AC 2011-2666: MANUFACTURING STRATEGIES: NSF ATE CENTERS

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Manufacturing Your Future: Student Recruitment Initiatives

Introduction

The globalization of manufacturing mandates that the United States manufacturing workforce be able to compete internationally. Therefore, manufacturing educators must develop a workforce that can keep pace with relentless global competition and educate their students with 21st Century skills. While preparing students to compete in this global arena, educators must maintain student enrollments and keep their programs, equipment and curricula current. Given the economic reality of state budgets, manufacturing programs are faced with numerous challenges including the need to increase or maintain enrollments, especially among underrepresented students. Historically, manufacturing programs are considered "expensive" and without sufficient enrollment, they potentially may not be sustainable. While policy makers are seeking ways to support economic development, very few policy makers realize the importance of manufacturing programs. Manufacturing is the driver of local and regional economies and without modern manufacturing educational programs; the United States will continue to loose its manufacturing companies to foreign countries.

As a result, there is a need for new models of recruitment and retention that can help sustain manufacturing programs. The Connecticut's College of Technology (COT), a statewide initiative that represents all twelve community colleges, six university partners and feeder secondary schools; industry, and government stakeholders was awarded a National Science Foundation (NSF) grant to establish a Regional Center for Next Generation Manufacturing (RCNGM).

For more than six years, the COT-RCNGM stakeholders have supported and implemented educational initiatives in Science, Technology, Engineering and Mathematics (STEM) in the state of Connecticut and the New England region. The focus of the COT's Regional Center is to promote manufacturing education through pathway programs, student recruitment and retention, as well as faculty and curriculum development.

One of the major goals of the COT- RCNGM is student recruitment and retention. The COT-RCNGM Center has created a robust marketing outreach initiative that presents manufacturing career pathways using innovative and immersive experiences for high school students and their teachers. The objective of the COT-RCNGM marketing initiatives is to provide information to high school students on manufacturing that will improve their ability to make informed decisions about manufacturing careers. For innovative learning environments that market STEM, in particular manufacturing technicians and engineers, the Connecticut's College of Technology's Center, has designed and piloted local expos entitled "Immerse Yourself in 21st Century Technology". The idea of developing the local expositions evolved from two highly successful statewide expositions held in 2006 and 2008. The techniques and lessons learned from the

statewide expos have guided the development of the more focused, local expositions that concentrate on an individual Connecticut community college, its feeder high schools, regional university partners and the local manufacturing industry. The COT-RCNGM statewide and local expositions are different from other marketing techniques used around the country.

According to the National Science Foundation (NSF) latest population predictions, minorities (Blacks, Hispanics, Asians/Pacific Islanders, American Indian/Alaskan Natives) are expected to be more than half (52 percent) of college aged (18-24) population in the United States by 2050, up from 34 percent in 1999[1]. Today, the retention rate of minorities in engineering programs is approximately one-third, compared to two-thirds for non-minority groups. The growing trend of the minority population provides opportunities and challenges for recruiting[2]. The COT-RCNGM expos market to students to consider the community colleges pathway as a gateway to careers in STEM and high education particularly for academically, economically and socially disadvantaged students.

Research indicates that there are many other marketing activities at different high schools, community colleges and universities throughout the United States. Based on the motivating rationale, the marketing or outreach activities may be categorized by a common theme and an approach. Table 1, summarizes the *motivation for outreach*, *common themes* for outreach and *common approaches*[3-7]. Some of the common themes for outreach are: active learning through hands on activities, inquiry-based learning, curriculum supplements and engaged role models (mentors).

Some of the common approaches for marketing and outreach are: develop classroom material including web-based resources; conduct outreach activities on the college campus; offer outreach activities at the K-12 school; sponsor engineering contest; provide teaching fellows as well as offer service learning courses and professional development for K-12 teachers. One noted manufacturing marketing and outreach activity by James Madison University is “Techfacturing”. The Telefacturing is a three-day summer day camp program implemented in 2009 in order to encourage middle school students to pursue STEM careers. Students go through an array of site visits of local manufacturing facilities such as local electronics, medical supply, and processed foods facilities.

Literature Review

There are numerous efforts to support student recruitment. Another manufacturing-based marketing strategy is “Gear up Utah” for high school students provide plant tours, interactive exhibits and hands on exhibits[8]. The staff at Robert Morris University “Expanding your Horizons”, provides hands on workshops held by female scientist, mathematicians and engineers[9]. Stanley Community College holds a weeklong event, “the Jim Wentz Manufacturing Camp”, for students to learn theory and hands-on events.

Table 1 Compilation of typical Marketing/Outreach strategies used by college and universities to encourage K-12 to pursue education and careers in STEM[3-7]

Motivation for Outreach	Common Themes for Outreach	Common Approach
Increase engineering enrollment	Active learning through hands-on activities	Develop classroom material including Web-based resources
Diversify engineering	Inquiry-based learning	Conduct outreach activities on the college campus
Educate our future	Curriculum supplements	Conduct outreach activities at the K–12 school
Undergraduate student development	Engaged role models	Conduct or sponsor engineering contests
-	Younger student focus	Sponsor teaching fellows or offer service-learning courses
-	K–12 teacher involvement	Offer professional development for K–12 teachers.

One of the challenges of marketing and outreach to showcase manufacturing careers is providing students with a comprehensive overview of the product development process. The COT-RCNGM is different in that it the manufacturing companies are specifically invited to the expos to participate in demonstrating, in its entirety, the engineering design process. Middle and High School faculty and their students learn about the entire product through manufacturing process.

As in all marketing activities, one of the goals of the program is to expose students to career pathways in STEM disciplines that the students may not have been aware of. Throughout the state of Connecticut, community colleges have also adopted and embraced the student expos and have committed to providing staff, in-kind and cash resources to support a local expo at their institution. Currently, there is a waiting list of community colleges who have requested having an expo during the 2011-12 academic year. Evaluation data collected from the expos has demonstrated that the expos have provided an immersive and effective strategy that has

contributed to an increase in the enrollment in the College of Technology programs with an emphasis on careers in manufacturing. The staffs of the COT-RCNGM have aggregated the evaluation data collected from the expos and have reported that the data indicates that these expositions have provided the participants with an awareness of manufacturing programs, in particular community college and university pathway programs. In addition, the data suggests that these expos have provided the participants with immersive, hands-on experiences that use modern, cutting-edge manufacturing technologies, creating the 21st century image of the clean, high tech, manufacturing industry.

Local expositions (expos) entitled, "Immerse Yourself in 21st Century Technology," use a Principles of Design (POD) framework that offers an opportunity for students to transfer knowledge learned in classrooms to the context of real world problems. The success of the "Immerse Yourself in 21st Century Manufacturing" expo is achieved by using scientific inquiry. The students are involved in the design of a product from cradle to bed and are introduced to the engineering design, development and manufacturing processes. The idea is that this engagement encourages exploration and excitement about next generation manufacturing. Learning about the manufacturing technology is greatly enhanced by a hands-on active approach that allows students to engage in a design and the associated manufacturing challenges. Students become an active part of the engineering design and manufacturing process. This inquiry-based learning is an integral component of the overall marketing strategy.

In addition the expo aims at changing the negative perception of manufacturing in particular for inner city high school students throughout Connecticut. Preparation for the exposition involves supplying high school educators with a curriculum module that they use in their classroom. The curriculum kit includes a pre and post-test, a design challenge supported with case studies, manufacturing related articles and video clips that explore the product development process.

Ultimately, the objective of the local expos is threefold. The first objective is to support student recruitment and retention in manufacturing programs at individual community colleges and their university partners. Next, these expos are designed to improve educators and their students' attitude towards manufacturing through participation in an informal science environment. Finally, the expos bring together industry, policy makers and educators, creating and strengthening the partnerships necessary for manufacturing to not only be sustainable but to grow and flourish.

Background

Based on the United States Census report, 2008, (Figure 1) the general education level of manufacturing workforce increased between 2000 and 2008. (Manufacturing Institute 2009) According to the 2008 census report, the total manufacturing workforce with Bachelors degree (B.A) increased from 16 percent to 19 percent. The total manufacturing workforce with graduate and professional degrees increased from 5.7 percent to 8 percent. These results suggest that the

manufacturing field is migrating towards a highly skilled workforce. Figure 1 illustrates the increase in the requirement for a more highly skilled manufacturing workforce.

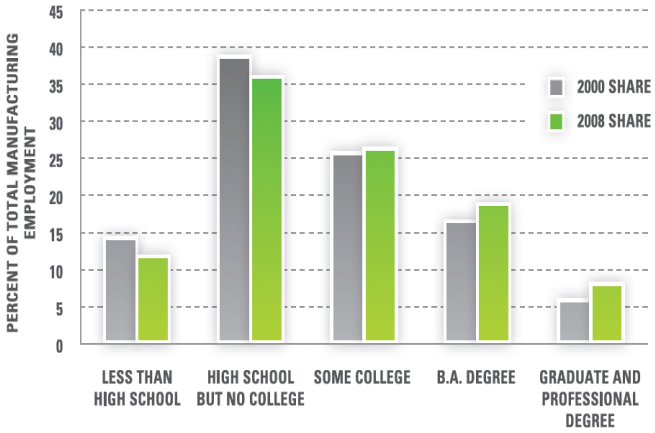

Figure 1 - Percent of Total United States of America manufacturing for 2000 and 2008 (manufacturing institute 2009)

Design of Project

The expos use a Learning by Design (LBD) concept that was first proposed by Koldner in 1998[10]. In LBD, the design challenge provides the model that is used in the expos for engaging students and facilitating the learning of science, engineering and technology content. Koldner's study demonstrated that students who had participated in LBD design and pilot programs learned science content as well or better than students involved in more traditional classroom settings such as lecturing and didactic pedagogy. Koldner's analyses show that LBD students who engage in collaboration, communication, informed decision making, and design of investigations perform higher in both educational as well as the workforce than peers who have not had a LBD experience[11]. As a result, Koldner et al. advocates deliberate reflective practice of targeted skills, such as learning in the context of doing that includes monitoring one's doing and learning and one's experience of learning, coupled with frequent, timely, and interpretable feedback. (note: Deliberate, in this instance, means that the skills are practiced in a context that promotes learning; reflective means that their practice is discussed and lessons drawn out from that discussion[12]). Figure 2 below summarizes the Learning by Design model.

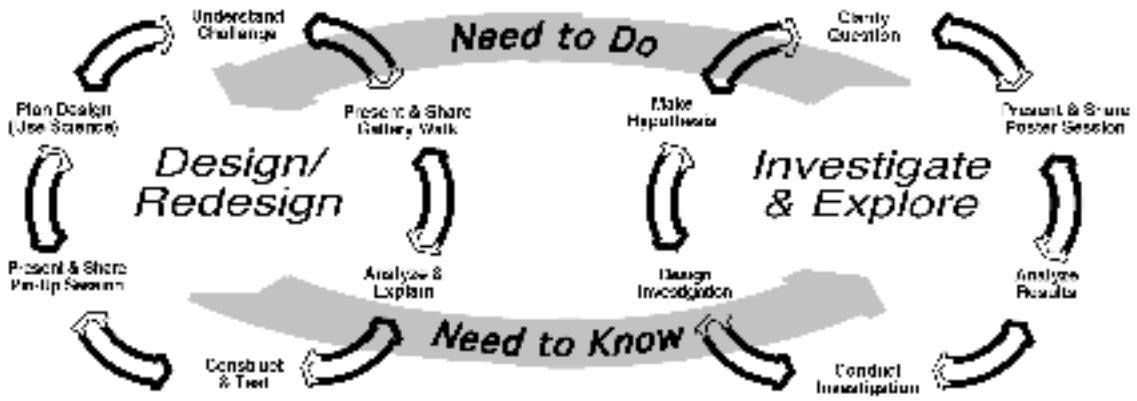

Figure 2 - Learn by Design (LBD), design cycle, Koldner 2002[15]

Connecticut's expos, be it statewide or local, apply Koldner's model and function as a design through manufacturing challenge. The expos are a student-centered education model in contrast to the traditional teacher- centered model. The advantage of the student-centered model is that it is more of an active learning environment in comparison to a passive learning environment. Felder[13] has identified the following six principles for teaching in an active learning environment: 1) write comprehensive instructional objectives, 2) model strategies and skills for your students 3) maximize experiential learning and minimize lecturing 4) use team-based learning extensively 5) do not make speed a factor on tests 6) positively reinforce successful performance. Others have incorporated "hands-on" experiences ranging from the use of multi-media[14] to the entry into collegiate design competitions[15]. In addition, the following seven objectives are introduced to the high school teachers who participate in the expo and are also incorporated into the expos as well; 1) model thinking/processing skills, 2) identify students' cognitive development, 3) develop questions that facilitate exploration/growth, 4) introduce visual tools to aid establishing connections, 5) provide group learning settings, 6) use analogies and metaphors, and 7) provide a "no-risk" student feedback channel for information[16]. The "Manufacture Your Future" statewide expos and more recently developed "Immerse Yourself in 21st Century Technology" local expos utilize many of these techniques to create an engaging learning experience.

Methodology and Design

The first statewide "Manufacture Your Future" expo held over in 2006, functioned as a campaign to increase the awareness of and need for manufacturing education and a highly skilled workforce for modern manufacturing companies throughout Connecticut. These statewide expos were held in 2006 and 2008 with an attendance of 3,000 and 3,500 high school and middle school students respectively. Additional events within these statewide expos included industry leaders holding workshops for faculty and teachers on the latest advances in manufacturing techniques. These hands on workshops included the demonstration and use of three-dimensional laser scanning equipment, additive technologies and advanced computer numerical controlled (CNC) equipment.

This paper examines the transition from statewide expos to local expos using lessons learned and promising practices garnered from the statewide expositions. Although similar, the local expo is an evolution from traditional marketing to an awareness of manufacturing careers that focus on

21st century skills and the need for a highly skilled workforce for the manufacturing industry. Statewide "Manufacture Your Future" expos typically involved 3,500 students, whereas local expos engage approximately 300 students. Whether an expo was statewide or local, the objective of the statewide and local manufacturing expos were to bring middle-school and high school students to a simulated design through manufacturing environment where they viewed manufacturing stations that gave them an understanding of next generation manufacturing.

The statewide "Manufacture Your Future" expos used a Principles of Design (PODs) approach which created a student-centered environment with inquiry-based learning. This format allowed students to explore manufacturing in its entirety, from initial concept to final product production. The idea was to enable the discovery and the effective usage of an engineered approach to product development. These earlier statewide expos used the POD concept that set up a sequence of individual workstations from product conception, prototyping, testing, fabrication and finally product assembly. Each POD continued the theme of designing a product that was first introduced in the initial POD and then manufactured. Each POD featured a speaker who challenged cohorts of students by questioning their knowledge of key concepts specific to that POD. They also discussed and demonstrated specific processes in a product evolution sequence. The manufacturing expo focused on steps 1-5 illustrated in Figure 3. These concepts are 1) idea to innovate and improve, 2) design, 3) build prototypes, 4) performance testing, 5) material and process selection and finally 6) manufacturing. The overall objective was to help students understand the gradual evolution of a concept to an eventual product in a step-by-step manner.

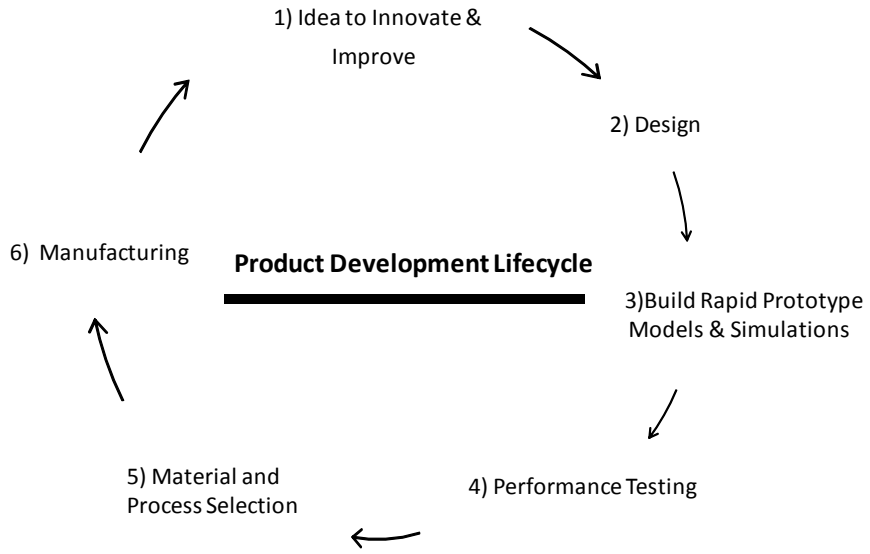

Figure 3 - Steps of the Engineering Design Process

The Expo: Creating a Manufacturing Experience

The statewide expos used nine PODs representing key design and manufacturing processes. Cohorts of from 30 to 40 students were guided through the sequence of PODS. The POD stations were: 1) Computer Aided Design; 2) CNC Programming and Machining; 3) Tooling; 4) Metals & Coil Slitting; 5) Stamping; 6) Wire & Spring; 7) Plastic & Injection Molding; 8) Finishing & Plating; 9) Assembly & Lasers and 10) Manufacturing Careers. Student cohorts were then guided to an area where they reviewed Connecticut's College of Technology and university program offerings. The floor plan for the statewide expo is shown in Figure 4.

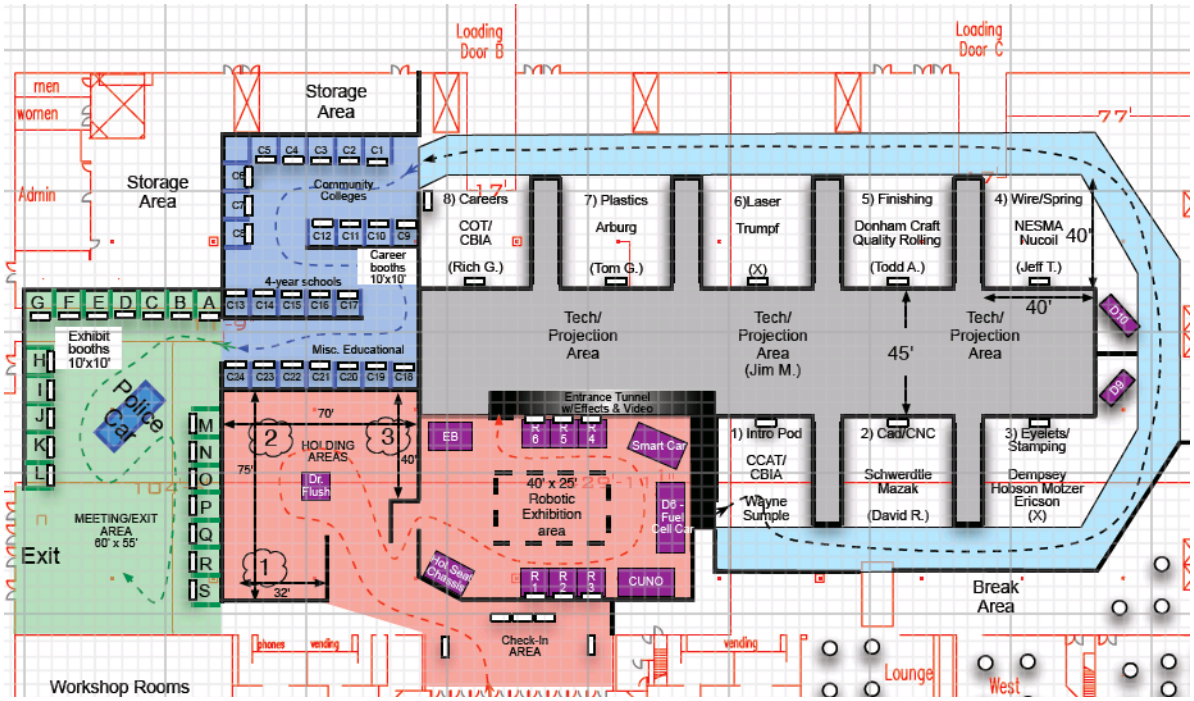

Figure 4 - Statewide Expo Floor Plan

Although the statewide expos were a tremendous success, the ability of over 50 manufacturing companies to provide in-kind support for future expos became a challenge. In addition, it was generally agreed that statewide expos had served their initial purpose and new models were needed. Therefore, local expos were designed and developed to ensure local impact by focusing attention on the strength of individual community colleges and partner universities and secondary schools while actively engaging faculty and their students, administrators, local industry personnel, policy makers which include district legislators.

The marketing strategies for the statewide expos provided promising practices that were adapted and implemented for local expos. Local expos were similar in design as the statewide expos but

included fewer PODS. The five PODs used for the local expos included: 1) Computer Aided Design; 2) Laser Scanning (3D Modeling); 3) Computer Aided Manufacturing (CAM); 4) Laser Cutting; and 5) Rapid Prototyping, please see Figure 7. This new format allows for smaller cohorts of from 20 to 30 students. This helps ensure improved engagement of students at each POD improving student interaction with the speaker.

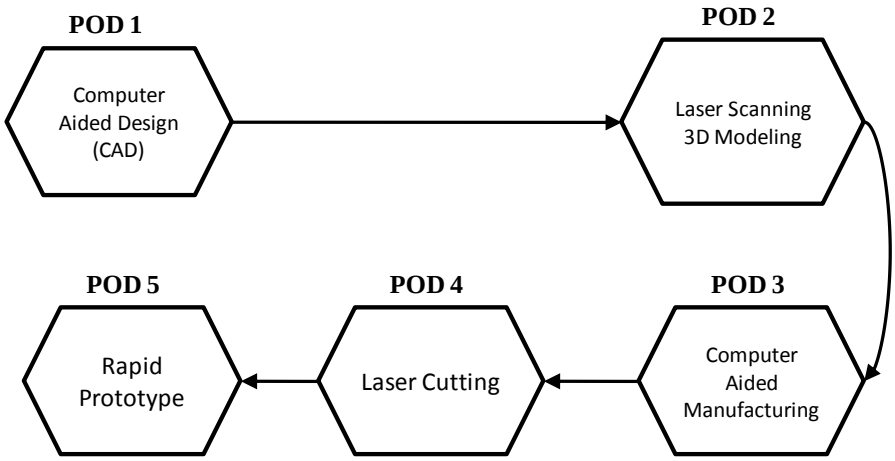

Figure 5 - Engineering Design process with POD stations for student interactive learning environments.

Marketing strategies*: Pre-manufacturing Expo Workshops*

For the statewide expos, students first entered an exhibition area and watched a video on manufacturing careers produced by the COT-RCNGM (see www.nextgenmfg.org for the videos used). Before the students entered the PODs, there was a pre-expo arena that included demonstrations of next generation manufacturing products such as a Hamilton-Sundstrand's interactive robot and space suit; a rocket model from the Connecticut Center for Advanced Technology (CCAT); a model of a submarine from Electric Boat; a guitar produced by Palm Guitar as well as a General Motors (GM) Hummer car. For the local expos, local companies were solicited and involved in a similar trade show component of the expo.

For local expos new engagement techniques are being developed. Social media is being deployed during pre-expo marketing phase. In addition the COT-RCNGM website (www.nextgenmfg.com) is being used to compliment social media sites. Students have the option to join specific groups on Facebook, follow on Twitter and visit the College of Technology website. The COT-RCNGM website was used to register students for the expos and also for future tracking purposes. These social media approaches have assisted the COT-RCNGM with identifying potential community college students and inviting them to events at the college. The pre-manufacturing marketing strategies provided a venue for the dissemination of the COT-RCNGM programs and established a data base and a variety of online methodologies

that were used to track students interested in COT Technology Studies and Engineering Science programs after the expos.

Marketing strategies*: Expo- Marketing by Simulating Actual Development and Manufacturing of Product*

The statewide expos were designed to fully engage high school students at each POD. Groups of approximately 100 students at a time first enter a darkened tunnel with flashing lights and techno music, and then moved on to a waiting area to view a DVD on manufacturing careers. This DVD was developed by the COT- RCNGM team and produced in partnership with the staff at the Connecticut Business and Industry Association (CBIA). Students then proceeded to each POD, stopping no longer than 10 minutes at each, where a moderator gave them an overview of the manufacturing process and how it related to product development. The product being developed and being manufacture in subsequent PODs was a key with a laser engraved key chain. For the statewide expo, the students followed the various fabrication steps to design and then manufacture this key chain. Throughout their journey through the PODs, references were made the individual components of the key and key chain and how individual manufacturing processes were integral in producing them. Students exiting the exhibit hall each received a key and key chain made by companies sponsoring the PODs. Roughly the same design and manufacture format was used for the local expo model.

Local expos in contrast can typically only accommodate approximately 300 students. The first local expo was held in Waterbury Connecticut in November 2010. The advantage of the local expos is that instead of being held at a large convention center, they were now held at the local community college. Local community colleges have the added advantage of active participation from admission staff, administrators, professors and their students. The community college setting immerses high school students in a higher education environment, often for the first time. In comparison to the statewide expo, the students toured the five PODs in groups of 30 and spend significantly longer times at each POD. Typically students were involved in a given POD for 20-30 minutes with a moderator who outlined the function of each POD. The students were not only exposed to advanced manufacturing but more importantly what the community college had to offer in terms of manufacturing programs.

In contrast to the statewide expo where the PODs were focused on mainstream manufacturing processes such as stamping, tooling, metal & coil slitting, plating and injection modeling, local expos played to the strengths of the community college programs. Therefore faculty at local expos were able to introduce students to technologies that represent both mainstream and more advanced product development and manufacturing techniques. These faculty members demonstrated advanced technologies such as 3D laser scanning, additive manufacturing, laser machining and CNC welding that is used to produce innovative next generation manufacturing products.

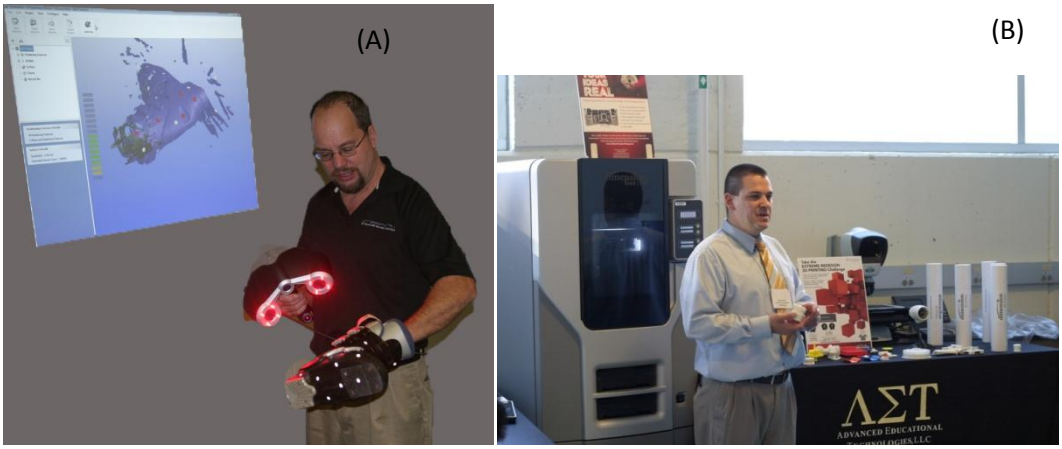

Figure 6 - (*A*) 3D Laser Scanning of physical ski boot with three dimensional rendered image on projection screen (*B*) Demonstration of the Rapid Prototyping machine and finished products

***Expo**: Final POD- COT Program Marketing*

After students completed the Principle of Design tour for next generation manufacturing stations, at the statewide expos, they entered an academic recruiting area to specifically explore College of Technology offerings in their Engineering Science and Technology Studies programs. This area included faculty, students and admissions staff from all of the community colleges. Local expos utilize area companies to finalize the students experience by demonstrating their expertise and the skills necessary to be a contributing employee for their company.

***Expo:** Marketing Strategies for Local Industry Recruitment*

Participation from local industry helped students integrate their previous experiences in the PODs and how it related to industry. Booths from nearby companies were staffed with experienced industry personnel to showcase their Connecticut made products. These booths highlighted what local companies contribute to Connecticut's economy. In addition, students were able to gain a better understanding about what skills sets and academic credentials were needed to be successful in these companies.

Results

Based on formative assessments, qualitative and quantitative outcomes of high school students before and after the local manufacturing expo evaluated the marketing strategy and overall impact. Approximately 250 students attended from five different high schools from Waterbury Connecticut. The schools include Kaynor Technical High School, Cheshire High School,

Promperaug High School, Emmet O'Brien Tech, Wilby High School and Oxford High School. Of the students who attended, 152 submitted pre-survey and 125 completed the post surveys.

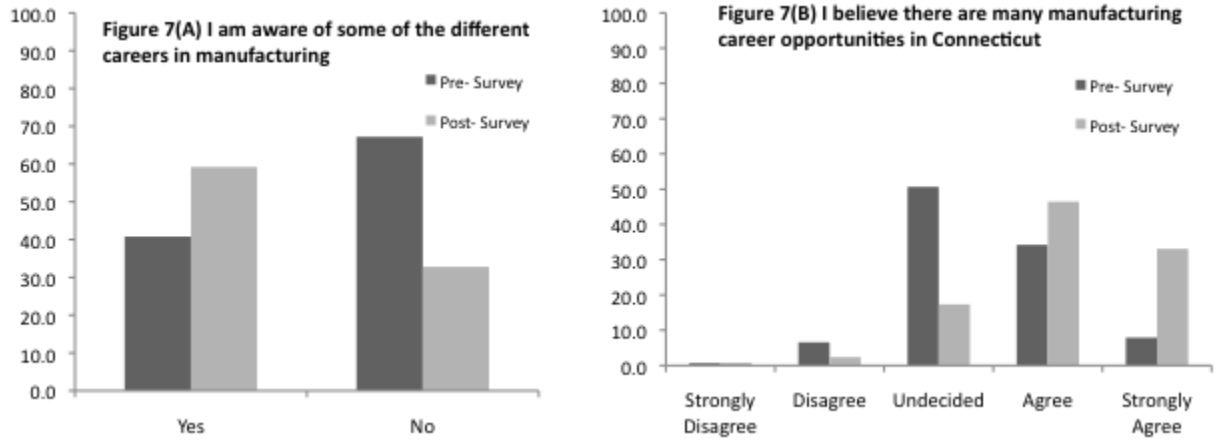

Figure 7 - Student responses to Pre and Post evaluation questions. (*A*) Student awareness of different manufacturing careers increased by 20% (*B*) Approximately 50% of the students were undecided by the manufacturing career opportunities in Connecticut based

Figure 7A and Figure 7B illustrates the results of two student evaluation questions, "I am aware of some of the different careers in manufacturing" and "I believe there are many manufacturing career opportunities in Connecticut," respectively. The results show that approximately 40% of the students were aware of manufacturing careers in the pre survey as compared to 60% in the post survey. The data depicted in Figure 7B, indicates that the majority of the responders were undecided (~50%).

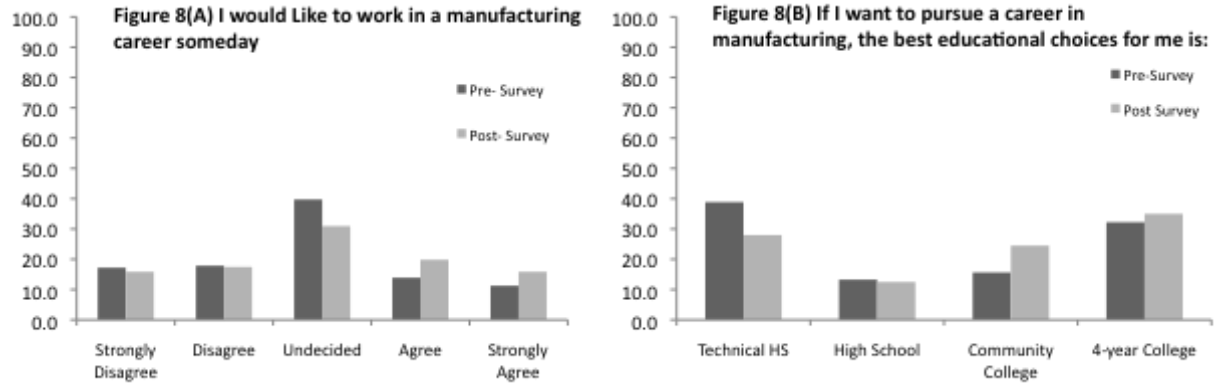

Figure 8 - Student responses to Pre and Post evaluation questions. (*A*) I would like to work in a manufacturing career someday (*B*) I want to pursue a career in manufacturing-educational choices

Student selection of manufacturing as a career option is shown in Figure 8A responding to the statement, "I would like to work in a manufacturing career someday." The results show that 40% of the pre surveyed students were undecided and aproximately 25% agreed/strongly agreed with working in a manufacturing career. Post survey results showed that approximately 36%

agreed/strongly agreed with manufacturing careers (a 11% increase). While responding to the type of educational pathway needed for a manufacturing career is depicted in Figure, 8B, "If I want to pursue a career in manufacturing, the best education choices for me is either a technical High School, a comprehensive High School, a community college and/or a 4-year College." Students reponses increased for all post education needed in order to pursue a career in manufacturing with the identification of a community college as a viable pathway increasing from 16% (pre survey) to 25% (post survey).

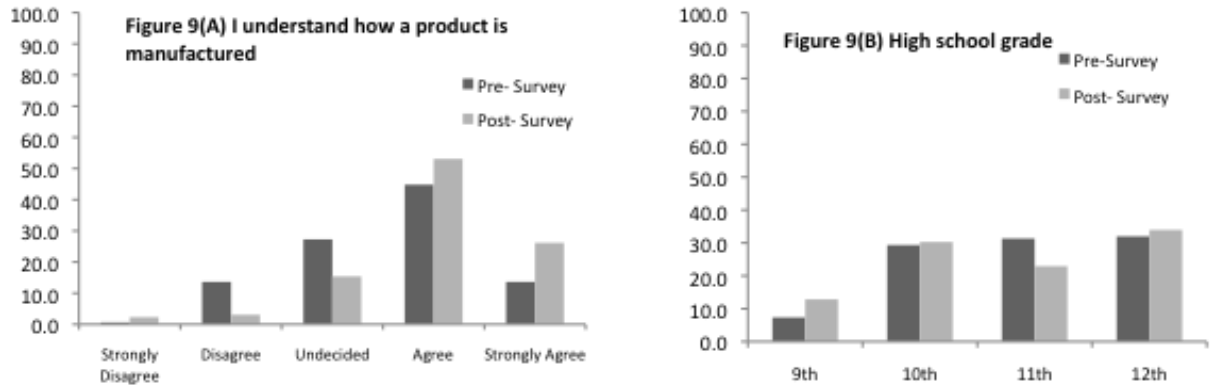

Figure 9 - Student responses to Pre and Post evaluation questions (*A*) Understand how a product is manufactured increased: approximately a 20% increase in the understanding from students who were undecided (*B*) Representation of the high school grade level

The results of survey question that addressed the students' ability to understanding design through the manufacturing process is depicted in Figure 9A. As illustrated in figure 9A, before the expo, approximately 59% of the students understood how a product was manufactured as compared to 79% after their expo experience, an increase of 20%. (note: Figure 9B shows the percentage of students that participated from each grade level in high school. The majority of the students enrolled in 10^{th}, 11^{th} or 12^{th} grade of high school).

A major objective of the COT-RCNGM is to ensure that the outreach programs address diversity. All marketing materials and specific activities were reviewed to ensure that they implemented strategies for the engagement of girls and diverse populations. For example, the expos included consistent examples and applications of how the manufacturing concept being presented was used in the manufacturing of products that girls would be interested in. In addition, the application of all of the activities in each POD included examples of how the manufacturing concept being presented was also used in a real world application that included a humanitarian focus. For example the rapid prototyping POD demonstrated applications of this technology in medicine and dentistry as well in the design of sneakers and high heels.

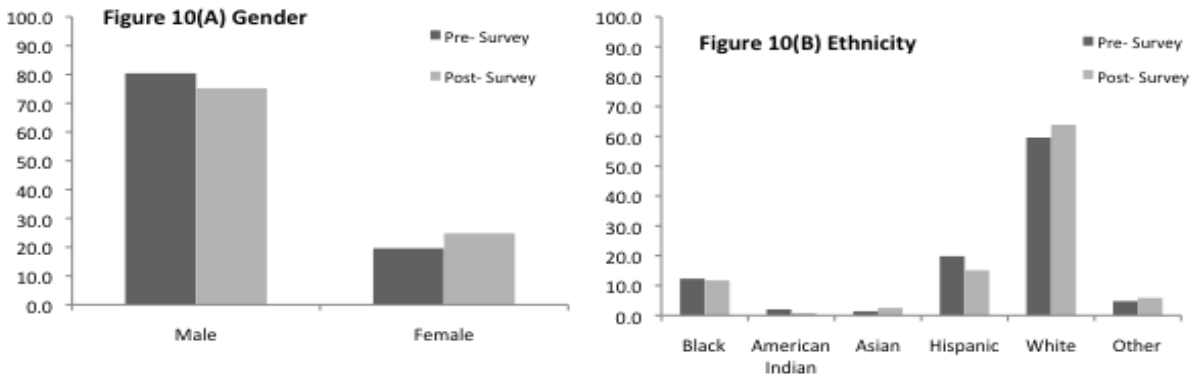

Figure 10 - Gender (A) and Ethnicity (B) of Local Expo participants who responded to the pre and post surveys

Approximately 80% of those who were in attendance were male Figure 10A. The breakdown by ethnicity for students attending the local expo at Naugatuck Valley Community College in November 2010, was as follows: 60% Caucasian, 20% Hispanic and 12% African American.

The teacher participants also completed pre and post surveys. The pie charts in Figure 11 provide a snapshot of their responses to two questions; (1) their perception of engineers and technicians and the role in manufacturing and (2) the impact of the expo experience on their teaching and what they do in their classrooms and labs. Figure 12 illustrates the teachers' responses to questions on how the expo might impact their curriculum.

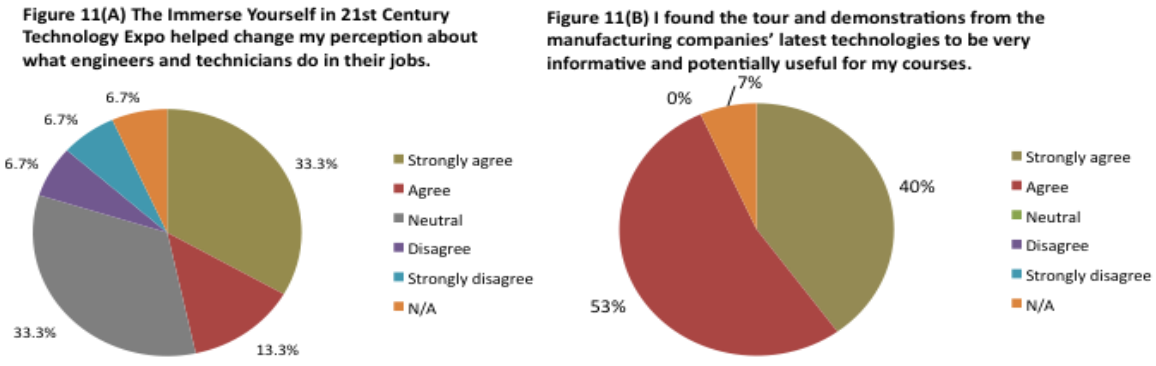

Figure 11 - Teachers Evaluation to local manufacturing expo (A) Approximately 47% of the teachers thought that the expo changed perception about what engineers and technicians do their jobs (B) Approximately 90% of the teachers surveyed thought that the tour and

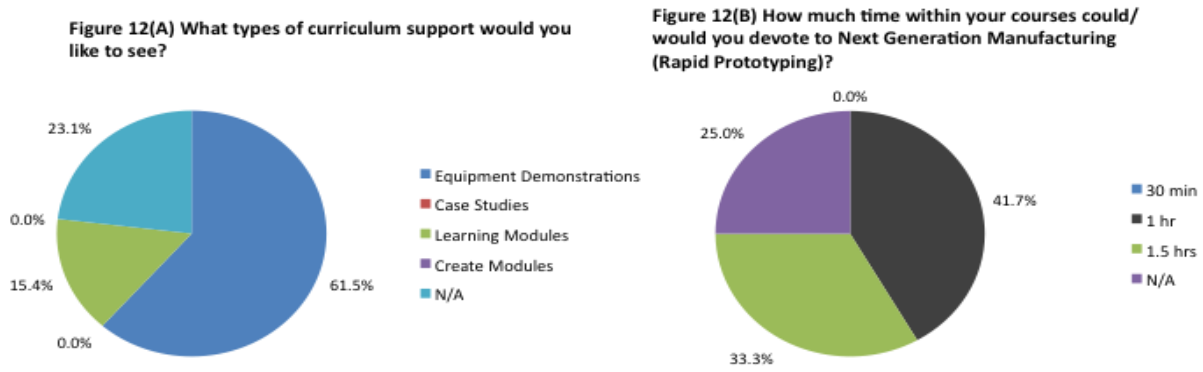

Figure 12 (A) Teachers response to curriculum support. Most of the teachers were interested in Equipment Demonstrations (61.5%) and Learning modules (5.4%) (*B*) Approximately 75% of teachers have expressed that they were willing to dedicate at least

As illustrated in Figure 11 (A), approximately 47% of the teachers thought that the expo changed their perception while 33% felt neutral about what engineers and technicians do their jobs. Approximately 90% of the teachers surveyed thought that the tour and demonstrations from the manufacturing companies latest technologies to be very informative and potentially useful for my courses, Figure 11 (B).

As shown in Figure 12(A) teachers' response to what types of curriculum support they would like to see in collaboration with the COT-RCNGM. The options were equipment demonstration, case studies, learning modules and creating modules. Most of the teachers were interested in equipment demonstrations (61.5%) and learning modules (15.4%) (*B*). Outlined in Figure 12 (B), the question was asked, "*How much time within your courses could or would you devote to Next Generation Manufacturing (Rapid Prototyping)"?* Most encouraging, approximately 75% of teachers expressed a willingness to dedicate at least an hour to a next generation manufacturing topic such as rapid prototyping into their curriculum. This result provides an opportunity for further collaboration between high school educators and community college faculty.

Discussion

Scaling of the Expo/Marketing Next Generation Manufacturing

The statewide expos were an opportunity to study the merits and limitations of the POD framework as a key educational and marketing strategy. Ultimately, the statewide expo was scaled to meet local recruitment needs utilizing promising practices. A critical component underlying this educational and marketing strategy was that local expos are being held at one of the community colleges as opposed to a convention center. An advantage of holding an expo at a community college is the opportunity to recruit students directly into one of the twelve state community colleges Technology Studies or Engineering Science programs. Additionally, the students have an opportunity to visit the campus and tour the state of the art technology and engineering facilities. This also allowed the COT-RCNGM team to utilize the resources of local manufacturers. The outreach strategy combined resources from academia, government and the

private sector to provide students with an engaging learning environment that attempted to answer the fundamental question of: What is next generation manufacturing? What are the affordable opportunities available in Connecticut to obtain a STEM education? Would the students be interested in a manufacturing career?

Based on the results, approximately 40% of those surveyed were aware of manufacturing careers as compared to the 60% awareness of manufacturing careers after the expo. The increase by 20% is most likely attributed to the new manufacturing technologies presented during the expo coupled with the Principles of Design format. Each of the POD presenters discussed how their particular technology enables new product development. When students were questioned if there were many manufacturing career opportunities, over 60% remarked that they were undecided or disagreed. However, after the expo, the post survey showed approximately 80% believed that there were many opportunities in manufacturing. Once again, the evaluation data suggests that exposing students to state of the art technology, demonstrating the novel technology and having an interactive, real world learning experience changed the students' perceptions of manufacturing. Finally, for the question, "Would you like to work in a manufacturing career someday?" 25% agreed in the pre expo survey versus 36% in the post survey. Therefore, there was an 11% increase in the number of students who after the expo were interested in pursuing a manufacturing career.

Conclusion

The local expo represents proven practices and lessons learned from the statewide expos. These local expos highlighted the programs of individual community colleges and universities as well as industry. As noted in the surveys, the students and teachers who participated in the expos, reported that they now had an increased awareness of career opportunities in manufacturing as well as created a more positive perception of manufacturing. In the future, the goal is to fully integrate the local expos into the high school curriculum. The modified "teachers kit" that have been distributed to the participating high school teachers included lesson plans on advanced manufacturing and the design process along with related career information including jobs and their pay scale. Teachers now have the option of having students work on a design project that is an extension of the expo experiences. The high school students and their teachers also now have the ability to work with their local community college faculty and the college students on a design project that can be prototyped at the community college. This concurrent strategy, outreach to high school educators and their students combined with a local expo at a local community college that includes industry as a key partner, is a potent recruitment strategy for engaging students in manufacturing.

The strategies developed and refined under the COT-RCNGM and summarized in this paper, can provide the outreach activities necessary for the long-term sustainability of manufacturing programs within Connecticut's College of Technology programs. They provide promising

practices that other institutions of higher education can adapt and implement in their manufacturing programs. Collectively, the implementation and dissemination of these strategies can ensure that as a nation we support education institutions that embrace manufacturing as a necessary and critical career pathway and in the process create the workforce necessary for the economic growth and stability of the United States.

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