

## The Roles of Ohio Two-Year Colleges in Science, Technology, Engineering and Mathematics (STEM) Education

*Tapping America's Potential: The Education for Innovation Initiative*, a report issued by fifteen prominent business organizations in the U.S. urges the United States as a nation to build up its infrastructure to support and encourage science, technology, engineering, and mathematics (STEM) education in order to maintain competitiveness in the 21<sup>st</sup> century. The American Association for the Advancement of Science (AAAS) Project 2061, *Science for All Americans* calls for total science education reform in our schools because most Americans are scientifically illiterate. As the world is getting “flatter,” as depicted by Thomas Friedman in *The World is Flat*, our nation is faced with fierce global competitions. They all concluded that we, as a nation, need to make a national commitment to improve STEM education. If not, we will be losing our scientific and technological superiority; and our economic well being and national security will be in jeopardy. Some basic facts of the status of STEM education in the U.S. are listed in Table 1.

In order to regain our competitiveness in science and engineering in the 21<sup>st</sup> century, *Tapping America's Potential (TAP)* recommends that the U.S. needs to “**double the number of science, technology, engineering and mathematics graduates with bachelor's degrees by 2015.**” Obviously, this is an ambitious goal and it needs the commitment from the government (at all levels) and collaborations from the business and education sectors.

Two-year colleges are quite often overlooked as a major partner and contributor in rebuilding the nation's competitive edge by contributing to the STEM education. In order to achieve this goal, policy makers and all stakeholders need to understand how the two-year colleges help contribute to the STEM education.

1. Two-year colleges provide a pipeline of students to baccalaureate institutions majoring in STEM programs.
  - Community colleges offer Associate of Science degrees preparing students to transfer to baccalaureate institutions in all STEM disciplines. In addition, technical colleges and community colleges also offer applied associate degree programs in engineering technology, computer information technology, as well as many health career programs in which their graduates may pursue a baccalaureate degree in one of the STEM programs. List of STEM related programs offered by two-year colleges is attached. (Table 2).
  - Two-year colleges established articulation agreements with many public and private four-year institutions, in-state as well as out-of-state, to provide students with the education pathway and a seamless transfer into baccalaureate STEM disciplines. (Table 3).
  - A significant number of students in baccalaureate STEM programs transferred or graduated from two-year colleges. According to the NSF report on *The Role of*

*Community Colleges in the Education of Recent Science and Engineering Graduates*, 44% of bachelor's and master's degree science and engineering graduates attended community colleges (Table 4). Among those, 28% earned an associate degree (Table 5).

- At the state level, among the 13 Ohio public universities, the percentages of baccalaureate STEM graduates from 2003 to 2005 who took courses at two-year colleges increased steadily over the years from 19% to 23% (Table 6).
2. Two-year colleges contribute significantly to the training of science and mathematics teachers who in turn have major influence on their students to pursue careers in STEM in the future.
    - According to the NSF report, *Investing in Tomorrow's Teachers: The Integral Role of Two-Year Colleges in the Science and Mathematics Preparation of Prospective Teachers*, a majority of elementary and middle school science and mathematics teachers took all their science and mathematics courses at two-year colleges. Thus, the two-year colleges provide the science foundation for these teachers. These elementary and middle school science and mathematics teachers are most crucial in influencing their students' future interest in STEM related disciplines.
  3. Two-year colleges play a major role in increasing the diversity of students in STEM education programs and hence the diversity of the future workforce in STEM.
    - Due to the commitment of two-year colleges to open access, they tend to attract the underrepresented population (women and minority). The current STEM work force is 82% white and more than 75% male (NSF data). Thus, by nurturing the "new majority"- the traditionally underrepresented population, two-year colleges play a critical role in increasing the diversity of the STEM work force.
  4. Two-year colleges are actively engaged in many STEM initiatives funded by external sources (state, federal and foundations) and local contributions. Millions of dollars have been awarded to two-year colleges for these projects. Many of the projects also involve partnerships with baccalaureate institutions. Most of these initiatives belong to one of these categories listed below: (Table 7 lists examples of these initiatives)
    - Initiatives to enhance and strengthen STEM programs.
    - Initiatives to reach out to K-12 students and particularly the underrepresented population to pursue a STEM career.
    - Initiatives that provide professional development opportunities for teachers.
    - Initiative to promote workforce development in a technology-related job.

5. Two-year colleges have also established seamless articulations with high schools in Tech Prep programs in engineering technologies, computer information technology, as well as health technologies. These postsecondary Tech Prep students are potential students for the baccalaureate STEM programs in the future.
  - Over half of the high school Tech Prep graduates who subsequently enrolled in an Ohio public college majored in one of the STEM related programs (engineering technologies and information technology). It ranges from 57% to 66% over the last five years (Table 8).
  - If health technologies are included, around 80% of the high school Tech Prep graduates who subsequently enrolled in an Ohio public college majored in the STEM related programs. It ranges from 78% to 83% over the last five years (Table 8).

Ohio two-year colleges' roles in STEM education are multidimensional. It is obvious that the two-year colleges play a critical role in providing STEM education for many. They establish education pathways and career ladders for students interested in STEM. They also engage in various initiatives to foster students' interest in pursuing a career in STEM. **Therefore, any statewide initiatives or discussions, be it budgetary or curricular that are related to STEM programs, should involve and actively sought out consultations from two-year colleges.**

Furthermore, the **Ohio Council of Chief Academic Officers for Two-Year Colleges** strongly feels that health technologies should be included in the discussion of STEM. Even though the traditional definition of STEM does not include health technologies, however, the major content as well as the prerequisite knowledge of these programs do require a good understanding of science, mathematics and technology.

Particularly important is the fact the Ohio is facing a critical shortage of health care practitioners. The **National Center for Health Workforce Analysis** predicts that Ohio will reach a shortfall of 32,000 registered nurses by the year 2020, a 29% shortage. Graduates of associate degree programs represent 65% of the RN graduates in Ohio, and 85% of all the first responders in the nation. According to the data, other healthcare professions with high vacancy rates are medical lab technicians, radiologic technologists and respiratory therapists. All these programs have a strong science, mathematics, and technology component. **Thus, we would strongly urge that health technologies should be included in the future discussions of statewide initiatives that promote or support STEM programs.**

When addressing the shortage of STEM baccalaureate, one needs to understand that there are many career opportunities in the STEM fields that do not necessarily require a baccalaureate degree. A 2004 NSF report indicated that more than four million individuals were employed in science and engineering occupations in 2003, with 22% of them hold an associate degree (17%) or a high school diploma (5%) as their highest level of educational attainment (Table 9). In Ohio, 17% of all bachelor's degrees awarded at four-year public universities in 2004 were in STEM compared to 22% at two-year colleges. The majority of the 22% associate degree graduates are either employed in a STEM related occupation or continuing their education in a STEM

discipline. **Thus, associate degree STEM graduates have a profound impact on the state economy as well as the future STEM talent pool.**

The recent Performance Report released by the OBR revealed that there is a significant growth in the value of the associate degree in Ohio. For the last three years, new associate degree graduates are making more than new baccalaureate degree graduates. New Ohio associate degree holders were making 8.3% or \$2,752 more than new baccalaureate degree holders six months after graduation. This is a good example of a **high return on educational investment** taking into the consideration the low cost of an associate degree education compared to the baccalaureate education.

Undoubtedly, the need for more STEM baccalaureate graduates is important, but the need for associate degree graduates in the workforce has an even greater demand, particularly in the health technologies and other engineering technology fields. The Ohio Department of Job and Family Services has projected that the Ohio economy needs a 21.7% increase in new associate degree graduates during the next decade. **Therefore, in the discussion of increasing baccalaureate STEM graduates, it is prudent to include the discussion of how to increase the pool of associate degree graduates in the health technologies, engineering, mathematics and science (or HEMS) as well.**

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## **Table 1**

### **A Few Facts About STEM Education in the U.S.**

- Among the 1.3 million college graduates in the U.S. in 2005, 70,000 are engineers, whereas China has 3.3 million college graduates with 600,000 engineers. Taking into consideration of the difference in number of college graduates, China still has four times more engineers than U.S.
- South Korea graduates as many engineers as the U.S. while its population is only 1/6 of the U.S.
- By 2010, more than 90% of all scientists and engineers in the world will be living in Asia.
- Only 6% of the 1.1 million high school seniors who took SAT or ACT in 2002 indicated plans to pursue a degree in engineering, a 33% decrease from the last decade.
- More than 50% of all engineering doctoral degrees awarded by U.S. colleges are foreign nationals
- The number of engineering degrees awarded in the U.S. is down 20% from the peak year of 1985.
- Although the U.S. fourth graders score well against international competition, they fall near the bottom or dead last by 12 grade in mathematics and science respectively.
- Basic research funding for physical sciences has declined by half since 1970.

**Table 2**

**Science, Technology, Engineering, and Mathematics (STEM) Related Degrees  
At Ohio Two-Year Colleges**

Associate of Science

- Biological sciences
- Environmental Sciences
- Computer Science
- Mathematics
- Physical sciences
- Pre-Engineering
- Pre-Professional (Pre-Medicine, Pre-Dentistry, Pre-Pharmacy...etc.)

Associate of Applied Science

- Biotechnology
- Engineering Technologies
  - Avionics
  - Ceramic
  - Chemical
  - Civil
  - Computer Networking
  - Digital Communication
  - Electrical/Electronic
  - Engineering Graphics
  - Environment
  - Fuel Cell and Alternative Energy
  - GIS
  - Industrial
  - Mechanical
  - Mining
  - Manufacturing
  - Plastic
  - Nuclear
  - Quality
  - Robotics
- Nursing
- Allied Health (Respiratory, Radiologic Technology, Medical Lab Technology...etc.)

Associate of Applied Business

- Computer Information Systems
- Computer Networking

**Table 3**  
**Colleges and Universities with Articulation Agreements**  
**For Baccalaureate Degrees in STEM Disciplines**

**State Institutions**

Bowling Green State University  
Central State University  
Cleveland State University  
Kent State University  
Medical College of Ohio  
Miami University  
Ohio University  
Shawnee State University  
The Ohio State University  
University of Akron  
University of Cincinnati  
University of Rio Grande  
University of Toledo  
Youngstown State University

**Private Institutions**

Antioch College  
Baldwin Wallace College  
Capital University  
Devry Institute of Technology  
Embry-Riddle Aeronautical University  
Franklin University  
John Carroll University  
Mount Vernon Nazarene College  
Ohio Dominican College  
Ohio Northern University  
Otterbein College  
Pennsylvania College of Technology  
University of Findlay  
University of Northwestern Ohio  
Ursuline College  
Wilberforce University

**Table 4**

**1999 and 2000 S & E Bachelor's and Master's Degree Recipients  
By Attendance at Community Colleges**

Degree	All Recipients	No. Attended	Percent
All Fields	903,400	394,200	44
Computer & Math	115,000	47,900	42
Life & Related Sciences	172,300	78,900	46
Physical & Related	41,100	15,100	37
Engineering	151,200	59,800	40

Source: National Science Foundation (excluding social sciences)

**Table 5**

**1999 and 2000 S & E Bachelor's and Master's Degree Recipients  
Who Also Received An Associate Degree**

Degree	All Recipients	Received Degree	Percent
All Fields	394,200	110,100	28
Computer & Math	47,900	18,300	38
Life & Related Sciences	78,900	15,400	20
Physical & Related	15,100	3,500	23
Engineering	59,800	13,000	22

Source: National Science Foundation (excluding social sciences)

**Table 6**

**Ohio Baccalaureate STEM Graduates in FY 2003-2005**

Year	Institution	Type	Number of graduates	Number taking courses at a 2-year institution <sup>1</sup>	Percent taking courses at a 2-year institution	Average semester credit hours taken at 2-year institution
2003	AKRN	STEM	352	59	17%	29
	BGSU	STEM	307	81	26%	22
	CINC	STEM	578	61	11%	22
	CLEV	STEM	266	104	39%	32
	CNTL	STEM	29	7	24%	20
	KENT	STEM	369	39	11%	22
	MIAM	STEM	458	31	7%	8
	OHSU	STEM	1,407	334	24%	21
	OHUN	STEM	465	75	16%	22
	SHAW	STEM	47	10	21%	22
	TLDO	STEM	621	114	18%	22
	WSUN	STEM	303	115	38%	26
	YNGS	STEM	316	4	1%	45
	<b>Total</b>			<b>5,518</b>	<b>1034</b>	<b>19%</b>
2004	AKRN	STEM	338	53	16%	30
	BGSU	STEM	308	87	28%	32
	CINC	STEM	539	72	13%	18
	CLEV	STEM	240	93	39%	37
	CNTL	STEM	28	10	36%	11
	KENT	STEM	348	45	13%	32
	MIAM	STEM	462	59	13%	20
	OHSU	STEM	1,686	455	27%	21
	OHUN	STEM	437	49	11%	21
	SHAW	STEM	61	11	18%	50
	TLDO	STEM	702	170	24%	29
	WSUN	STEM	293	111	38%	32
	YNGS	STEM	327	17	5%	23
	<b>Total</b>			<b>5,769</b>	<b>1232</b>	<b>21%</b>
2005	AKRN	STEM	362	59	16%	33
	BGSU	STEM	287	100	35%	31
	CINC	STEM	569	74	13%	24
	CLEV	STEM	207	101	49%	41
	CNTL	STEM	25	7	28%	9
	KENT	STEM	467	73	16%	32
	MIAM	STEM	490	58	12%	19
	OHSU	STEM	1,672	477	29%	22
	OHUN	STEM	425	81	19%	27

	SHAW	STEM	53	10	19%	51
	TLDO	STEM	609	153	25%	40
	WSUN	STEM	258	102	40%	35
	YNGS	STEM	320	15	5%	21
<b>Total</b>			<b>5,744</b>	<b>1310</b>	<b>23%</b>	<b>30</b>

\* HEI data dating back to beginning - FY 1998

**Table 7**  
**Examples of STEM Initiatives at Two-Year Colleges**

- Under the President's High Growth Job Training Initiative, Lakeland Community College received a \$335,000 U.S. Department of Labor grant to address job training needs for careers in the biotechnology industry. Part of the grant will be used to develop a Bio-Center to teach biotechnology lab skills to high school students. The Bioscience Technology program also received a \$35,000 NSF ATE grant for equipment and a \$30,000 grant from Tech Prep to develop a model Biotechnology Tech Prep curriculum for the state.
- Columbus State Community College was the only two-year college in a 19- institution consortium grant from NSF to reform the pedagogy of undergraduate chemistry. The grant awarded the consortium \$5 million to involve undergraduate chemistry students in a research experience throughout their general and organic chemistry coursework. Additionally, CSCC will receive \$50,000 for the next five years including a \$10,000 of research grant money, and two full scholarships for students from CSCC to attend OSU in chemistry and scientific instrumentation.
- Marion Technical College is helping manufacturers remain competitive by developing training in advanced integrated manufacturing. A \$232,000 grant from the Ohio Department of Development's Ohio Investment in Training Program enabled MTC to partner with **Honda of America Manufacturing, Inc.**, and purchased a Simulated Integrated Manufacturing (SIM) Cell to use in automation technology and troubleshooting training for Honda employees, suppliers, and other manufacturing firms in Ohio.
- The Society of Manufacturing Engineers (SME) Education Foundation selected Terra Community College as one of four recipients of its 2002 grants geared to advance educational opportunities in manufacturing, engineering, science, and technology. In addition to the \$163,000 SME grant, area industry partners contributed an additional \$319,000, while Terra contributed approximately \$271,000 to the grant to develop a Center for Integrated Manufacturing Solutions (CIMS). The funds were also used to revise the current manufacturing curriculum and to renovate technology labs. Curriculum changes have allowed students to work for one full academic year on projects from design through implementation using the latest manufacturing processes and equipment.
- The partnership between Lorain County Community College and The Ohio State University was awarded a collaborative grant by NSF's Advanced Technology Education Program to work on the preparation of 21<sup>st</sup> Century welding and material joining technicians.
- Sinclair Community College was awarded a \$5 million NSF grant to establish a National Center for Advanced Manufacturing Education. The grant supported the development of an integrated manufacturing curriculum that is interdisciplinary and competency-based.

- Stark State College of Technology received over \$4 million from the Third Frontier to build a Fuel Cell Prototyping Center to support research, development, and commercialization of fuel cells. The college also received \$780,000 from NSF to develop a Fuel Cell Technology curriculum.
- As part of a \$5 million NSF grant, Lakeland Community College collaborated with six other colleges and the University of Illinois to develop a new two plus two program in Network Security. In this collaboration, Lakeland received \$300,000 and is responsible to develop several courses for the new curriculum.
- Columbus State Community College was awarded a \$200,000 NSF grant to provide 40 scholarships for two years for underrepresented groups wishing to pursue careers in STEM.
- Partnering with Lakeland Community College and the **FirstEnergy Corporation**, Central State University was awarded a \$2 million grant for its STEM UP-OUT (STEM Upgrade and Outreach) program by the U.S. Department of Energy. Lakeland will receive \$50,000 for scholarship and \$350,000 seed money to establish the Lakeland Electrical Power Institute - a workforce development program to recruit and train students for operating the nation's nuclear and fossil fuel power plants. In addition, Lakeland and Stark State College also received federal legislative funding of \$100,000 each to expand their Nuclear Engineering Technology program.
- A NSF funded joint venture between Capital University and Columbus State Community College's mathematics and science departments to establish undergraduate majors in science disciplines that focus on mathematical sciences and undergraduate research experiences. The intent of the program is to combine science/math and computer sciences into career pathways that will address the R &D needs of the 21st century.
- A unique articulation agreement in Bioscience Technology between Ursuline College and Lakeland Community College, where junior year biology majors at Ursuline take biotechnology classes at Lakeland for one year; while Lakeland's biotechnology graduates with an associate degree can move seamlessly into the Ursuline baccalaureate program in biology.
- Funded by NASA, the Science, Engineering, Mathematics, and Aerospace Academy (SEMAA) is designed to foster an interest of science, mathematics, and engineering in K-12 students. Its long term goal is to increase the number of students (particularly underserved populations) to pursue careers in science, engineering and mathematics. Millions of dollars have been provided to Cuyahoga, Lakeland, and Sinclair to operate this academy over the last 10 years.
- Project Lead the Way, a high school pre-engineering program that combines college-prep mathematics science and technology. Supported by five \$20,000 grants, Marion Technical College faculty work with faculty from five area middle and high schools to

prepare more young people for engineering careers so vital to Ohio's future. This project supports the Third Frontier, a knowledge economy initiative focused on high-tech, high paying jobs.

- Similarly, Rhodes State College participated in the Miller City School in Project Lead the Way program. Rhodes State offers digital electronics and computer integrated manufacturing courses to high school juniors and seniors to prepare them for careers in engineering and technology.
- Project Discovery was funded by NSF and OBR to provide summer workshops for science teachers using graphing calculators to control robots (Sinclair and Lakeland).
- Project GECKO, Girls Engineering Camp funded by NSF to offer summer camp for middle school girls to learn about engineering sciences (Rhodes State).
- Sponsored Engineering Technology Explorers Post as one of the Boy Scouts of America's Learning for Life program. Also offered was a Health Technologies Explorers Post. In addition, partnered with Tech Prep, the college offered a Forensic Science Camp for middle school students (Rhodes State).
- An Upward Bound Math Science Program is offered by Cincinnati State Technical and Community College. This program is a TRIO program funded by the U. S. Department of Education. It provides first generation or low income high school students interested in math and science careers with experiences that will excite them and prepare them for the college of their choosing.

**Table 8**

**Tech Prep Graduates by Program who Enrolled in an Ohio Public College  
the Following Academic Year**

Tech Prep Program	Year of High School Graduation				
	2000	2001	2002	2003	2004
Agricultural & Environmental Systems	59	37	44	111	73
Arts & Communication		14	20	10	11
Business & Administrative Services	97	114	150	291	245
Construction Technologies	22	19	24	39	6
Education & Training					6
<b>Engineering &amp; Science Technologies</b>	374	344	446	451	380
Finance	71	75	68	75	27
<b>Health Science</b>	238	277	374	538	618
<b>Information Technology</b>	305	688	911	1,124	1,108
Law & Public Safety		4	7	12	12
<b>Manufacturing Technologies</b>	33	59	44	48	40
Marketing			4	40	68
Transportation Systems	9	58	59	85	100
Other					13
<b>Grand Total</b>	<b>1,208</b>	<b>1,689</b>	<b>2,151</b>	<b>2,824</b>	<b>2,707</b>

\*HEI Data

**Table 9**

**Persons Employed in Science and Engineering Occupations  
By Occupational Group and Educational Attainment**

<b>Occupational Group</b>	<b>Total</b>	<b>H.S. Diploma or Associate's Degree</b>	
		<b>Number</b>	<b>Percent</b>
Total	4,632,400	1,036,200	22
Computer and math science	1,146,300	454,200	40
Life science occupations	295,400	29,000	10
Physical science occupations	380,900	24,800	7
Social science occupations	363,600	35,300	10
Engineering occupations	2,496,100	492,900	20

\* U.S. Department of Labor, Bureau of Labor Statistics and U.S. Department of Commerce