F(7, 528) = 10.047, p < 0.000$]. A main effect of gender did not exist [$F(7, 528) = 1.521, p = 0.158$]. Additionally, the interaction between gender and ethnicity was not significant [$F(7, 528) = 1.040, p = 0.402$].

Follow-up between subjects' tests examining the main effect of ethnicity revealed significantly

Table 1. Effects of YES! Expo on self-reported career and educational goals

Statement: My participation in the YES! Expo . . .	Strongly disagree	Disagree	Agree	Strongly agree
led me to a better understanding of my own career goals	4.1%	14.1%	37.5%	44.2%
made me think more about continuing my education after graduating from high school	2.6%	5.0%	28.1%	64.3%
increased my interest in studying engineering in college	6.9%	18.2%	41.6%	33.3%
increased my interest in studying science in college	5.9%	17.5%	45.4%	31.2%
caused me to decide to take different classes in high school than I had planned to take	10.2%	30.5%	32.3%	27.0%
made me decide to work harder in school	4.1%	13.6%	34.2%	48.1%
gave me a much better understanding of what engineers do	3.2%	8.6%	41.8%	46.5%

higher agreement ratings by African American students to the items displayed in Fig. 2.

PRE- AND POST-EVENT COMPARISONS

From the original sample of 773 students who attended the 2007 YES! Expo and completed the post-event survey, we were able to match both the pre- and post-surveys from 450 students (the remaining students did not choose to provide identifying information on one or both surveys to allow a pre- and post-survey match). Thus, we conducted a series of within-subjects analyses on responses to items before and after event attendance to determine the impact of the YES! Expo on student educational and career goals.

Of the 450 students who took both the pre and post-event surveys, 41.5% were female; 44.8% were middle school students (6th–8th grade) and 47.1% high school (the remaining were below 6th grade). A majority of respondents (61.5%) reported being Caucasian, with 31.9% reporting African Ameri-

can ethnicity. Variations in reported n exist across analyses due to missing data points, as some students did not complete the entire survey.

A series of paired-samples t -tests were conducted examining differences in self-reports before and after attendance at the YES! Expo. In addition, to gauge the magnitude of the effect of the YES! Expo, a modified calculation of Cohen's d was used. The modified statistic corrects for the possibility of overestimation of the effect size due to the use of repeated measures [5]. While effect size can range from a -4.0 to a $+4.0$ for Cohen's d , behavioral interventions rarely have an effect size greater than $1/-1$. For example, analyses of treatment effectiveness have demonstrated an average effect size of about 0.45 within the program evaluation paradigm of the behavioral sciences [6, 7]. Thus, Cohen defined effect sizes as small when $d = 0.2$, medium for a value of $d = 0.5$, and large effects when $d = 0.8$ or more [8]. The modified Cohen's d is reported for each comparison below as a measure of the meaningfulness of the statistically significant differences.

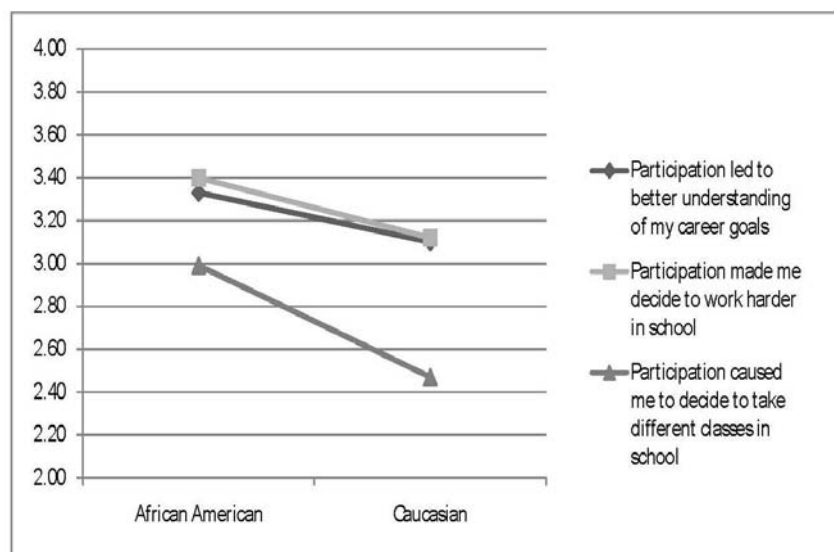


Fig. 2. Mean agreement to statements by ethnicity (each mean rating is significantly different between ethnic groups at $p = 0.05$).

The reported importance of pursuing a career in science/engineering, as measured on a 10-point scale (1 = not at all important, 10 = very important), significantly increased after attending the Expo [$t(438) = -4.016, p < 0.000$] from a pre-event mean of 6.98 to a post-event mean of 7.36. Despite this statistically significant difference, the magnitude of the effect of the Expo on students' answers to this item was small ($d = 0.15$). Similarly, the attendee's response to 'What is the chance of majoring in engineering in college?', measured on a 10-point scale (1 = no chance, 10 = definitely), significantly increased [$t(438) = -7.632, p < 0.000$] from pre-event ($m = 5.66$) to post-event ($m = 6.43$). The effect size of the YES! Expo on this item was somewhat larger, with $d = 0.28$.

Several items on the pre and post-event surveys were adapted from the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) instrument [9]. The LAESE was designed and validated for use with undergraduate women studying engineering by the NSF-funded Assessing Women in Engineering Project, or AWE (NSF HRD 0120642). Items in the original LAESE address numerous aspects of engineering self-efficacy, a concept that is an important contributor to success in STEM career education. Engineering self-efficacy is a measure of one's perception of their ability to be successful in his/her engineering education and career. Numerous studies examining the role of self-efficacy in students' pursuit of engineering careers have generally found a positive correlation between self-efficacy and academic achievement in engineering disciplines. For example, it has been found that one's self-efficacy beliefs influence effort, persistence, and perseverance in goal attainment [10–12]. Similar findings reveal that high self-efficacy beliefs influence the academic persistence necessary to maintain high academic achievement amongst college students enrolled in science and engineering courses [13, 14].

The modified version of the LAESE used in this research was designed to be applicable to both male and female middle and high school students. Thus, items from the original LAESE regarding college courses, academic advisors, and other items relevant only to college students were not used. The modified instrument contained 15 agree/disagree statements on which respondents rated their level of agreement using a 7-point Likert-type scale (0 = strongly disagree, 6 = strongly agree). Example statements on the modified self-efficacy instrument were: *I can complete any engineering degree at college*; *I can complete the physics requirements for most engineering majors*; and *A degree in engineering will allow me to get a job where I can use my talents and creativity*. Self-efficacy scores were computed as the mean response across these 15 items, as is the norm in self-efficacy research. Thus, higher scores reflect higher self efficacy beliefs.

Students' self-efficacy scores significantly increased from a pre-event mean of 4.39 ($s =$

0.94) to a mean of 4.95 ($s = 1.01$) after attendance at the YES! Expo [$t(409) = 12.28, p < 0.000$]. The magnitude of the effect of the YES! Expo on engineering self-efficacy was $d = 0.58$, a relatively large effect size in the behavioral sciences. Using a mixed-model analysis, gender and ethnicity were not statistically significant factors within the pre- and post-event self-efficacy score differences (i.e., attendance at the YES! Expo did not differentially affect males and females, or students of different ethnicity).

ENROLLMENT OUTCOMES

While one never should point to a silver bullet, evidence supports that the YES! Expo has contributed to enrollment successes at Michigan Tech. By revisiting the ACT indication of interest and contrasting that with the number of Michigan based freshmen enrolling at Michigan Tech for engineering, one sees that Michigan Tech has been able to maintain its enrollment, despite significant shrinkage of market (see Fig. 3).

An alternative method of examining the impact of the YES! Expo is in terms of marketing science and engineering programs to students. While the survey data reported earlier was generated from the 2007 YES! Expo, the data reported next was generated from the 2006 YES! Expo. We examined the inquiry rate from attendees at the 2006 Expo who reported a graduation year of 2008 (they were juniors when they visited the YES! Expo) to allow a comparison to fall 2008 admission inquiries (2007 addresses from juniors in high school would currently be inquiring to universities, and we are in the process of tracking those as well). Of 9,000 viable addresses obtained from the 2006 YES! Expo, 798 indicated a graduation year of 2008. Some form of inquiry to Michigan Tech was later received from 172 (22%) of these students, as they began gathering information and applying to colleges. Compared with a search mailing (1–4% rate of inquiry), this is a phenomenal return. Other than attending the event, these students were not prompted to contact us in connection with the YES! Expo. Furthermore, we compared the gender and ethnicity of all of Michigan Tech's fall 2008 inquiries with a graduation year of 2008 with those generated from the 172 student inquirers who had attended the YES! Expo. Overall, 36% of all inquires came from females, whereas females accounted for 43% of the YES! Expo-generated inquires. Some 20% of all inquires to Michigan Tech came from minority students, while students reporting minority ethnicity accounted for nearly half of those generated from the YES! Expo (47%). While actual matriculation data are not yet available, the characteristics of inquiring students provides strong evidence that the YES! Expo can directly impact the lack of gender and ethnic diversity within science and engineering

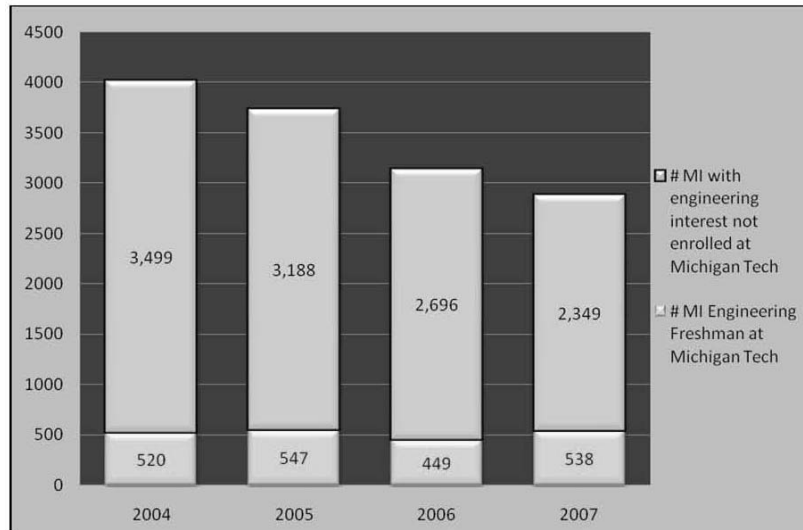


Fig. 3. Number of Michigan ACT Test takers indicating interest in engineering.

professions. Continued exploration into response rates will occur as organizers plan mailings to upcoming graduating students prompting them to consider applying to a STEM based programs at Michigan Tech.

CONCLUSION

The YES! Expo is a unique approach in which many stakeholders come together in a collaborative outreach to encourage the exploration of STEM careers by youth. At the heart of its success is providing students with the opportunity to meet and interact with role model engineers, scientists, mathematicians, and technologists. These role models and the activities and demonstrations they provide tend to increase the participants' self-efficacy, their perception in their ability to be successful in engineering education and careers according to the results of our assessment. Perhaps more importantly, participation in the YES! Expo may have an

even larger impact on African American students, who are one of several underrepresented groups within STEM fields. The value of this event will only truly be known through a longitudinal investigation in which attendees and matched non-attendees are tracked as they graduate from high school, major in STEM fields, and are persistent through college graduation and into their career. A longitudinal investigation of this nature would be extremely labor and cost intensive, and would require cooperation among all of Michigan's colleges and universities. We hope to secure grant funding to engage in such research, and have already obtained the commitment of collaboration by the members of the Michigan Directors of Admission professional group. While a large hurdle has been overcome in getting admissions directors to agree to share their enrollment data, the reality of the project is contingent upon funding and identifying a reliable mechanism for 'tracking' the students. In the mean time, Michigan Tech will continue to host the YES! Expo as well as assess the program's effects and outcomes.

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Peter J. Cattellino earned his BS degree from Michigan Technological University and is the Director and co-founder of the YES! Expo. He is responsible for all aspects of this premier career awareness event including sponsor and school/student recruitment, budgeting, logistics, and communications and promotion. He has previously managed environmental research projects and directed university development and outreach efforts.