AC 2008-831: MANUFACTURING A WORKFORCE

Stan Komacek, California University of Pennsylvania

Stan Komacek earned a BS from California University of Pennsylvania, MEd from Miami University, and EdD from West Virginia University. He served as the Project Director for the PA State System of Higher Education in PA's Nanofabrication Manufacturing Technology Partnership and for the PA Governor's Institute for Technology Education. A Professor of Technology Education and Chair of the Department of Applied Engineering and Technology at California University of PA, Dr. Komacek is currently PI and Project Director for the NSF ATE Advanced Manufacturing in PA Project.

Carol Adukaitis, PA State System of Higher Education

Carol Adukaitis received a BS degree from the University of Delaware, an MS from Bloomsburg University, and an EdD from Temple University. She has been a faculty member at Reading area Community College, Temple University, and adjunct at Montgomery County Community College, and has held the position as Industry/Curriculum Coordinator at several Career and Technology Centers. She has served as a PA Department of Education Evaluator for ten Governors Institutes and was a consultant for NOCTI Assessment Development and Test Preparation for the Massachusetts Department of Education. She is currently employed by the PA State System of Higher Education (PASSHE) on a Department of Community and Economic Development (DCED) funded position as statewide Program Manager for 2+2+2 Workforce Leadership Grants. Dr. Adukaitis is co-PI on an NSF-ATE Advanced Manufacturing Project in PA.

Manufacturing a Workforce for the Future

Abstract
This paper will describe the Pennsylvania State System of Higher Education's (PASSHE) three-year $810,000 grant from the National Science Foundation's Advanced Technological Education (NSF-ATE) program to develop a full pipeline of students from grade 9 through 16 focused on careers in advanced manufacturing technology to address Pennsylvania's critical manufacturing shortages. The NSF-ATE project focuses on recruitment and retention of students from middle school through high school to post-secondary education by marketing, recruitment, mentoring and updating manufacturing curriculum. Females and minorities receive special outreach and mentoring.

The project focuses on two PA regions: Allegheny and Washington Counties, (southwestern PA) and Lancaster County (south-central PA). The southwestern PA educational partners include California University of PA, Community College of Allegheny County, Steel Center Career and Technology High School, and five of its sending school districts. The south-central PA educational partners include Millersville University, Harrisburg Area Community College, Lancaster County Career and Technology High School, and five of its sending school districts.

Manufacturing Workforce Shortage

The impetus for the 2006 NSF-ATE proposal was continued reporting by PA manufacturers experiencing a shortage of advanced manufacturing workers. Manufacturing remains vital to Pennsylvania's economy accounting for 12% of the employment and more than 20% of wages paid. These workforce shortages threaten PA's manufacturing base. One explanation for the shortage is rapid technological change from a traditional labor-intensive industry to a highly technologically skilled advanced manufacturing one. A study commissioned in 2004 of the dynamics of PA manufacturing, titled *Manufacturing Pennsylvania's Future*[1] stated that 'manufacturing remains an essential element of PA's economy, contributing $64 billion annually to the Gross State Product. This is by far the largest share of any sector.' Governor Rendell's Manufacturing Work Group published additional findings in which business leaders reported that innovation and workforce investment were among the seven most important challenges facing PA manufacturing. The findings of a 2005 NAM Skills Gap[2] reinforced previous manufacturing labor shortage reports by stating … '90 percent of respondents indicated a moderate to severe shortage of qualified skilled production employees. These skills shortages are having a widespread impact on manufacturers' abilities to achieve production levels, increase productivity, and meet customer demand.'

An additional impetus for the NSF-ATE proposal was reporting in the 2003 *National Coalition for Advanced Manufacturing*[3] that recommended outreach efforts begin at the middle school. Delaying these efforts may preclude students from the required academic courses and allows time for the outdated stereotypes to take hold, eliminating manufacturing as a career choice. Today's advanced manufacturing employees need to be educated in STEM (science, technology, engineering, and math).

Student perceptions of advanced manufacturing careers also play a role in the workforce shortage. In 2005, Harry Moser[4] reported to the Advanced Manufacturing Career Collaborative, a southwestern PA education / business group dedicated to enhancing the manufacturing workforce, that a survey of several thousand Pittsburgh-area high school students revealed not one student chose 'manufacturing' as a career goal. The majority of our youth perceive manufacturing jobs as dirty, dangerous assembly lines, requiring low skill, and offering poor pay.

Females and minority students are receiving special attention because PA's statewide enrollment of these populations in high school and post-high school Trade and Industrial Education programs are low. According to the PDE Trade and Industrial Education statistics[5], females comprise 23.7% of total student enrollments at the high school level and 29.8% of post-high school enrollments, while minority students comprise 12% of high school level enrollments. In addition, only 1.8% of PA's Trade and Industrial Education teachers are female. At the University partners in this project, female and minority enrollments in the relevant degree programs are lower than the statewide Trade and Industrial Education percentages. Millersville University's programs have 10% females and 4% minorities, while California University has 5% females and less than one percent minorities.

This paper will address these two major challenges in advanced manufacturing education: first, the poor image and resulting lack of interest in manufacturing as a career, and, second, recruit more students, particularly females and minorities into the manufacturing workforce. Activities such as marketing, updating manufacturing curriculum, teacher professional development, and in-school student activities that create 'buzz' or excitement at middle, high school and post-secondary education that begin to change the misconceptions about PA's advanced manufacturing industries will be presented. Additionally, state and national funding sources that have supported this project as it addresses the future need for a technologically skilled workforce will be identified.

Current Perceptions about Advanced Manufacturing Careers

When manufacturing was done 'in the village' by craftsman and metal workers, finished products were simple and everyone knew how things were made. With decades of diversification of labor and increasing access to global transportation, product parts are now made all over the world and assembled in factories, which are equally dispersed. These products/parts are 'invisible' and the people who currently manufacture them are 'invisible'. The premise of this project is students are 'clueless' about manufacturing and manufacturing careers: what it involves, how parts are manufactured, what is manufactured in their own backyards, and the skills required for manufacturing them.

A Spring 2007 NSF-ATE survey asked middle school students involved in the project to name their Top Three Career Choices. The project evaluators categorized the choices using the 16 federal career clusters[6]. **Table 1 Students' Choices & Parents' Recommendations** reveals that student responses for 'Manufacturing' careers were very low. However, an additional career category, "Recreation / Sports" had to be added to the list of 16 career clusters because of the overwhelming number of students responses who named careers in professional sports and recreation industries.

A similar survey was conducted of the Parents and Educators of the middle school students. Parents and Educators were asked to name the Top Three Career Fields that they recommend to the middle school students. **Table 1** reveals that 'Manufacturing' was the least-recommended career path chosen by parents. Parents' recommendations included careers in 'Education', 'Health Sciences' and 'STEM'.

Table 1. Spring 2007 survey results for Students and Parents

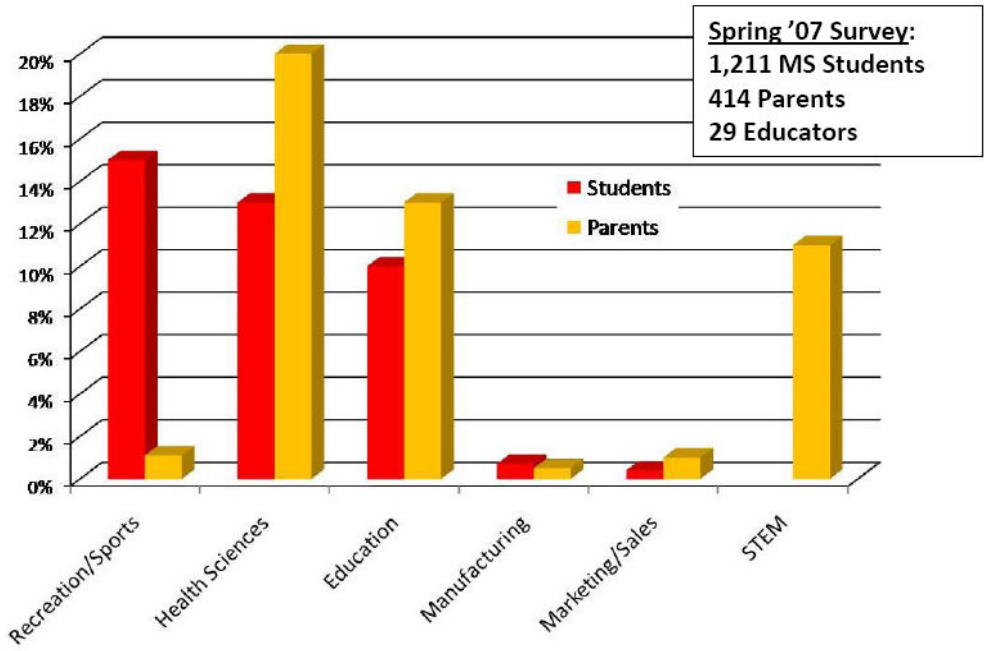
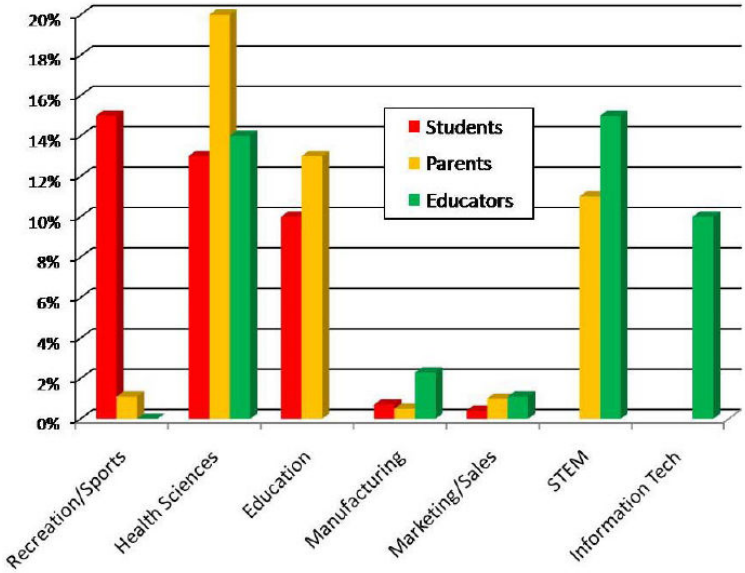


Table 2 Students – Parents – Educators reveals the only career choice selected by all three populations was in the 'Health Sciences'. Again, only a small percentage of educators report recommending a career in 'Manufacturing' to students.

Table 2. Spring 2007 survey results for Students, Parents, and Educators



These results reinforce the earlier-mentioned studies that middle school students may not be aware of manufacturing careers and are not choosing manufacturing as a future career path. Opportunities must be available for middle school students to interact with and experience manufacturing professionals and careers as a recruitment to build a future workforce. The following activities were introduced to project schools last year to provide manufacturing awareness to students.

School-Based Manufacturing Activities that Create Student 'Buzz'

Given the state and national reports that few students are selecting careers in advanced manufacturing, the NSF-ATE project identified numerous hands-on student-centered activities that could be integrated into the curriculum at each educational level. These activities introduce students to manufacturing careers, equipment used, and interaction with mentors from the manufacturing and engineering fields all with the purpose of creating student interest or 'buzz' toward manufacturing careers. The intent in implementing these activities was to dispel persistent myths that manufacturing is dirty, dark, and dangerous and provides jobs that require low levels of technological skills and little or no fundamental knowledge in science, math, and other fundamental school subjects.

Formula 1 in Schools **Competition**

The NSF-ATE project purchased six *Formula 1 (F1*) *in Schools* systems for six project middle schools. The *F1 in Schools* challenge engages student teams in design engineering, parametric modeling, rapid prototyping, and computer simulation testing of model *F1* race cars. The *F1* system includes a computer, CNC microrouter, wind tunnel, and CAD/CAM software.

Teachers were provided with hands-on education and training in using the design / production software and computer-controlled prototyping equipment, as well as the pedagogical approaches required for instruction that focuses on the engineering design process and high-tech, advanced manufacturing. In the first year of the project, two of the six middle schools competed at the 2007 PA state Technology Student Association (TSA) *F1* Competition.

In the southwestern Allegheny region, the South Park Middle School team, composed of 3 males and 2 females, placed 1st at the TSA Competition. In the south central Lancaster region, the Conestoga Valley Middle School team, composed of 5 males, placing 2nd at the state Competition. These placements at the state competition made both school teams eligible for competing at the National *F1* Competition in Nashville in June 2007. The South Park *Screaming Eagles* (photo below) placed 4th at the national competition with the Conestoga Valley team placing 8th.

The second year of the NSF project saw a fourfold increase in the number of F1 teams organized to compete: eight *F1* teams have been formed, five in the south central Lancaster region and three in the southwestern Allegheny region. The composition of teams registered for the Lancaster middle schools totaling 48 students, 43 males and 5 females. Three schools in

Southwestern PA are expected to field four teams with South Park organizing two teams, one predominately female. The exact numbers of students registered and their demographics will be known at the March *F1* trials.

Middle and High School Advanced Manufacturing 2007 Summer Camps

The project leveraged NSF-ATE fund to secure foundation funding to offer the following summer camps as the culminating activities for the first year of the project.

Nanotech Camp In cooperation with NSF-ATE funded Center for Nanotechnology Education and Utilization at Penn State University, 40 high school students were recruited from two project sites to attend a three-day residential Nanotech Camp that provided an orientation to nanofabrication processes and applications. The students conducted science experiments and observed nanofabrication processes in the Penn State Nanofabrication Facility, one of four such nanofabs in the National Nanotechnology Infrastructure Network.

Photo: Students in the cleanroom facility during the Penn State University Nanotech Camp

Manufacturing Camps Several manufacturing-focused summer camps were initiated in summer 2007. The Private Industry Council (PIC) of Southwestern PA hosted a two-week day camp for 20 middle school students (11 girls, 9 boys) from five project partner schools in Southwestern PA. Lancaster County Career & Technology center offered several one-week middle school day camps in South Central PA that attracted 109 students. California University conducted a five-week advanced manufacturing class for 22 students (16 girls, 6 boys) in the Upward Bound program, which focused on first-generation, low-income high school students. The manufacturing camps featured hands-on learning activities in design, engineering, rapid prototyping, manufacturing processes, advanced materials, and other topics.

Science Technology & Engineering Preview Summer Program (STEPS) Academies With $25,000 in funding from the Society of Manufacturing Engineers-Educational Foundation (SME-EF), South Park Middle School technology education teacher Josh Cramer attended a two-week training workshop at Penn State Berks Campus for Project Lead the Way's (PLTW) middle

school curriculum called Gateway to Technology. The two-week training on engineering software and equipment provided the teacher with curriculum to offer week-long non-residential summer camps for all-boys (25 boys) and all-girls (14 girls). Camp activities included Design & Modeling, the Science of Electrons, Automation & Robotics, Flight & Space, and the Science of Technology.

A South Park Middle School student works on her VEX agile robotic system during the 2007 Summer STEPS Academy

TECH Awareness Camp The Technology and Engineering Coalition to Heighten (TECH) Awareness Camps for high school girls was offered at California University during summer 2006 and 2007. Female university professors and students in applied engineering and technology degree programs served as camp instructors and near-peer mentors. Female industry champions served as guest speakers. The residential one-week camp provided 40 female students with STEM (science, technology, engineering, and math) learning activities over the two summers.

High School Advanced Manufacturing Student Activities

BotsIQ Competition One of the fastest-growing student activities in the NSF-ATE project that has tripled in the past three years is the BotsIQ Competition. The BotsIQ competition engages teams of students in hands-on designing, building, and competing with battling remote-controlled agile robots. Started as a grassroots effort by Hamill Manufacturing Company President Jeff Kelly to recruit secondary students to manufacturing careers has grown from six teams, composed of 66 male students, competed in 2006. During the second year of the BotsIQ Competition, 2007, the committee controlled the growth of the competition to cap the number of teams competing during the one-day event to 18 teams, with a waiting list should a team drop out. These 18 teams were composed of 111 males and 9 females of which 114 were Caucasian and 5 were African American. The third year of the BotsIQ has experienced an almost doubling of the number of school teams to 32 teams scheduled to battle it out in March 2008. The composition of the team registrants reports 268 males and 19 females. This group of students identified their demographics as 129 Caucasian, 15 African American, 1 Asian, 1 Hispanic, 1 Middle Eastern, and the remaining 121 checked 'Other'.

The 2007 competition engaged 120 students from 18 high schools who were advised by 20 teachers mentored by 14 manufacturing partners. With the 2008 Competition scheduled for March 29 at the Century III Mall, Jefferson Hills, PA, the Committee has worked to secure 32 teacher advisors each mentored by a manufacturing partner. The exact number of students, teacher advisors and company mentors will be finalized in the next few weeks. The southwestern BotsIQ Competition created such excitement in the school greater Allegheny community that it has been replicated in northwestern PA in Meadville area in 2007. Reports from the Meadville BotsIQ Committee indicated that over 1,000 people attended their first annual BotsIQ Competition.

A BotsIQ team from the Western Pennsylvania School for the Deaf poses its robot, the "Deafinator"

Adventures in Technology The Adventures in Technology (AiT) Program is an industry-focused business, education and community partnership that brings visibility to manufacturing, information technology and biomedical/ biotechnology careers by teaming high school students with local companies to complete real world problem resolution activities. With funding provided by the Catalyst Connection Industrial Resource Centers and the Private Industry Council, students are engaged in an eight-week, hands-on project to design and build a product or to re-engineer an existing product, process or system. Throughout the eight weeks, students have an opportunity to interact with industry professionals and learn about materials, equipment and processes used by specific businesses and industries. In 2007, the AiT Program engaged 22 school teams with more than 150 students and 24 teacher/ advisors that collaborated with 22 companies to solve industry problems.

Professional Development for Educators

The NSF-ATE project has provided numerous professional development activities for educators to interact with manufacturing professionals to change their image of manufacturing from one of low skill, dead-end, dirty to the highly-skilled, technologically-advanced, gold collar that it has become.

Educator in the Workplace During the 2007 summer, two Educator in the Workplace workshops were conducted, one at Millersville University offered as *EDW 628 Preparing Students for the Student Workforce,* and one at California University as *TED 565 Educator in the Workplace.* These workshops focused on advanced manufacturing and included industry tours, panel discussions and industry presentations. A partial listing of companies that provided tours

includes Covanta Energy, Hamill Manufacturing, Kurt J. Lesker Company, MAGLEV Inc., MeKesson Automation, and Precision Medical. The NSF-ATE funds provided scholarships to 20 educators to enroll and update their knowledge of advanced manufacturing career opportunities to share with possibly hundreds of students each year.

Inventor and *F1* Teacher Training The NSF-ATE project provided two days of hands-on training for 15 middle school teachers on parametric modeling software (Autodesk Inventor) and rapid prototyping (F1). These 15 middle school teachers have implemented the F1 into their curriculum and can impact approximately 1,000 middle school students.

Identify Advanced Manufacturing 'Champions'

With the NSF project goal of educating students, teachers, parents, guidance counselors and the community about the current state of manufacturing, its career prospects, and high tech nature, a cohort of advanced manufacturing professionals or 'champions' were recruited to change the antiquated perceptions about manufacturing. Industry and government partners have identified females and minorities working in manufacturing companies within the project service regions. The Society of Manufacturing Engineers (SME), the Society of Women Engineers (SWE), a Speakers Bureau organized by the Outreach Coordinator at the Westinghouse Electric Company, Monroeville have identified over 100 Champions to volunteer to participate in project-sponsored events by speaking to students in middle and high school classes during Engineers Week, speaking to students and parents during summer camps, Career Fairs, Open House, or other school events, and speaking to teachers during Educator in the Workplace activities. Champions also mentor and advise middle school students in the *F1 in Schools* activities, and mentor and advise high school students in two project-sponsored manufacturing-related educational experiences: BotsIQ and Adventures in Technology. The project has sought guidance on issues related to females and minorities from recognized organizations, such as the National Institute for Women in Trades, Technology and Science, the Society of Women Engineers, the Society of Manufacturing Engineers, and the National Action Council for Minorities in Engineering.

Outreach Activities for Students, Parents and Educators

Several outreach activities have involved all three populations to advanced manufacturing careers. These have been well received and will be offered again in the future.

Gold Collar Night Organized by the Lancaster County Career and Technology Center and offered at three sending middle school partner schools, a county-wide 'Pathways to Gold Collar Careers Night' was conducted. The event highlighted 15 careers, one of which was advanced manufacturing. Industry representatives and post-secondary career counselors were on hand to discuss these gold collar careers and the career pathways to achieving them. Attendance was estimated at over 1,000 parents, students and educators.

Summary and Conclusions

Now in its second year, the NSF-ATE project is beginning to see a shift in student, parent, and community perceptions toward advanced manufacturing careers. One of the project middle

schools applied in June 2007 to PDE for a program name change from Technology Education to Applied Engineering Technology. The instructor and administration felt the new name better reflected the change in the focus of the program from more hobby-oriented teacher-focused activities to student-centered, hands-on activities utilizing more highly technical robotics and engineering equipment. The South Park Middle School Applied Engineering and Technology Program received oven $100,000 from SME-EF and PA Labor and Industry to upgrade the curriculum and equipment used in the classroom. The curriculum follows the Project Lead the Way (PLTW) model, a rigorous tested and proven standards-based STEM-focused multidisciplinary curriculum that provides advanced placement/ college credit for those programs that become PLTW certified. The leap forward to upgrade and mirror advanced manufacturing skills has brought much attention to the district from the positive comments from students, parents, interest from other school faculty, and the manufacturing community.

After conducting interviews with project teachers after less than one year into the project operations, our external evaluators[7] reported many positive changes, including:

> teachers re-energized by the new approaches…, high numbers of students seeking to be part of the project activities…, students taking responsibility for planning, designing, and fund-raising…, and student engagement in meaningful, active activities that produce positive attitudes… and higher achievement in some of the critical skills essential in advanced manufacturing: teamwork, problem-solving, communications, project management, mathematics, and critical thinking.

During the next two years of the NSF-ATE project funding, the team will continue to seek funding to upgrade other middle school classrooms/ labs to reflect the equipment used in manufacturing industries. The team will also continue to organize the numerous activities mentioned, and many others not listed in this paper, to engage students, parents, educators and the community in general to manufacturing career opportunities.

Bibliography

1. Deloitte Consulting, LLP (2004) *Manufacturing Pennsylvania's Future: Regional Strategies that Build From Current Strengths and Address Competitive Challenges.* Harrisburg, PA: Pennsylvania Industrial Resource Centers, Team PA Foundation. Available at website*:* http://www.teampa.com/docs/MFG Report.pdf

2. National Association of Manufacturers. *Skills Gap 2005: A Survey of Advanced Manufacturing Workforce.* Available at: http://www.nam.org/2005skillsgap

3. National Coalition of Advanced Manufacturing (November 2003). *Manufacturing Skills Crisis: Solutions for this National Challenge Conference Report*. Washington DC: NACFAM. Available at: http://www.nacfam.org/Nov21SkillsCrisisReport.pdf

4. Moser, Harry. "A Career in Toolmaking or Machining Technologies: The Right Choice for Students, Community and Country" (Oct 5 2005). Presentation to AMC2, Western Area Career & Technology Center, Canonsburg, PA.

5. Pennsylvania Department of Education (various). *Career and Technical Education Secondary Programs 2001-2002. Postsecondary Career and Technical Education, 2002-2003. Vocational-Technical Education*

Classroom Teachers, 2001-2002. Harrisburg, PA: Pennsylvania Department of Education. Retrieved from website: http://www.pde.state.pa.us

6. States' Career Clusters Initiative (SCCI). The 16 Career Clusters, 2008. http://www.careerclusters.org/16clusters

7. Teahen, R. and Stehouwer, K. (2008). *Abstract of Highlights from External Evaluators' School Site Visits in December 2008*, NSF ATE Advanced Manufacturing in Pennsylvania Project.