AC 2009-1978: THE STEM OUTREACH INITIATIVE AT ROBERT MORRIS UNIVERSITY

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The STEM Outreach Initiative at Robert Morris University

Abstract

Numerous reports have called attention to the STEM crisis that threatens the competitiveness of the United States[1, 2, 3]. The National Academies report "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future", identifies high priority actions that the United States needs to take for the nation to successfully compete, prosper, and be secure in the global community of the 21st century. These actions include K-12 STEM education improvement including strengthening the skills of teachers through training and education programs and enlarging the pipeline of students who are prepared to enter college and graduate with a degree in science, engineering, or mathematics. Since its inception, the School of Engineering, Mathematics, and Science has been actively involved in outreach activities and reaches over 750 students, parents, and teachers each year. This paper discusses the rationale for the School's outreach efforts, describes the various programs and their design, analyzes the impact of the outreach program to date, identifies attributes of a successful outreach program, and discusses the future direction and growth of the STEM outreach initiative at the institution.

Introduction

The appreciation of the importance of manufacturing to the economy dates back to the writings of Adam Smith and Alexander Hamilton. While the manufacturing sector has experienced cyclical change (growth and contraction) over time, it has been one of the most important contributors to the prosperity and competitiveness of industrialized nations. A recent report by from the Economic Policy Institute highlights the continued importance of manufacturing to our economy[1]. The report states "While U.S. manufacturing has been hit hard by a decade of rapid import growth and job loss, the manufacturing sector remains a vital part of the U.S. economy. The manufacturing sector supported 14 million jobs in 2007, or about 10.1% of total employment." Manufacturing still accounts for a significant share of U.S. economic production, generating $1.6 trillion or 12.2% of the GDP in 2006. As documented by the Bureau for Economic Analysis, manufacturing casts a bigger shadow by virtue of the trillions of dollars worth of commodities and services that serve as inputs to the sector.

However, the nature of the manufacturing profession has changed over time. Advances in computing, communications, and distribution systems have fundamentally changed the face of manufacturing (Friedman, among others has written extensively about the flattening of the globe) and have resulted in companies manufacturing and competing on a global playing field[2, 3]. For example, the Boeing 777 airliner has 3 million parts that are provided by over 900 suppliers from 17 countries around the world. The development effort for the new 787 airliner involves 10 countries[4, 5]. Similar stories may be found across the manufacturing sector. Changes in political, social, and economic conditions in many parts of the world continue to provide interesting new opportunities and challenges to manufacturers.

What has stayed constant in the manufacturing profession is the importance of and the reliance on the innovation and creativity needed to seed technological advances and the leadership, vision, and strategic thinking needed to translate them into competitive advantage. Andrew Carnegie has elegantly stated "Take away my people but leave my factories, and soon grass will grow on the factory floors. Take away my factories but leave my people and soon we will have a new and better factory." More recently, Lester Thurow in his book, Building Wealth: The New Rules for Individuals, Companies and Nations, writes that "Knowledge is the new basis for wealth. This has never before been true. In the past, when capitalists talked about their wealth, they were talking about their ownership of plant and equipment or natural resources. In the future when capitalists talk about their wealth, they will be talking about their control of knowledge.[6]"

While the critical role of human capital is widely understood, we face a significant challenge in terms of the incumbent and emerging workforce along the dimensions of both quantity and quality. A recent Advanced Technology Services/Nielsen Research survey of 100 senior manufacturing executives in the United States indicates an emerging and costly skilled labor shortage triggered by baby boomer retirement and a lost generation of factory workers[7]. This is not purely a numbers issue, the changing face of manufacturing and the global playing field that was referenced earlier mean that the skill set needed of newly graduating engineers is both broad and deep and include both technical and professional skills. This is the crisis that faces STEM education today.

Numerous reports have called attention to this STEM crisis that threatens the competitiveness of the United States. The National Academies undertook a study and documented its findings in a report entitled "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future". This report identifies high priority actions that the United States needs to take for the nation to successfully compete, prosper, and be secure in the global community of the 21st century[8]. Several such research studies and position papers have been undertaken in recent years and many of the findings and recommendations are similar in nature.

Rising Above the Gathering Storm identified four areas for action that include improving K-12 STEM education, strengthening the commitment to basic research, STEM human capital development through domestic and international recruitment, and the creation of a climate of innovation. The recommendation pertaining to K-12 STEM education improvement included language relating to strengthening the skills of teachers through training and education programs and enlarging the pipeline of students who are prepared to enter college and graduate with a degree in science, engineering, or mathematics.

The pipeline is a source of significant concern across the United States. The US once had the best high school graduation rate in the world but as of 2008 it is now ranked 15th among industrialized nations. The following information has been taken directly from the executive summary for "Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future":

- Fewer than one-third of US 4th-grade and 8th-grade students performed at or above a level called "proficient" in mathematics; "proficiency" was considered the ability to exhibit competence with challenging subject matter. Alarmingly, about one-third of the 4th graders

and one-fifth of the 8th graders lacked the competence to perform even basic mathematical computations.
- In 1995 (the most recent data available), US 12th graders performed below the international average for 21 countries on a test of general knowledge in mathematics and science.
- US 15-year-olds ranked 24th out of 40 countries that participated in a 2003 administration of the Program for International Student Assessment (PISA) examination, which assessed students' ability to apply mathematical concepts to real-world problems.

The problem is exacerbated by the shortage of adequately prepared teachers in the K-12 system. Additional information from the executive summary for "Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future" indicates the following:

- In 1999, 68% of US 8th-grade students received instruction from a mathematics teacher who did not hold a degree or certification in mathematics
- In 2000, 93% of students in grades 5–9 were taught physical science by a teacher lacking a major or certification in the physical sciences (chemistry, geology, general science, or physics)

Recent data from the Department of Education and results from the National Science Foundation's Math Science Partnership program indicate upward movement. Even so, much remains to be done. Organizations at many levels are attempting to implement local and short-term fixes through continuing education, additional training, retraining, enhancement to undergraduate programs, etc. These efforts are laudable and are indeed making a small but noticeable impact. However, a longer term strategic solution must be developed and such a system would address the entire K-20 pipeline. The information presented in this section should make it clear that a logical starting point for addressing the human capital shortage is the K-12 system. That is why outreach programs have taken on both significance and urgency in the last decade.

Outreach Programs at Robert Morris University

The School of Engineering, Mathematics and Science (SEMS) at Robert Morris University affirms that students get excited about STEM careers in Engineering, Mathematics, and Science through interaction and hands-on demonstrations. With that in mind, SEMS has been active in outreach activities enabling middle and high school students and their teachers to get involved at the university level.

STEM outreach programs began in the area of Manufacturing Engineering in 2002 when the institution was a lead partner in the PRIME (Partnership for Regional Innovation in Manufacturing Education) coalition – a partnership delivering innovative manufacturing education and career development in Southwest Pennsylvania. A series of events that were offered under an umbrella called "Molding Minds in Manufacturing" enabled the authors to test and implement several ideas and programs that engaged over 700 students and teachers. Building on this foundation, the current STEM outreach campaign was launched across the school in the fall of 2005. STEM outreach efforts take place throughout the year and there are enough activities to keep students busy during the school year and over the summer. SEMS has

approached STEM outreach programming by focusing on teachers and students. Programs range from workshops and camps to conferences and competitions. While the majority of the programs are non-credit-bearing, the School has launched a credit-bearing initiative that offers students up to 6 credits of university credit towards a STEM degree.

The mission of the STEM outreach program at RMU is to increase the number of middle and high school students who view STEM careers favorably and matriculate into and ultimately graduate from post-secondary programs in these areas. The vision for STEM outreach at RMU is a vibrant pipeline that progressively and continuously engages elementary through high school students in a range of activities that draws them into STEM post-secondary programs while strengthening their mathematics, science, communication, and professional skills. The strategy that has been employed by SEMS includes STEM awareness events, workshops, competitions, conferences, and campus. The outreach initiative targets students, parents, and teachers over the entire academic year with non-residential events during the school year and some residential events over the summer. STEM outreach activities have been largely co-ed in nature with some events specifically designed for female or minority students. The SEMS outreach philosophy is one of repeated contact with a group of students over time in order to realize the conditioning and education needed prepare students for college STEM programs. STEM outreach programs at SEMS/RMU are now presented in some detail.

Student Programs

Expanding Your Horizons Conference

The "Expanding Your Horizons" EYH Conference is an annual event that takes place in October and is for young women in grades 6 – 9 who demonstrate an interest in Science, Technology, Engineering & Mathematics. This event was developed to get middle school girls interested in those fields by inviting them to participate in fun & exciting hands-on workshops led by women scientists, mathematicians and engineers. Through career conversations, professional women share their expertise, education, and discuss job satisfaction. This also allows young women to interact with positive, female role models who encourage them to pursue these careers and not give up. Girls are encouraged to discuss the education necessary for such careers and learn what a typical day on the job is like.

Based on the first Expanding Your Horizons Conference in 2007, 71% of the young women indicated that they became more interested in math and science based on what they learned that day and 78% learned about new careers in the STEM fields. Over the past two years, this event has impacted 551 students, parents, teachers, and other attendees.

Middle and High School Student Workshops

STEM workshops are held on an on-going basis throughout the year and typically take place on Saturday mornings and afternoons. These three-hour workshops cover topics from the three disciplines of engineering, mathematics, and science with an average class size is 15 students. In the most recent year, there 156 students enrolled in 11 workshops. SEMS faculty, staff, alumni, and students staff the workshops. In addition, the school has built partnerships across the region with various professional organizations and societies. One such example may be found in the

partnership with the Society of Automotive Engineers (SAE) International Foundation where SAE colleagues used the "A World In Motion" program to offer the "Jet Toy Olympics".

The workshops held in the past three years include:

- Lego Mindstorms
- Math Competition
- Modern Lab Instrumentation
- Computer Aided Engineering for Future Engineers
- Perfume Science
- Robotics
- Ready, SET, Let's Play
- Digital Communications
- ZOOB Mania
- Legos NXT
- The Rubik's Cube and other Mathematical Puzzles
- SAE International presents A World in Motion, Jet Toy Olympics
- VEX Robotics
- Blood & Enzyme Experiments
- Robotic Arms

Since the Fall of 2005, over 500 middle and high school students have participated in workshops at the University.

Science Bowl

The Science Bowl takes place in December and is a high school competition that consists of a team of four students (9th grade, 10th grade, 11th grade, and 12th grade) with a teacher or parent serving as the "coach". The areas covered are Biology, Chemistry, Physics, Environmental Science, and Geology. This contest takes the form of a trivia game with elimination rounds (this way it is fast-paced to keep the students attention). The contest ends with an awards ceremony. The 3rd Annual Science Bowl was held in December 2008 and we experienced growth for the third year in a row in terms of the number of teams competing with the most recent year featuring 12 teams and 46 students.

MathCounts

In 2008, the University established a partnership with the Pittsburgh chapter of the Pennsylvania Society of Professional Engineers (PSPE). One facet of the partnership involves the hosting of the MathCounts competition for Allegheny County. This is an annual Spring event and in 2008, the event attracted 173 students from 29 middle schools. Over 40 university faculty, staff, students, and alumni served as proctors and graders for the event.

Middle & High School Summer Residential Camps

SEMS summer camps are designed to give middle and high school students an in-depth STEM experience. The camps consist of class time in the morning and afternoon in their respective areas. In addition, the students also tour local companies and listen to presenters from industry that reinforce what they are learning and see it applied in the "real world". Camp costs include room and board on campus at the student apartments. Chaperones are drawn from local middle and high school teachers. The camps conclude with a ceremony and dinner with their parents. In 2008, 100 middle and high school students attended the summer camps. Examples of residential camps are now overviewed.

The *Animatronics Camp* was designed to introduce high school students to animatronics and robotics. Students worked in teams and individually to design, build and integrate components

that gave them the background to create their own animatronic model. The Animatronics camp curriculum covered the following topics: Introduction to Robotics and Animatronics, Engineering and Product Design and Development, Project Management and Teamwork Basics, Concept Development and Artistic Design, Modeling/Prototyping, Mechanism Design and Assembly, Electricity and Electronics Basics, Costuming and Integration, and Animatronics in Entertainment or Daily Life.

The interaction with the "real world" through company tours was a significant feature of the camps. The Animatronics camp toured The Creegan Company's "Animation Factory" in Steubenville, Ohio. Creegan's motto is "We make things move" and this family owned and operated company is the nation's largest manufacturer of animated and costume characters. They have been featured on the Travel Channel's "John Ratzenberger's Made in America" and they have designed many characters for Disney World, Sea World, etc. The President/CEO of Creegan spent a considerable amount of time talking to the students and answering their questions.

The ***F1 Engineering Camp*** charged students to research, design, manufacture, and ultimately race a CO_2-powered model cars – a process that replicated many facets of real F1 racing. Students used CAD (computer-aided design) software to create virtual 3-D models of their cars. Once a car was designed to the satisfaction of the student, the models were transferred to a virtual wind tunnel for performance analysis of the design. The models were then transferred to a CNC (Computer Numerical Control) software package and machined on a CNC milling machine (Denford MicroRouter). The camp ended with races conducted on an 80-ft long race track.

The F1 Engineering Camp participants toured the BeaveRun Motorcomplex in Wampum, PA. They were greeted by the owner who talked to the students about BeaveRun and showed them cars similar to the ones they were designing and manufacturing in class. The students also had an opportunity to meet a young, female engineer on staff at the complex. The timing of the tour was remarkable in that the campers were able to see several actual Formula 1 cars at the complex – a phenomenon that happens infrequently during the year. The tour ended on an unexpectedly high note when the complex staff took all the students and chaperones on a ride around the track in the race cars.

The ***Forensics Camp*** introduced students to this exciting field. Chemistry, biology, and mathematics professors taught students in the school's state-of-the-art laboratories. The students were exposed to many areas that real crime scene investigators use in their line of work: Trace Analysis (hair & fingerprints/tools & markings) Blood Spatter & Typing, Digital, DNA and Mathematical Forensics, and Forgery Detection. At the end of the week, the students put their newfound knowledge to use by playing the role of a crime scene investigator to examine evidence and analyze data to solve a murder.

The ***Legos NXT/Robotics*** camp featured a day of beginner and advanced Legos NXT led by an RMU Software Engineering alumna from the class of 2003. Students learned the basics in the morning and by the afternoon they were building robots to navigate around obstacles using the NXT software. Students were able to learn about robots and machines used by the engineering

students in the program. Their experiences were further enhanced by a tour of the Sony Plant in Mt. Pleasant, PA where industrial robots are used in the production line of televisions. The students were able to follow the entire manufacturing process of a television set. The next two days were spent building their own robots with a different robotic system of VEX robots under the expertise of a veteran engineering faculty member.

College to High School (CHS) Program

In addition to the various programs listed above, the School has developed a "College to High School Program". This program offers students the opportunity to earn college credits in their high schools during the regular school day. CHS courses are co-taught by a high school teacher (lecture portion) and an RMU professor (laboratory portion). Student can earn college credit at a fraction of the cost and come to campus about 5 times over the course of the semester. Course offerings have included Biology, Environmental Science, and Introduction to Engineering. At the present time, the School has agreements with 5 schools for such programs.

Teacher Programs:

Tours & Adopt a School

Many K-12 educators in the region are not aware of the programs offered by SEMS. Of those who do, not all realize that the school has a state-of-the-art facility. SEMS offers tours of all its facilities throughout the year to middle and high school students and teachers. The School also works with area middle and high schools to provide faculty presentations/demonstrations in the classroom upon request.

SEMS Speaker Series

Preceded by receptions in which educators received overviews of our programs and tours of our laboratories and the Learning Factory, SEMS continues to reach out to teachers during the school year with a "Speaker Series" in which a professor in each designated area of engineering, mathematics, and science presents a technical seminar in an area of expertise. These content-deepening events may then be used by the audience in its classes or to identify areas of mutual interest for future projects.

STEM Educator Conference

The STEM Educator Conference for middle and high school teachers enables educators to learn tips and techniques in the areas of Science, Technology, Engineering, and Science (STEM) that they are able to incorporate in their classroom. These are presented in the form of plenary sessions, lunch presentations, and workshops. The workshop leaders are drawn from SEMS faculty and industry. All attending educators (47 in the last year) earn Act 48 activity hours during this summer conference.

Impact of Outreach Programs

85% of Robert Morris University students are drawn from southwestern Pennsylvania and the tri-state region. 90% of our alumni stay and work in this same region. Thus, the university serves as a significant regional economic driver. Outreach activities draw from the same geographical area and inspire young men and women to embrace STEM professions. By

impacting, enhancing, and strengthening this vital pipeline, XYU is making measurable impact on the human capital that is needed for the long-term growth and prosperity of the region. Table I summarizes the results of Robert Morris University's STEM outreach programs since their inception.

Table I: STEM Outreach Activities from October 2005 – January 2009

Activity	Audience	Attendance				
		2005	2006	2007	2008	2009
TEACHER EVENTS						
Adopt a School	Teachers and students				13	
Educator Reception	Teachers, Guidance Counselors, Principals, Superintendents	15	28	9		
STEM Speaker Series (replaced receptions)	Teachers, Guidance Counselors, Principals, Superintendents				15	
Expanding Your Horizons Conference	Teacher Workshops in 2007			19		
Science Bowl	Teachers serving as coaches		7	12	14	
STEM Educator Conference	Math, Science, Technology & Gifted Teachers				47	
Summer Residential Camps	Teachers serving as chaperones & class helpers				20	
STUDENT EVENTS						
Expanding Your Horizons Conference	Young Women in 6-9th Grade			181	179	
	Parents			50		
	Workshop Leaders/Career Panelists & Volunteers			64	58	
Fall & Spring Outreach Workshops:	Middle & High School Students	60	150	119	156	54
Science Bowl	High School Students (Teams of 4)		28	45	46	
	Audience (Parents & Students)		28	50	50	
Summer Residential Camps	Middle & High School Students				99	
VEX Robotics Day Camp	High School Students				12	

Note: The grey areas on the table in 2005, 2006, and 2007 indicate that the events had not yet been launched. Grey areas on the table in 2008 and 2009 reference discontinued activities.

Since 2005, 817 students have attended STEM outreach activities at the University. Of these students, 505 (62%) are female, due to the increased attendance of young women at our Expanding Your Horizons conference. 183 students (22%) have attended our events two or more times, which is an indicator of their interest in STEM. One measure of the success of the STEM outreach initiative may be seen in the 23 students who have matriculated into various programs at Robert Morris –this number includes both SEMS and other University programs. While the entering class of 2009 has not yet been finalized, 5 outreach students will start at RMU as freshmen in SEMS degree programs. In the last two years, we have also seen significant gains in students asking to be added to our database to receive upcoming STEM outreach activities.

From October 2007 through January 2009, our database grew by 1,142 new students, which was a 95% increase.

In addition, 149 educators have attended events, with 39 (26%) attending two or more events. This is also very important because when educators leave RMU and "take their information back to the classroom" the University has indirectly impacted those students as well.

Attributes of Successful STEM Outreach Programs

The ultimate objective of any successful STEM outreach programs is to recruit well-prepared talent into science, technology, engineering, and mathematics-related professions. The process may take over a decade and it is easy to lose sight of higher level goals while engaged in process-based minutiae. Working backwards from the goal of infusing STEM talent into the workforce, one might see the pipeline that sequentially includes success at the post-secondary level, the right courses in mathematics and science accompanied by appropriate guidance at the high school level, the kindling of the spark and exploration at the middle school levels and beyond. STEM outreach activities have to be carefully designed and implemented in order to draw students into the pipeline, sustain their interest over time, and ultimately see them enter the workforce as leaders of the future. Based on their experience, the authors believe that successful outreach programs share many attributes. These are now presented along three dimensions:

<u>Students</u>

- It is never too early to start interacting with students on a range of STEM topics. It is also very beneficial to have students engaged in a range of outreach programs over time. While this may limit the total number of students exposed to STEM, it increases the depth at which the audience is engaged.
- It goes without saying that hands on activities that supplement what is taught in the classroom is a very effective way of engaging students, promoting inquiry, and deepening their understanding of the material.
- It is desirable to promote learning in a robust, fun, and challenging environment that allows the instructors to link the concepts being taught to real-life applications of engineering, mathematics, and science.
- The infusion of real-world experiences further reinforces the experience and its value to the participant. Supplementing classroom learning and hands on activities with tours of industry at this early stage of a student's life opens their eyes as to "how all the pieces fit" and what they might be doing with their lives several years down the road.
- Career exploration may be effectively incorporated into many an outreach program by linking the material presented to topical areas, programs of study, and employment opportunity as appropriate to the audience. For high school audiences, career progression may well constitute a part of the dialog. A survey of area high school freshman in 2002, yielded information that demonstrated that these students were thinking about careers, graduate school, opportunities for growth and promotion, and other related topics of considerable sophistication.
- A student's interest in subject areas that may have the reputation of being either dull or hard to master may be piqued by presenting unusual applications from the subject. For example, in one case, Chemistry concepts were taught using perfume science as the goal. In another,

mathematics concepts were conveyed using the Rubik's Cube and encryption as the vehicles. In both cases, students demonstrated their prowess in a range of creative endeavors.

- While the School has historically offered all outreach activities to a co-ed audience, it recognizes the significant gender and race imbalances that exist in the workforce. The school has offered and continues to develop targeted programs for women and minorities with the objectives of motivating them, bringing together groups with similar desires and challenges, and providing them the opportunity to interact with role models.

Teachers

- Teachers are an integral part of any effective outreach program and need to be fully engaged in an institution's outreach efforts. At Robert Morris University, this has extended to recruiting teachers to serve as chaperones for residential camps – a strategy that has resulted in the word of mouth promotion of STEM outreach at the University.
- Presenting content deepening seminars and partnering with middle and high school teachers on ideas to supplement their curriculum or university-sponsored classroom demonstrations is an effective vehicle for teacher engagement. In addition, it allows the students to be engaged in STEM activities while at school.
- The preparation of materials and experiments for the classroom along with appropriate training in their use ensures that the STEM enhancement programs for teachers extend beyond personal development initiatives into the classroom.
- The credentialing of professional development activities through graduate programs, certificates, or continuing professional education (Act 48) credits enables a teacher to document and use a valuable investment of time and effort towards their personal growth and career advancement.
- Post-secondary institutions must be flexible in their approach to outreach and work with middle and high schools to offer programs that are of mutual benefit. The "one size fits all" approach may well be attractive from the ease of deployment standpoint and be easy to manage. However, deeper engagement and partnerships are enjoyed by those who flex to meet the needs of the customer – a fundamental tenet of Quality Function Deployment.

Infrastructure

- Having faculty doing the teaching with the assistance of students or even alumni makes for a rich experience that also provides participants with the best of both worlds – the experience and wisdom of the faculty coupled with the youth and vibrancy of the students and alumni.
- STEM outreach is an endeavor that takes time to bear fruit – it is not a quick fix and institutions expecting to see immediate results will be disappointed. It is therefore necessary to have institutional buy in at various levels. Strong champions are needed at the institution, school, and program level to sustain such a campaign over time.
- Faculty buy in may take time at some institutions and may not even be a priority to some faculty. However, over time a successful STEM outreach program will attract a range of committed and passionate faculty who "recharge their batteries" through interactions with youth who may well be the industry captains of tomorrow. Mentoring relationships that begin at this stage may well translate into student decisions on colleges and universities or relationships that grow over time.
- External support from philanthropic organizations, corporations, and professional societies allow institutions to launch or expand programs in short order. This infusion of resources

enables institutions to build their infrastructure, subsidize its offerings, and even provide additional assistance for truly needy students. However it is incumbent upon the institution to develop and implement a realistic sustainability plan that will enable the continuation of programs beyond funding lifecycles.

- Networking with like-minded individuals and organizations is highly recommended. STEM outreach programs may be found at virtually every institution and institutions must network with affinity groups to glean/share best practices as part of their continuous improvement efforts.
- Tracking the responses of student and teacher participants in STEM outreach programs allows an institution to keep its finger on the pulse of the community and allows the institution to be agile in making programmatic/operational changes in response to feedback.

The attributes that have described above are not exhaustive in nature. They reflect the experiences and findings of the authors over two decades of outreach programs and work.

Future Direction and Growth

The STEM outreach initiative at Robert Morris University was started on a small scale with no external funding. It was based on existing laboratory capabilities and resources. Modest fees assessed of the workshop participants were used to defray operational expenses associated with each event. A grant from the Claude Worthington Benedum Foundation was used to significantly grow the infrastructure of the University's outreach program. It was also used to launch a series of new programs and events for students and teachers. In addition, some of the funding was used to subsidize expenses associated with the residential camps.

All SEMS outreach events are currently oversubscribed and significant wait lists are a common by-product of the program. At the present time the authors will be working on several initiatives as part of the enhancement of the program. These initiatives include the following:

The School of Engineering, Mathematics, and Science is a young school with 35 faculty and staff. While the facilities are exceptional, they are small and the examination of the capacity of the school is a necessary component of its planning activities. Capacity planning will help the institution "right-size" the outreach program in terms of the number of events and the participation in individual events. The process of right-sizing will include evaluating the mix of events that are developed by the university as well as those that are nationally-normed.

Another initiative involves the evaluation of the quality of applicants for the School's outreach events. The program has evolved from open enrollment on a first come first serve approach to merit-based selection that will include the evaluation of candidate essays, STEM-related interests, and teacher recommendations for selected events. While the school is committed to providing STEM outreach programming to a wide range of students, the school will apply the higher quality requirement to the summer camps in order to attract the most interested and committed (this does not automatically translate to the most academically advanced) students.

The school will continue to identify and build strategic partnerships to extend its geographic reach, scope of work, and expertise. For example, a new partnership with a non-profit in West

Virginia will enable the school to implement social networking for pre-college students. In addition, the school will continue to grow its focus on women and minorities.

STEM outreach at Robert Morris University will continue to focus on the most critical issues facing the nation including energy, the environment, etc. Publications such as the National Academy of Engineering's "Grand Challenges for Engineering" will continue to inform the school and help set the agenda for its outreach programs[9]. Finally, the school continues to focus on sustainability of its outreach programs by investing in infrastructure using grant funds while using event revenues to cover all operational costs.

Conclusion

Rising Above the Gathering Storm identifies high priority actions that the United States needs to take for the nation to successfully compete, prosper, and be secure in the global community of the 21st century. These include improving K-12 STEM education, strengthening the commitment to basic research, STEM human capital development through domestic and international recruitment, and the creation of a climate of innovation. The recommendation pertaining to K-12 STEM education improvement focuses on strengthening the skills of teachers through training and education programs and enlarging the pipeline of students who are prepared to enter college and graduate with a degree in science, engineering, or mathematics.

STEM outreach can no longer be considered as an optional activity or a public relations effort on the part of an institution to reach out to the community. Rather, it is a necessity and an investment in the future of our nation's youth who constitute the future workforce, and by extension - the nation's competitiveness.

Discussions about STEM outreach and scope are sometimes sidetracked by considerations of perfect solutions that fix the entire system of education. The nation does not have the luxury of waiting for the perfect, universal solution that resolves any shortcomings of K-12 educational systems. The nation also does not have the luxury of wallowing in the assignment of blame for the shortcomings of students and teachers or bemoaning the diminishing number of high school graduates. Rather, it is imperative that time, effort, energy, and resources be directed at the development and implementation of systems that enable the educational pipeline that start during a student's early years in school and result in well prepared STEM graduates in the workforce or in graduate school. This is not a trivial task and involves everybody – students and families; school systems, corporations, economic development agencies, non profits, and universities. It is up to every educational institution to determine its role in this process. SEMS is unwavering in its commitment to this vital mission of growing the human capital necessary for the competitiveness and survival of our nation on a global playing field.

Bibliography

1. Robert E. Scott, The Importance of Manufacturing: Key to recovery in the states and the nation, Economic Policy Institute, Briefing Paper #211, 2008.

2. Thomas L. Friedman, The World is Flat: A Brief History of the Twenty-first Century, Picador, 2007.
3. Made in North America, A Deloitte Research Manufacturing Study, The Manufacturing Institute, National Association of Manufacturers, Canadian Manufacturers and Exporters, 2008
4. http://www.boeing.com/commercial/777family/background.html
5. http://www.boeing.com/commercial/787family/background.html
6. Lester C. Thurow, Building Wealth: The New Rules for Individuals, Companies and Nations, Collins Business, 1st Edition, 1999.
7. ATS Survey Shows Baby Boomer Retirement Fuels Skilled Labor Shortage In Manufacturing; Puts U.S. Industry In Crisis, http://www.advancedtech.com/press-releases.aspx
8. Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, 2007
9. Grand Challenges for Engineering, National Academy of Sciences, on behalf of the National Academy of Engineering, 2008.