Review of the NSF's Advanced Technological Education (ATE) Program:

ATE's Role in Advanced Manufacturing Education and Training

February 2013

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Executive Summary for "Review of the NSF's Advanced Technological Education (ATE) Program: ATE's Role in Advanced Manufacturing Education and Training"

Founded by the National Science Foundation (NSF) in response to the Science and Advanced Technology Act of 1992, the Advanced Technological Education (ATE) program partners two-year community colleges with industry in order to close the skills gap in US technician-level careers and improve the education of America's technician workforce. The NSF accepts ATE proposals for projects, centers, and targeted research in technician education. With over 30 nationwide centers providing education for technician-level careers in seven technology sectors and many more projects responsible for materials development, professional development, student recruitment and retention, articulation agreements, and program improvements, ATE is the NSF's largest community college initiative.

From middle school science fairs to online courses designed for the science, technology, engineering, and mathematics (STEM) workforce, projects funded by the ATE strive to recruit students to STEM fields of study, enhance the community college experience with 21st-century technical skills, and ease the transition to a career in innovation technologies.

The growth of the number of NSF-funded ATE centers has roughly followed that of the program's overall budget. In FY 2006, 17 centers were in operation; this number more than doubled to its peak of 41 in FY 2011 before settling on the current profile of 38 centers. The ATE budget has increased by approximately $50 million in nearly two decades, with a plateau at $64 million in the past three fiscal years. ATE estimates that 30-40% of its budget goes towards the program's regional, national, and resource centers whereas the rest supports other projects in technician education nationwide; ATE's success rate (the number of proposals rewarded funding divided by total number of received proposals) of 25% exceeds that of the NSF average overall (22% for FY 2011 and 2012).

One of the seven technology focus areas of the ATE is advanced manufacturing, with seven nationwide ATE centers dedicated to the strengthening of this sector's talent pipeline. Within this program, manufacturing refers to much more than machining. ATE centers support specific manufacturing areas, such as the auto industry, mechatronics, robotics, control systems, logistics, bio-manufacturing, micro- and nano-manufacturing, optical devices, medical devices, welding, additive manufacturing, shipbuilding and repair, chemical processing. See the table at the end of this executive summary for more details on each ATE center dedicated to advanced manufacturing technologies.

Researchers from Western Michigan University studied the direct and indirect impacts of three ATE centers that have been active for more than four years. Qualitative examples of the direct impacts include improved quality of programs in the targeted technology field, established partnerships with industry or professional societies, additional external funding, increased number of students, improved instructional technology, and improved external reputation of the program. Examples of the indirect impacts include contributing to the host's ability to obtain other grants, increasing the prestige of the host institution, and making it easier for other similar centers to operate on campus.

At a time when America's skills gap is leaving many technician-level careers open, the mission of the ATE program is more relevant than ever. In 2012, the Advanced Manufacturing Partnership (AMP) Steering Committee provided a list of recommendations to President Obama to address such issues in the advanced manufacturing sector specifically; many ATE initiatives already address certain suggestions

and could be expanded to build on the AMP proposals. Looking to the future, there are a number of opportunities for the ATE community to grow in size and target more specific advanced manufacturing technology areas. These are just a few areas that would help to make the ATE program more pervasive in its mission to build a better technician workforce.

Increase the supporting role of four-year colleges and research universities

Community colleges must maintain a leading role for this program to reach its intended audience, but support from four-year institutions could bring new resources to two-year colleges while providing new opportunities for students and faculty at four-year colleges and universities. From lab facilities to academic faculty, leading advanced technology resources at four-year colleges and research university institutions could act as important resources in advanced manufacturing technologies for two-year schools. A number of four-year/research institutions are becoming increasingly involved in online education, and most ATE centers design some sort of online curricula for their students. Some of these links are occurring already. Collaboration between universities and community colleges has been shown to not only benefit ATE participants, but also university students enrolled in ATE courses. The ATE Engineering Challenges effort offers a promising opportunity to recruit students to STEM fields of study while exposing them to a higher education setting; students and faculty at universities could design and host activities within their state-of-the-art facilities to show the real-world applications of advanced technologies, in partnership with two-year schools. In particular, additional online courses focused on advanced manufacturing technology skills could benefit from this collaboration. This must remain a community college program, but four-year and research universities could play more of a supporting role.

Expand into more specific areas of advanced manufacturing

In its report to President Obama, the AMP Steering Committee named 11 cross-cutting technologies in need of increased R&D focus and funding. ATE centers are currently targeting several of these technologies, but one use of the AMP's recommended increased R&D could go to future ATE centers and projects to develop or maintain ongoing education programs based on the specific technologies on this AMP list.

Expand to new regions

Currently, ATE projects are spread across all states. Regional and national centers, however, have headquarters in only 24 states (larger centers provide resources to community colleges in multiple states). There are advanced manufacturing centers in seven states. Expanding the ATE community to host physical ATE advanced manufacturing centers in more states could train a more diverse workforce and strengthen the presence of advanced manufacturing.

Link to NIST's MEP

NIST runs an extensive Manufacturing Extension Program cost-shared with states, which reaches out to small and mid-sized manufacturers in every state. The program aims at getting optimal technologies and processes into the manufacturing base. It has been well-reviewed (although some state programs , of course, are stronger than others) and popular with manufacturers. While there are some links between ATE centers and area MEPs, expanding the connections between education and training and MEP technology and process transfer could create synergies for both programs.

Increased funding support

Hundreds of proposals are submitted to the NSF ATE program each year; no more than 75-90 can be accepted. The AMP Report has recommended increased advanced manufacturing R&D; ATE should be considered in that context. The ATE's mission of closing the advanced technology skills gap while encouraging young students to explore STEM fields depends on resources provided by the government.

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Introduction

Founded by the National Science Foundation (NSF) in response to the Science and Advanced Technology Act of 1992, the Advanced Technological Education (ATE) program partners two-year community colleges with industry in order to close the skills gap in US technician-level careers. This congressionally-mandated program accepts proposals for projects, centers, and targeted research in technician education. From middle school science fairs to online courses designed for the fields of science, technology, engineering, and mathematics (STEM), products of the ATE program strive to recruit students to STEM fields of study, enhance the community college experience with 21st-century technical skills, and ease the transition to a career in innovation technologies.

The growth of the number of NSF-funded ATE centers has roughly followed that of the program's overall budget. In FY2006, 17 regional and national centers were in operation; this number more than doubled to its peak of 41 in FY2011 before settling on the current profile of 38 centers. The ATE budget has increased by approximately $50 million in nearly two decades, with a plateau at $64 million in the past three fiscal years. ATE estimates that 30-40% of its budget goes towards the program's regional, national, and resource centers whereas the rest funds other projects in technician education nationwide; ATE's success rate (the number of proposals rewarded funding divided by total number of received proposals) of 25% exceeds that of the NSF average overall (22% for FY 2011 and 2012).

One of the seven technology focus areas of the ATE is advanced manufacturing, with seven of the program's 38 nationwide ATE centers dedicated to the strengthening of this sector's talent pipeline. Within this program, manufacturing refers to much more than machining. ATE centers support specific manufacturing areas, such as the auto industry, mechatronics, robotics, control systems, logistics, bio-manufacturing, micro- and nano-manufacturing, optical devices, medical devices, welding, additive manufacturing, shipbuilding and repair, chemical processing.

As part of the NSF's Division of Undergraduate Education, ATE was proposed specifically with two-year associate-degree-granting colleges in mind, but private colleges and universities also have a role to play in this program. There are already a number of universities involved in the advanced manufacturing sector. Penn State houses the ATE nanotechnology network; UC Irvine partners with area community colleges in developing additive manufacturing curricula (in fact, many UC Irvine students interested in additive manufacturing have taken classes at local community colleges under this program); Purdue University designed a guitar-building class with the ATE's National Center for Manufacturing Education in Dayton, Ohio. The variety of ATE stakeholders is only matched by the variety of offerings this program brings to the nation's talent pipeline each year.

Program Overview

From 2000-2010, US manufacturing employment decreased by more than 30%, with every state but one showing a drop in the number of manufacturing jobs. On average, 17 factories were closing each day (ITIF, 2012). Nevertheless, in 2009, almost one-third of US manufacturing companies said they needed more skilled workers. (Deloitte, 2009) The manufacturing sector lost jobs as productivity gains slowed, manufacturing fixed capital investment (adjusted for cost changes) declined, and the skills gap widened. What's more, the US was beginning to lose its grip on the title of worldwide leader in innovation (ITIF, 2012).

Thus, in June 2011, President Obama announced the Advanced Manufacturing Partnership (AMP), where the federal government, industry, and universities could collaborate in driving innovation and closing the skills gap.

Just over one year later, the AMP Steering Committee released its final recommendations, which were organized into three categories: enabling innovation, securing the talent pipeline, and improving the business climate of manufacturing in the US (AMP, 2012). In order to address technician-level careers, the AMP recommended that community colleges play an expanded role in the education and training of specialized employees in innovation technologies. This could build on the long-standing community college involvement in US advanced manufacturing.

The NSF's ATE program calls on two-year associate-degree-granting colleges to inspire a bigger and better-educated technician workforce; as noted, it dates from the Science and Advanced Technology Act of 1992.

Since then, 972 ATE grants have been distributed across all 50 states, Guam, and Puerto Rico. Each year, NSF offers 75-90 awards for new and continuing projects that coincide with the ATE objective of expanding and upgrading the system of technological education in the US by leading dynamic, productive partnerships among industry, community colleges, and other education sectors. For FY2013, approximately 230 formal ATE proposals were submitted to the $64 million competitive program (NSF, 2011), up from $45.5 million in FY2006.

Composition of ATE

Out of a total of 75 to 90 grants awarded by the ATE each year, the program uses 30-40% of its budget to fund National, Regional, and Resource centers; the remainder goes to project grants. Whereas National centers articulate a vision for technological education and oversee the program's progress as a whole, Regional centers work much more on the local scale with two-year colleges, four-year colleges and universities, high schools, industries, government and professional societies. Resource centers act as core funding for National centers after about seven years. Currently, ATE hosts 38 centers committed to educating high-skilled workers in community colleges found in some of the country's most active innovation hubs, making ATE the largest community college initiative in the NSF portfolio.

The centers' areas of focus are:

Advanced Manufacturing Technologies
Agriculture/Energy/Environment Technologies
Biotechnology and Chemical Processes
Electronics (including micro- & nanotechnologies)
Engineering Technologies
Information/Geospatial/Security Technologies
Learning/Evaluation/Research

The structure of ATE education depends on the center. Courses available online and at night offer flexibility to adults looking to gain valuable work skills whereas technical competitions and internships strive to recruit young students to STEM fields, which is considered to be one of the largest barriers to closing the skills gap. In all cases, there is collaboration between associate-degree-awarding community colleges and industry in the design and execution of these ATE center offerings, and the courses are geared towards a career in innovation-related technologies (for example, mathematics courses are taught in the context of a career as a technician rather than covering fundamental algebra).

Evaluation of ATE Program, Including Program Hubs

Three ATE centers (ATE Central, EvaluATE, and SC ATE) study the learning techniques and education programs used to train the technician workforce and evaluate the performance of existing ATE programs.

ATE Central (Madison, WI) is the overall information hub for the ATE community, archiving ATE resources to foster collaboration between centers.

EvaluATE (Kalamazoo, MI) helps ATE grantees to assess their projects and find areas for improvement while hosting webinars and a resource library on its website, http://evalu-ate.org/.

South Carolina ATE, or SC ATE, (Florence, SC) ensures a growing participation by students, faculty, and industry in the ATE program. Its Technology Gateway classes have been shown to improve graduation rates of at-risk students; its ATE Scholars internship program has paired more than 100 students with one of 20 companies between 2000 and 2010; SC ATE curricula for technician educators teaches compliments the STEM skills with soft skills such as conflict resolution and teamwork to promote workplace success.

Private sector partners provide both financial and intellectual support for the ATE program because it responds to the skills gap faced by much of the US advanced technology industry. In fact, one in three US companies report the need for more skilled workers (Deloitte, 2009). A number of research studies have

found that the ATE's mission of advancing the knowledge base necessary for technician education programs has already benefitted its stakeholders.

Wayne Welch of Rainbow Research found that 90.9% of the 216 surveyed grant recipients either agreed or strongly agreed that the program changes initiated by their grants would continue after NSF funding ends (Welch, 2011). The same survey found that 82.5 percent of responders disagreed or strongly disagreed that their centers' liaisons with industry and academia will end and 92 percent agreed or strongly agreed that teaching methods developed for ATE will continue to be used.

Researchers from Western Michigan University studied the direct and indirect impacts of three ATE centers that have been active for more than four years. Qualitative examples of the direct impacts include improved quality of programs in the targeted technology field, established partnerships with industry or professional societies, additional external funding, increased number of students, improved instructional technology, and improved external reputation of the program. Examples of the indirect impacts include contributing to the host's ability to obtain other grants, increasing the prestige of the host institution, and making it easier for other similar centers to operate on campus.

More results of ATE's evaluation efforts can be found in Appendix B of this report.

Two Case Studies of ATE Centers

ATE in the Boston area

Boston's variety of education systems and high density of college campuses, combined with an active hub of innovative industries, contribute to the city's success as an ATE location. Broadening Advanced Technological Education Connections (BATEC), an ATE Center also recognized as a National Center of Excellence for Computing and Information Technologies, represents one of two Massachusetts ATE Centers (the other being the Information and Communications Technologies Center in Springfield).

BATEC reaches out to secondary school students via its Tech Apprentice program, recruiting and selecting talented high school juniors and seniors for paid IT internships at over 50 Boston companies, such as Apple, BlueCross/Blue Shield, IBM, Microsoft, Verizon, and Xerox. Since 2006, 350 students have participated in the Tech Apprentice program, and 75% of them went on to pursue technical degrees. Additionally, BATEC hosts a number of college and tech fairs to connect high school students to higher education opportunities, admissions counseling, and career information.

For adults, BATEC's Bridge to Community College program offered two for-credit night courses (Computer Essentials and Introduction to Information Technology), tutoring in math and English, and workshops on college admissions, financial aid, course registration, and advising up until June 2011. Industry partners Dotwell Technology Center and Dorchester Bay Economic Development Center collaborated with Bunker Hill Community College throughout this program, which saw 20-30 students enroll each year.

Blurred boundaries among ATE centers

It is important to note that even centers that are not explicitly dedicated to advanced manufacturing technologies are still relevant to this sector. For example, despite being listed on the ATE website as a Biotechnology and Chemical Processes center, the Northeast Biomanufacturing Center and Collaborative (NBC^2) in Blue Bell, PA, offers a number of biomanufacturing curricula and hosts a professional development website, http://www.biomanonline.org.

Technicians are needed in the biomanufacturing sector with cell culture, purification, and quality control microbiology skills as the industry expands beyond biopharmaceuticals to include biofuels, bioplastics, industrial enzymes, and replacement tissues and organs. In 2009, 34 of the nation's 47 biotechnology degree programs (considering both two-year and four-year institutions) included at least one NBC^2 biomanufacturing course. One year later, the center's "6 Protein is Cash" workshops in six states advised more than 100 high school teachers in professional development, indirectly benefitting more than 10,000 high school students. Virtual labs, online support, the industry-authored "Introduction to Biomanufacturing" textbook, the Biomanufacturing laboratory manual, and the BIOMAN website make up the primary products of this ATE center.

ATE Manufacturing Programs

Seven of the 38 ATE centers are dedicated to advancing manufacturing technologies, making this sector the second-largest in the ATE profile in terms of number of sites.

Of the seven advanced manufacturing ATE centers (listed in a table on the next page), three are dedicated to the automotive industry, one to additive manufacturing, one to welding, and four to the general education of technicians. Each has its own website for more details on partnerships, objectives, and latest news.

Note that the NCME and TIME centers are no longer being funded, but their activities have been sustained. These centers were deemed to have served the purpose of their initial grants, and a number of their products, such as college curricula, are still available to the remaining ATE centers.

Like all the sectors represented by ATE centers, advanced manufacturing benefits from this program's efforts to recruit students to STEM fields and ease the transition from education to employment. The following are just a few examples of initiatives from ATE manufacturing centers that address these expectations.

Example initiatives from ATE advanced manufacturing programs

Recruiting students to STEM fields

Since 2006, CARCAM (Gadsden, AL) has sponsored one-week STEM summer camps in order to encourage underrepresented student populations to consider technical careers. Participants visit a college campus environment, observe STEM courses, visit labs, interact with faculty, and perform team-building activities. As of 2010, 75% of the 560 enrolled STEM camp students were female and/or minority, and 85% of the students from underrepresented populations have enrolled in at least one high school STEM course. CARCAM collaborate with the Alabama Automotive Manufacturers Association (AAMA), which offers scholarships for students to pursue automotive-related degrees. Of the 197 AAMA scholarships awarded from 2005 to 2010, 190 recipients were students enrolled in CARCAM partner college programs.

Although its grant has recently expired and the center is no longer active, the NCME (Dayton, OH) reached out to high school and college students through its social networking site, http://www.mycareerME.org, and connected them to other students, companies, and mentors. NCME also provided a searchable database of materials at http://www.meteconline.org, which has proved to be a valuable resource for educators. These two websites are still active today. The center partnered with Sinclair Community College, Ohio's affiliate for Project Lead the Way, in offering a nationally recognized pre-engineering program for high school students; NCME also developed a popular guitar-building course for two-year colleges with Purdue University, Butler Country Community College, Mott Community College, and Fox Valley Community College. A variety of students were engaged in this hands-on course while learning the physics of tension and compression, the mathematical logarithms of the musical scale, and the electronics of connecting to an amplifier (more information available at http://www.guitarbuilding.org). A 2010 National Association for Workforce Improvement conference included a presentation illustrating how students in this course learned about software programs, the mathematics of sound, and the design of electronics (PowerPoint slides available at http://www.nawionline.org/conference/2010/presentations/guitar_building.pdf).

Enhancing the college experience

Many of the students at community colleges already have a B.S. or M.S. degree and are looking to upgrade competencies or obtain hands-on experience. In fact, some four-year colleges encourage their undergraduates to attend community colleges, where they will learn how to use industry equipment. In the biotechnology industry, for example, employers look not only for applicants' degree but also their familiarity with relevant technology. Students within the ATE program have the opportunity to obtain industry-specific experiences before seeking employment.

In 2010, 24 students in AMTEC's (Versailles, KY) advanced automotive manufacturing and mechatronics pathway pilot split their days between working at the Toyota Motor Manufacturing plant in Kentucky and attending classes at Bluegrass Community and Technical College. At school, students are still expected to meet the plant's attendance, dress code, and safety expectations as they learn about electronics, hydraulics, and other automotive manufacturing skills. AMTEC is a multi-state endeavor, connecting 30 community colleges in 12 states with 34 automotive-relates facilities. More than 50 of the center's stakeholders, such as college faculty, industry representatives, and union representatives, developed an online, modularized curriculum, consisting of 12 courses and 57 modules led by industry employees. This provides highly targeted instruction for students as they pursue industry-endorsed assessment and certification.

Transitioning to careers

RapidTech (Mission Viejo, CA) works with more than 197 educational institutions and 529 companies and agencies, which provide employment opportunities for students in a wide range of industries including aerospace, animation, automotive, defense, consumer products, and medical devices. Instructors, too, benefit from this ATE center through the National Teacher Training Workshop, which offers hands-on experiences in the classroom and connects participants with industry and equipment manufacturers. This workshop is just one example of RapidTech's professional development initiatives; more than 300 participants have attended a workshop designed for the Vital Link Career Counselor, Industry 3D User, or Faculty Professional.

RCNGM (Hartford CT) engages underrepresented populations by hosting statewide and regional expos, Saturday outreach programs, peer mentoring, and industry-driven curriculum that addresses real-world problems. This way, students are introduced to business, industry, professional and organizational partners such as the 10,000-member Connecticut Business and Industry Association (CBIA), the Connecticut Center for Advanced Technology, the National Association of Workforce Improvement, the Office of Workforce Competitiveness, Department of Labor, and Department of Economic Development. Working with CBIA, RCNGM placed 130 educators with advanced manufacturing companies for 4-week externships to learn how to implement new curricula and classroom activities using real-world, hands-on design projects.

CARCAM (Gadsden, AL) matches secondary school students with career coaches hired by Alabama community colleges, who act as career mentors and introduce students to the automotive industry. According to ATE staff, CARCAM has also succeeded in bringing 11 community colleges in Alabama that normally compete to work collaboratively in automotive technology.

More data needed

Outreach to secondary schools, development of curricula, and professional development of faculty are just a few of the program's accomplishments. The production of technicians and industry's satisfaction with employees who participated in an ATE-supported community college education program are two additional results that currently lack quantitative evidence and thus require more evaluation.

Table: ATE Centers Dedicated to Advanced Manufacturing Technologies

AMTEC (Automotive Manufacturing Technology Education Collaboration) (Versailles, KY) **http://www.autoworkforce.org** *National Center of Excellence in Automotive Manufacturing* *Leads collaboration with 30 colleges & 34 auto facilities in 12 states*
CAAT (Center for Advanced Automotive Technologies) (Warren, MI) **http://www.macomb.edu/CAAT** *Partnership between Macomb Community College and Wayne State University* *Developed one-year Electric Vehicle Development Technician Certificate Program at Macomb Community Developed one-year Electric Vehicle Service Technician Certificate via Indiana's Ivy Tech Community College* *Education outreach and academic professional development efforts reached over 5,000 people in two years*
CARCAM (Consortium for Alabama Regional Center for Automotive Manufacturing) (Gadsden, AL) **http://www.carcam.org** *Automotive Manufacturing Technology degree offers courses in electronics, hydraulics, programmable logic controllers, welding, machine tool technology, and robotics*
FLATE (Florida Advanced Technology Education Center) (Tampa, FL) **http://www.fl-ate.org** *Partners with 10 Florida community colleges* *Made in Florida campaign encourages middle and high school students to consider future in manufacturing* *Unique Engineering Technology (ET) degree program aligned with Manufacturing Skills Standard Council (MSSC)*
RapidTech National Center for Rapid Technology (Mission Viejo, CA) **http://www.rapidtech.org** *Actively collaborates with more than 197 educational institutions & 529 companies and agencies across the US* *Rapid Digital Manufacturing Program at Saddleback College had 207 students* *Participates in SME Rapid and the ASTM F42 Committee on additive manufacturing* *Offered not only certificates and degrees for students, but also programs for educators, industry personnel, and career counselors in its first three years*
RCNGM (Regional Center for Next Generation Manufacturing) (Hartford, CT) **http://www.nextgenmfg.org** *Placed 130 educators in 4-week externship with advanced manufacturing companies, co-sponsored by Connecticut Business and Industry Association; Outreach activities have involved 40,000 students since 2004* *Engineering Challenge for the 21st Century program has hosted 355 students since 2006* *Since 2004, worked with industry to develop 30 new programs and 65 new courses for advanced technology careers* *Partners with US Coast Guard Academy to sponsor Teachers' Engineering Challenge week-long summer residential workshop, where teachers from 15 states and Puerto Rico have learned skills to educate their 5,000 students*
Weld-Ed (National Center for Welding Education and Training) (Elyria, OH) **http://www.weld-ed.org** *Graduated more than 1,700 students at 10 partner academic institutions in three years* *Helped nine colleges revise welding technician programs; created new associate degree at tenth institution* *Created faculty professional development workshops, designed an Introduction to Materials Joining course, and convened the annual National Welding Educators Conference at FABTECH, a prominent industry trade show* *Published State of the Welding Industry Report after convening 33 welding industry leaders in 2008*
NCME (National Center for Manufacturing Education) (Dayton, OH) **http://www.ncmeresource.org No longer active – grant expired** *More than 50,000 annual unique visitors to searchable database of materials designed for educators* *Acted as Ohio affiliate of Project Lead the Way, a nationwide STEM initiative for high school students*
TIME Center (Technology and Innovation in Manufacturing and Engineering) (Baltimore, MD) **http://www.time-center.org No longer active – grant expired** *Partner with five Maryland colleges; 3,448 students enrolled in TIME programs in 2010 (only 1,979 students in 2003)* *Outreach activities involved more than 10,000 students since 2003* *Received the 2010 Maryland Advocacy Award of Excellence from the Technology Education Association of Maryland* *Developed 5 core electronics courses with partners that will be offered in an online blended format* *Implemented a FAB Lab (fabrication laboratory) at the Community College of Baltimore County to provide access to design and prototyping capabilities for industry, students, and the community.*

Comparing ATE Portfolio and AMP Technology List

In its report to the President, the Advanced Manufacturing Partnership (AMP) Steering Committee offered 16 recommendations designed to enable innovation, secure the talent pipeline, and improve the business climate of the US manufacturing sector. The report, released in 2012, mentioned a number of tasks that fall under the scope of the ATE program. The relevant AMP recommendations are cited below, followed by a description of relevant ATE efforts:

- AMP Recommendation: Increase R&D funding in the following top cross-cutting technologies selected by AMP committee
    - Advancing Sensing, Measurement, and Process Control
    - Advanced Materials Design, Synthesis, and Processing
    - Visualization, Informatics, and Digital Manufacturing Technologies
    - Sustainable Manufacturing
    - Nanomanufacturing
    - Flexible Electronics Manufacturing
    - Biomanufacturing and Bioinformatics
    - Additive Manufacturing
    - Advanced Manufacturing and Testing Equipment
    - Industrial Robotics
    - Advanced Forming and Joining Technologies

ATE has centers supporting a number of these technologies, including biomanufacturing, robotics, additive manufacturing, nanomanufacturing, controls systems, and advanced forming and joining technologies such as welding. In fact, ATE's OP-TEC center addresses the area of optics and photonics, which is absent from the AMP list. One potential source of future growth in the ATE program would be to align new centers with other leading technologies recommended in the AMP report.

- AMP Recommendation: Foster regional ecosystems and public-private partnerships in advanced manufacturing technologies through a National Network of Manufacturing Innovation Institutes (NNMI)

The ATE serves regional communities focused on the education of advanced technology workforce, and evaluations have been performed on the impact of this program on students, employers, and industry in affected areas. Many aspects of the ATE program design potentially could connect with the NNMI model.

- AMP Recommendation: Establish a National Advanced Manufacturing Portal as a searchable database of manufacturing resources

ATE Central in Madison, Wisconsin, is the ATE community's information hub, providing access to curricula and other resources developed at ATE centers nationwide.

- AMP Recommendation: Correct misconceptions about manufacturing

ATE hosts a number of internships, workshops, and competitions to highlight the cutting-edge technologies and modern facilities used in manufacturing today.

- AMP Recommendation: Invest in community college level education

An important goal of the ATE program is to involve two-year associate-degree-granting colleges in the training and education of tomorrow's technicians. ATE centers offer curricula designed to teach technical and professional workplace skills necessary for technician-level careers. In October 2012, the American Association of Community Colleges (AACC) announced its partnership on the Mentor-Connect project, which advises new ATE applicants and strengthens STEM faculty members' leadership skills. AACC also supports the MentorLinks program for instructors specializing in undergraduate STEM education and hosts the annual ATE Principal Investigators Conference.

- AMP Recommendation: Enhance advanced manufacturing university programs

Through partnerships with community colleges, industry, and four-year college and university institutions, students in ATE programs targeted towards advanced manufacturing technologies are exposed to the university setting while learning how to succeed as a technician.

- AMP Recommendation: Develop partnerships to provide skills certifications and accreditation

ATE curricula are designed with industry criteria in mind to provide specific, practical skills for a career as a technician. In fact, some ATE projects propose advanced certificates for skills beyond those normally attained in a two-year program.

- AMP Recommendation: Launch national manufacturing fellowships and internships

ATE centers partner with regional industry companies in order to provide students with a network of real-world opportunities.

In summary, ATE offers an established program platform active in eight of the sixteen AMP recommendation areas concerning advanced manufacturing technologies. ATE's offerings could be expanded to provide implementation platforms for AMP policy proposals in these and other areas.

Opportunities for Making ATE Lessons More Pervasive in Higher Education

Through discussions with representatives from the NSF and research on ATE centers' projects, a number of potential opportunities for four-year colleges and research university institutions to play a role in this program have been identified. Community colleges must maintain a leading role for this program to reach its intended audience, but support from four-year institutions could bring new resources to two-year colleges while providing new opportunities for students and faculty at four-year colleges and universities.

Opportunity for online education and balancing learning-by-doing

In his 2010 report, Albert Lorenzo named three challenges for modern-day online education: increased student demand for online opportunities, strained faculty supply, and ongoing skepticism towards the effectiveness of online learning. Given higher education's increasing involvement in online education, there exists an opportunity for further collaboration with the ATE and its unique online curricula targeted towards innovation technologies. Those involved with the ATE program recognize that this does not replace, but rather supplements, opportunities for learning-by-doing.

In fact, a 2011 EvaluATE report found that 89% of the 17 surveyed ATE PI's agreed that online courses are critical to the long-term strategy of their program, 78% agreed that faculty and instructors in the program accept the value and legitimacy of online courses, and 83% agreed that online courses have the same or higher level of quality as traditional courses.

Certain centers follow a hybrid program of online and hands-on education, offering online courses initially to cover fundamentals of the course coupled with lab experience a couple times a week in order to put those lessons into practice. This notion of a "flipped classroom" of a problem-based learning-by-doing context is supplemented by fundamentals and content through online courses that play an increasing role in reaching out to students, means that online curricula is a promising development to which higher education can lend its experience.

According to ATE staff, the regional Center for Automotive and Aerospace Technology Education Using Virtual E-School (CA2VES) is developing high-end visualizations for online education of automotive and aerospace technicians. Instructors can program faults into virtual simulations that cannot be put into real systems. The center, hosted by Clemson University, works with the other automotive centers and community colleges in South Carolina.

This online and blended learning field in advanced manufacturing presents a major opportunity area for university and community college partnerships. Based on the AMP advanced manufacturing technology recommendations, online and blended learning courses to train the workforce in the skills required to implement these advances could be a major focus area for ATE in the future, supplementing its existing work.

Opening labs and designing hands-on experiences

A number of higher-education institutions are already directly involved in ATE programming. In fact, the Nanotechnology Applications and Career Knowledge (NACK) network headquarters are hosted on the Penn State campus. This network partners five other ATE centers with 22 community colleges and nine universities across the nation. The four-year institutions provide resources for educators and students to create and sustain economically viable nanotechnology education across the U.S., according to the NACK website. Additionally, the University of Minnesota's state-of-the-art Nanofabrication Center has proved to be a valuable resource for researchers.

In another example, faculty and students from UC Irvine have taken advantage of the additive manufacturing technologies coming out of the ATE's RapidTech center, which moved from its location at Saddleback College to the UC Irvine campus in 2010. UC Irvine students interested in these technologies have even taken courses designed by RapidTech for community colleges. Research institutions have the cutting edge facilities and academic stakeholders ideal for meeting ATE's objectives, and partnerships have already proven to benefit not only ATE students, but also university faculty and students and industry partners. The labs and "learning by doing" efforts represented by these efforts could be the basis for expanded ATE programs to be implemented at larger scale.

Hosting "Engineering Challenges" Efforts

Perhaps the largest barrier to closing the technician skills gap is generating interest in innovative technologies. Widespread misconceptions of careers in advanced manufacturing often paint the work environment as dull conditions in an aging bleak factory, not as the modern, up-to-date facilities relying on 21st-century technologies. ATE centers offer many interactive internships and events to recruit more students to pursue STEM fields of study.

For example, ATE's RCNGM center in Connecticut hosts a widely popular "Engineering Challenge for the 21st Century" program in collaboration with the US Coast Guard Academy. Through interactive activities and labs, young participants of this program gain critical thinking and problem-solving skills while learning about the importance of accountability and understanding in a workplace environment. RCNGM also hosts numerous manufacturing expos and workshops on community college campuses to teach high school students about the promising opportunities that come with a college degree and a career in manufacturing.

The aforementioned NACK allows ATE students to complete their capstone semester on Penn State's campus, so students are exposed to a higher education environment while still paying community college tuitions.

These are just a few examples of how ATE centers are building a better-prepared workforce of technicians; higher education institutions have many opportunities to become involved with hands-on activities offered in ATE curricula, whether by physically hosting events on campus, developing online courses, designing interactive labs and workshops to put STEM lessons into practice, or inviting students to use state-of-the-art facilities, especially those who otherwise would not be able to access those resources.

Conclusions

In the past two decades, NSF's ATE program has partnered community colleges with industry in order to improve the education of America's technician workforce. Having distributed nearly 1000 grants nationwide providing education for technician-level careers and established more than 30 centers in seven technology sectors since its creation, ATE is the NSF's largest community college initiative.

ATE has formed strong partnerships with both the private sector and government agencies, so while its budget is sensitive to changes in federal funding, this congressionally-mandated program's mission is well-regarded on Capitol Hill. ATE will continue to fund projects supporting the education of skilled technicians for which there is a demonstrated regional need.

At a time when America's skills gap is leaving many technician-level careers open, that mission is more relevant than ever. The Advanced Manufacturing Partnership (AMP) provided a list of recommendations to President Obama to address such issues in the advanced manufacturing sector specifically; many ATE initiatives already address certain suggestions.

Looking to the future, there are a number of opportunities for the ATE community to grow in size and target more specific technology areas.

Increase the supporting role of four-year colleges and research universities

This must remain a community college program, but four-year and research universities could play more of a supporting role by providing access to leading advanced technology resources. A number of four-year institutions are becoming increasingly involved in online education, and most ATE centers design some sort of online curricula for their students. Additional online courses focused on advanced manufacturing technology skills could benefit from this collaboration. Collaboration between universities and community colleges has been shown to not only benefit ATE participants, but also university students enrolled in ATE courses. The ATE Engineering Challenges effort offers a promising opportunity to recruit students to STEM fields of study while exposing them to a higher education setting; students and faculty at universities could design and host activities within their state-of-the-art facilities to show the real-world applications of advanced technologies, in partnership with two-year schools.

Expand into more specific areas of advanced manufacturing

In its report to President Obama, the AMP Steering Committee named 11 cross-cutting technologies in need of increased R&D focus and funding. ATE centers are currently targeting several of these technologies, but one use of the AMP's recommended increased R&D could go to future ATE centers to develop stronger education programs around the specific technologies on this AMP list.

Expand to new regions

Currently, ATE projects are spread across all states. Regional and national centers, however, have headquarters in only 24 states (larger centers provide resources to community colleges in multiple states). There are advanced manufacturing centers in seven states. Expanding the ATE community to host physical ATE centers in advanced manufacturing more states could train a more diverse workforce and strengthen the presence of advanced manufacturing.

Link to NIST's MEP

NIST runs an extensive Manufacturing Extension Program cost -shared with states, which reaches out to small and mid-sized manufacturers in every state. The program aims at getting optimal technologies and processes into the manufacturing base. It is well-reviewed (although some state programs, of course, are stronger than others) and popular with manufacturers. While there are informal links between some ATE centers and area MEPs, expanding the connections between education and training and MEP

technology and process transfer could synergies for both programs.

Increased funding support
Hundreds of proposals are submitted to the NSF ATE program each year; no more than 75 to 90 can be approved. The AMP Report has recommended increased advanced manufacturing R&D; ATE should be considered in that context. The ATE's mission of closing the advanced technology skills gap while encouraging young students to explore STEM fields is dependent on resources provided by the government.

These are just a few areas that would help to make the ATE program more pervasive in its mission to build a better technician workforce, particularly in the advanced manufacturing area.

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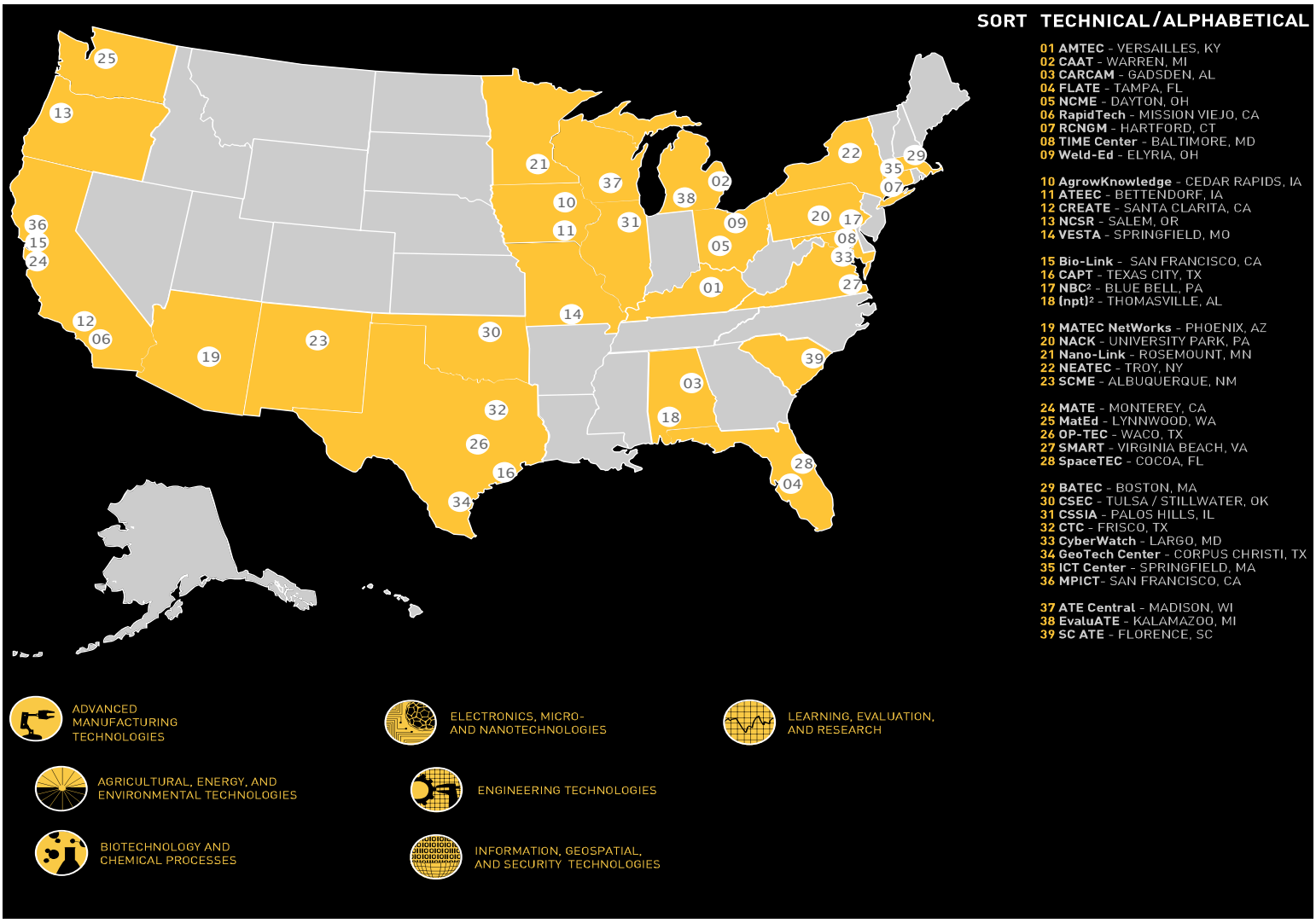
Background information also derived from discussion with NSF ATE staff members

Appendix A. Map of ATE Centers

Numbers organized by technology focus area
1-9 Advanced Manufacturing Technologies
10-14 Agricultural, Energy, and Environmental Technologies
15-18 Biotechnology and Chemical Processes
19-23 Electronics, Micro- and Nanotechnologies
24-28 Engineering Technologies
29-36 Information, Geospatial, and Security Technologies
37-39 Learning, Evaluation, and Research

Note: this is the most recent map of ATE centers available from http://atecenters.org/centers-map/ Updates are expected soon



Appendix B. Overview of ATE Evaluations

As mentioned, ATE grants fund projects, centers, and targeted research in technician education. This last track is the focus of not only the three above-mentioned ATE centers, but also the University of Colorado's Discovering the Educational Consequences of Advanced Technological Education (DECA) Project, coordinated by the Boulder, CO, campus' Institute of Behavioral Science. More than 20 DECA researchers representing seven institutions The project's website, http://www.colorado.edu/ibs/decaproject/index.html, compiles reports that have studied the performance of ATE centers and their nationwide, local, and personal impacts.

Project I: Strategies for Improving Recruitment, Retention and Placement

A survey led by Ron Anderson of Rainbow Research a Minnesota nonprofit that researches, assesses, and evaluates social organizations, showed that demographics, namely gender, race, and age, played a major role in the student pipeline, particularly in the rate of success in course completion and program persistence (Anderson, 2009). Of the more than 85,000 students who took at least one ATE-supported course in 2009, just over half were enrolled in two-year colleges, while another third were secondary school students; the male-to-female ratio of all ATE students in 2009 was approximately 3:1, up from 2:1 in 2006 (in community colleges overall, the student ratio is 2:1 (AACC)); 55% of ATE students were white whereas 19% were Hispanic/Latino (up from 7% in 2006) and 14% were Black/African American. (Eval[u]ate) These percentages are almost identical to the overall community college demographics nationwide. (AACC) The report concluded that further evidence was needed to explain the apparent drop in female student enrollment and increase in Latino student enrollment in the ATE program.

Part I
http://www.colorado.edu/ibs/decaproject/pubs/Report%20I1%20%20Gender%20and%20Race%20Gaps%20in%20ATE-Funded%20Program%20Enrollments.pdf
Part II
http://www.colorado.edu/ibs/decaproject/pubs/Report%20on%20Feasibility%20of%20Using%20SURs%20for%20ATE%20Retention%20v2%206july10.pdf

Project II: Individual Differences in Technological Proficiency: An Exploratory Research Study

According to researchers from the University of North Texas and Baylor University, two-year college students in technological programs, defined to be optics/photonics, robotics, or manufacturing, were found to demonstrate higher cognitive ability and better spatial ability than students in non-technological programs in the same college.

http://www.colorado.edu/ibs/decaproject/pubs/Poster_Hull8Dec2010.pdf
http://www.colorado.edu/ibs/decaproject/pubs/Hull%20%20Glover%20DECA%20Report_Final.pdf

Project III: Framing Research to Develop Successful Articulation Models Between Two- and Four-Year Technology Programs

http://www.colorado.edu/ibs/decaproject/pubs/Final%20Revision_%20w_Cover%20Page.pdf

Project V: Identifying the Impacts of ATE Centers on Their Home Institutions: An Exploratory Study

The direct and indirect impacts of three ATE centers that have been active for more than four years were studied. Examples of the former include improved quality of programs in the targeted technology field, established partnerships with industry or professional societies, additional external funding, increased number of students, improved instructional technology, and improved external reputation of the program. Examples of the latter include contributing to the host's ability to obtain other grants, increasing the prestige of the host institution, and making it easier for other similar centers to operate on campus. The researchers also found that awareness of the existence of the ATE centers was generally low; on average, less than 50% of faculty and staff and less than 10% of students on the campuses with

one of the three surveyed ATE centers were aware of the center's existence. In effect, the centers are better recognized nationally than they are locally.
http://www.colorado.edu/ibs/decaproject/pubs/Henderson%20Project%20Report%201-26-11.pdf

Project VI: Identifying the State of Online Instruction in ATE-Funded Technical Education Programs at Community College
http://www.colorado.edu/ibs/decaproject/pubs/ATE%20Final%20Report%20-%20Horvitz%20&%20Zinser-1.pdf

Project VII: Developing Scales for Classifying Innovative ATE Instructional Materials
http://www.colorado.edu/ibs/decaproject/pubs/The%20ATE%20Suitability%20Inventory%20FINAL%20kb%20110210_2.pdf
http://www.colorado.edu/ibs/decaproject/pubs/ATE_report_042111.pdf

Project VIII: Research Needs Identified by ATE Leaders
http://www.colorado.edu/ibs/decaproject/pubs/ImportantInfoNeedsForATE-DelphiStudyReportFinal120131b.pdf

Project IX: Research to Define and Measure Effectiveness of ATE Centers/Projects
http://www.colorado.edu/ibs/decaproject/pubs/COATE_Eval_Center_07.08.11-REV.pdf

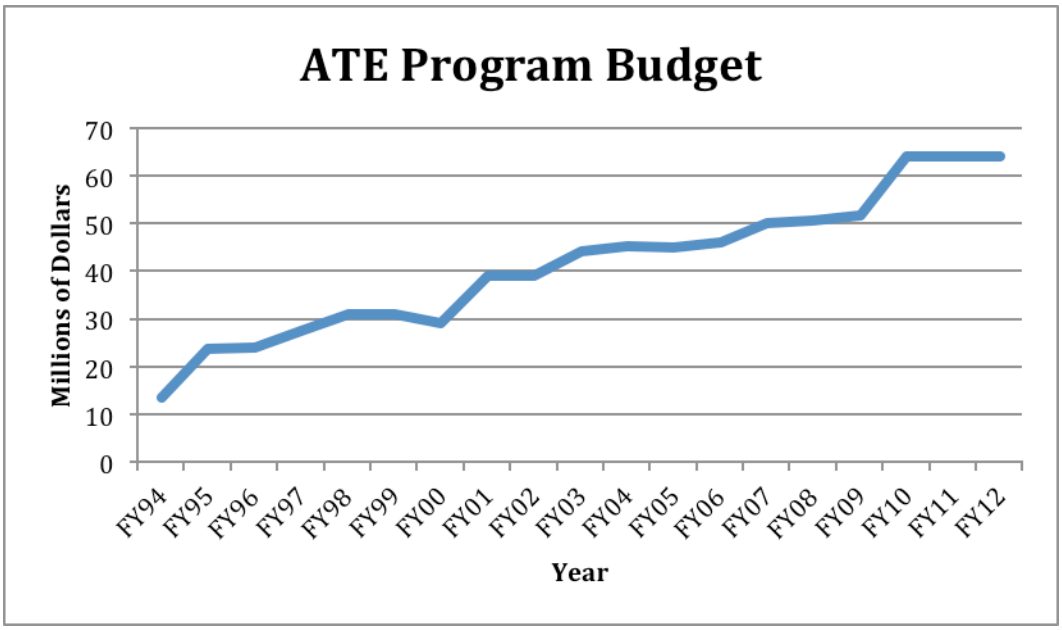
Project X: Assessing the Impact and Sustainability of ATE-Supported Projects and Centers
Wayne Welch of Rainbow Research found that 90.9% of the 216 surveyed grant recipients either agreed or strongly agreed that the program changes initiated by their grants would continue after NSF funding ends (Welch, 2011). The same survey found that 82.5 percent of responders disagreed or strongly disagreed that their centers' liaisons with industry and academia will end and 92 percent agreed or strongly agreed that teaching methods developed for ATE will continue to be used.
http://www.colorado.edu/ibs/decaproject/pubs/Measuring%20Sustainability%20Report%20Welch%20May%202012.pdf
http://www.colorado.edu/ibs/decaproject/pubs/Welch%20ATE%20Sustainability%20Report%20_rev.%20Dec.%202011_.pdf
http://www.colorado.edu/ibs/decaproject/pubs/Welch%20ATE%20Impact%20Report.pdf
http://www.colorado.edu/ibs/decaproject/pubs/Welch%20%20Ritchie%20Sustainability%20Briefing%20Paper%20Final%20October%202010.pdf

Note: Western Michigan University (WMU) has also published a number of evaluations for the ATE program. WMU's ATE Evaluation Center was active from 2000 to 2009, but many of its documents are still accessible. More information is available at http://evaluation.wmich.edu/evalctr/ate/publications.htm

Appendix C. Information on ATE Program Budget

For nearly two decades, the ATE program has experienced growth both in its geographic distribution of centers and its budget. As a congressionally-mandated program, ATE will continue to support projects that meet demonstrated regional needs for technician education. NSF staff estimate that 30-40% of the program's budget goes towards National, Regional, and Resource Centers.

Year	Number of NSF-funded centers
FY06	17
FY07	19
FY08	28
FY09	29
FY10	39
FY11	41
FY12	38



Source: NSF ATE staff