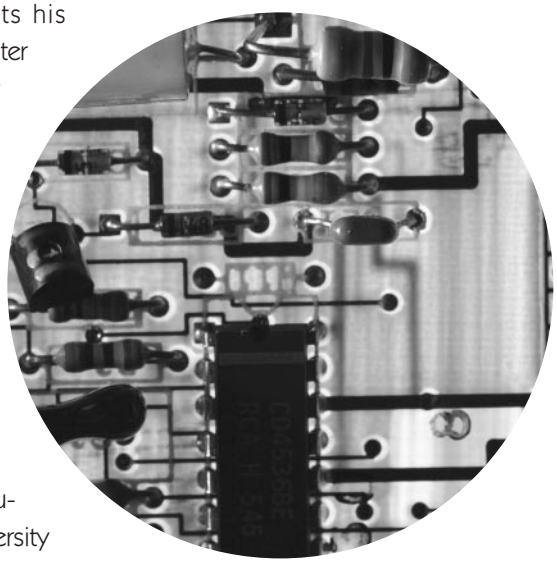
synergy

Advancing Technological Education

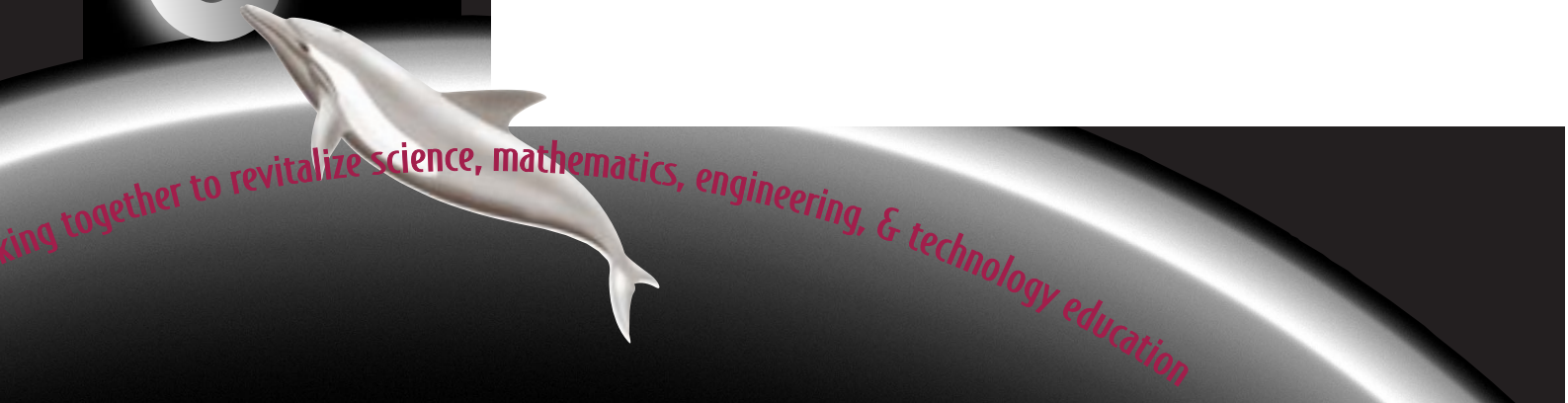
Oliver Stewart, 25, credits his associate's degree in computer engineering technology as the impetus for his life-changing leap from a fast food worker to a well-paid, entry-level software developer at CompuMight—a New York-based provider of computer systems for elderly care homes. Stewart enrolled in Queensborough Community College of the City University of New York in the fall of 1995. "I learned the latest in new operating systems, new tools, and new hardware," he says.



Meanwhile, near Seattle, Washington, Asha Nelson, a 53-year-old grandmother of five, is developing multimedia computer packages thanks to her degree from Bellevue Community College. And in Dayton, Ohio, Chris Cornelius, 20, is teaching "lean" manufacturing to senior automotive parts workers after earning an associate's degree in applied science and industrial technology from Sinclair Community College.

> "We believe we are creating a revolution in how skilled technicians will be educated nationwide in the 21st century."

Elizabeth Teles
National Science Foundation



synergy

About Synergy

Synergy is a publication about programs of the National Science Foundation's Directorate for Education and Human Resources (EHR). Each ***Synergy*** issue highlights an EHR activity that is demonstrating progress in reforming the teaching and learning of science, mathematics, engineering, or technology, prekindergarten through career entry. The "synergy" derives from EHR working in partnership with organizations throughout the United States and in all sectors of the economy to help foster the positive changes in education to which NSF is dedicated. The ingredients of these outcomes-based stories are unchanging: access to quality instruction, high expectations for success, proven excellence of materials and their delivery, and gains in learning by all students.

In this Issue...

Synergy examines the Advanced Technological Education (ATE) program, created in 1992 to strengthen and broaden the education of technicians for high-skill occupations. With two-year colleges at the hub, the program is creating synergy by engaging industry, four-year institutions, high schools, and other organizations in producing a new generation of versatile technicians who are well-versed in the fundamental concepts of science and engineering and can critically apply their knowledge and experience in the workplace. This issue focuses on two of the major technological areas served by ATE—information technology and environmental technology—to illustrate how the program is creating and inspiring dynamic models for change across the nation. Welcome to ***Synergy!***

Advancing Technological Education

These three are among the first graduates to benefit from the National Science Foundation's Advanced Technological Education (ATE) program, which is jointly managed by NSF's Division of Undergraduate Education and Division of Elementary, Secondary, and Informal Education—two branches of the Directorate for Education and Human Resources. "We believe we are creating a revolution in how skilled technicians will be educated nationwide in the 21st century," explains Elizabeth Teles, lead program director for the ATE program in the Division of Undergraduate Education. Oliver, Asha, and Chris are early evidence that this "revolution" is taking hold. Not only were they able to quickly find better jobs than they had before, but their educational experiences—including a solid foundation in science, mathematics, engineering, and technology—make their career outlooks bright well into the future.

For more than a decade, U.S. employers clamored for more and better skilled technicians in a host of fields—from mature industries like manufacturing, which had modernized, to younger industries built on environmental management and information technology, which had been redefined by an explosion of new technologies and fueled by economic and social demands. Economists projected that the U.S. workforce had an insufficient number of highly skilled workers to optimally drive the nation's economic growth. In 1992, Congress responded by passing the Scientific and Advanced-Technology Act, which authorized the ATE program.

The act directed NSF to develop models of advanced technological education centered at two-year colleges in order "to expand the pool of skilled technicians in strategic advanced-technology fields, to increase the productivity of the nation's industries, and to improve the competitiveness of the United States." The act envisioned that the projects funded under the ATE program would establish innovative partnerships with both the public and private sectors; create and disseminate new educational materials, courses, and degree programs; provide professional development for high school and college faculty; provide internships and other workplace training mechanisms for students and faculty; and make use of state-of-the-art machinery and instrumentation.

Congress emphasized two-year colleges because of their flexibility and close touch with employers, which positioned them to respond rapidly to changing workforce needs in their communities. David Price, Congressman from the Fourth District in North Carolina and the original sponsor of the bill that engendered the ATE program, explains, "I was motivated to authorize the Advanced Technological Education program by the need to improve community colleges' science, math, and technology education programs. I wanted to make the resources of the NSF, long available to our nation's four-year institutions, also available to America's community college students."

Besides enrolling traditional students fresh from high school, community colleges had cornered the market in offering fast-paced, focused programs to meet the needs of career-changers, displaced workers, and workers wanting to upgrade skills in their fields. Many of these colleges had wanted to strengthen their ability to meet industry's demand for technicians, but as Lynn Barnett of the American Association of Community Colleges explains, "Before ATE, no one knew whom to turn to for advice."

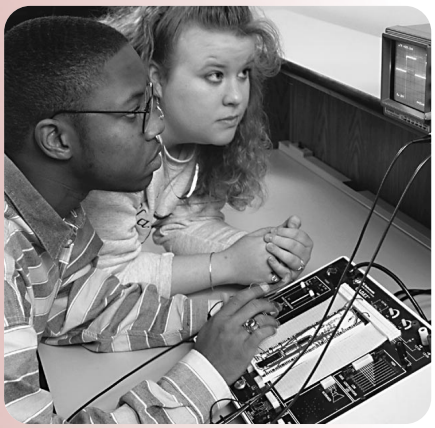
Just six years later, "the ATE program is helping to ignite a learning revolution," declares Neil Evans, director of the NorthWest Center for Emerging Technologies funded by the ATE program. Evans believes that the program is redirecting the goals of technical education to better address employer needs, while centering the instructional experience around the student, not the teacher. Arnold Packer, a prominent Johns Hopkins University labor economist, ATE project leader, and adviser to several other ATE projects, adds, "There is a sense that the nation's neglect of technician education is being addressed. Faculty are changing priorities, recognizing they must teach skills which lead to careers."

Recognizing the important role of community colleges is only part of the reason for the ATE program's success as a cultivator for the nation's high-tech workforce.

An equally significant part of the ATE vision is that two-year college programs should reach backward to the high school level and forward to four-year programs, so that students can follow a coordinated educational pathway from high school into a two-year college, and then into the workplace lor on to a four-year institution.

Beginnings of the ATE Program

DECEMBER 1992	JULY 1993	AUGUST 1993	NOVEMBER 1993	JAN-MAR 1994	MARCH 1994	SUMMER 1994	OCTOBER 1994
ATE authorized by Scientific and Advanced-Technology Act	Workshop: *Gaining the Competitive Edge*	ATE approved by National Science Board	First preliminary proposals and planning grant proposals due	First planning grants (6) awarded	First formal proposals due	First Center (3) and Project (39) grants awarded; 10 more planning grants awarded	First annual conference for ATE Principal Investigators



"[Our] ATE grant has become a catalyst for revolutionary change across the institution that would have otherwise taken many more years to develop."

Bob Williams
Daytona Beach Community College

Inside the Program: Centers and Projects

The ATE program promotes educational reform by supporting centers, which are large and comprehensive in their mission and scope, and smaller projects, which have a more limited focus. Each of the 11 centers supported in 1998 is based at a two-year college campus, and each specializes in a different area of technology, such as biotechnology, information technology, or manufacturing. The approximately 140 active projects are based at high schools, community colleges, four-year institutions, professional societies, and research laboratories. These projects constitute more than two-thirds of the program's annual budget, which was $31 million in 1998.

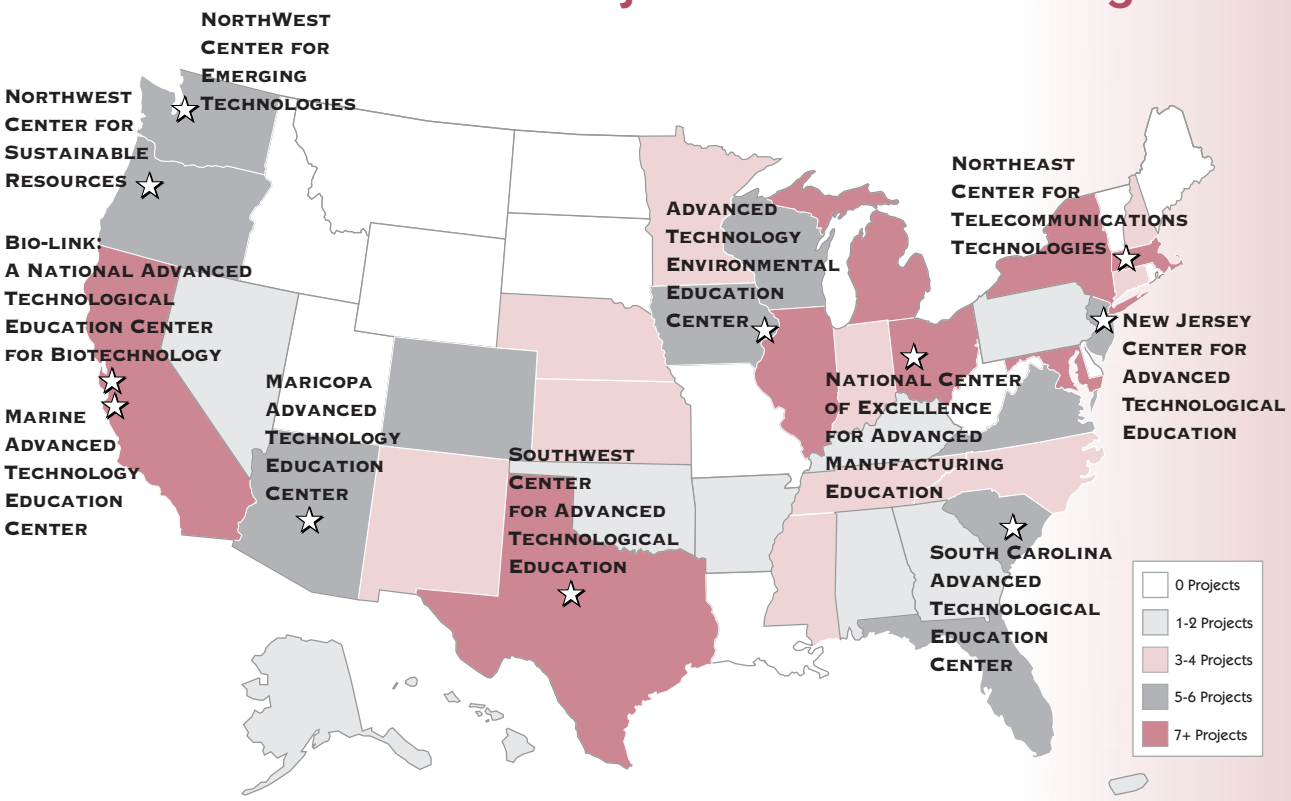
Both centers and projects typically follow a similar set of strategies regardless of their particular technological specialty. They:

- establish partnerships among high schools, two- and four-year colleges, businesses, government agencies, and professional societies in order to respond to educational needs of the industrial workforce;
- define knowledge and skill requirements for particular occupations, in collaboration with employers;
- create instructional materials (often supported by multimedia technologies) that stress the content and the real-world, team-based, problem-solving skills needed by industry;
- develop high-quality courses, course sequences, and degree programs that make it possible for students to move easily from high school to postsecondary study and into the workforce;
- offer professional development activities for high school and college faculty, opportunities for working technicians and career-changers to further their education, and internships and other workplace experiences for students;
- recruit students—especially those from populations underrepresented in technical disciplines—while monitoring and assessing their progress, job placement, and career advancement; and
- establish or contribute to national clearinghouses of educational materials and practices, so that the outcomes from ATE programs can be widely disseminated and implemented in other settings.

"Centers are models for how to put together all the issues in technician education," explains Gerhard Salinger, lead program director for the ATE program in the Division of Elementary, Secondary, and Informal Education. "Projects, on the other hand, allow more intense testing of the component parts of technical education," he continues. "Since project grants are smaller, we are able to fund more two-year colleges and benefit from their different viewpoints. We can take more risks."

The ATE program expects all its centers and projects to address a number of areas important to NSF's educational agenda. Grantee institutions are expected to share the costs of the project by raising outside resources, and their annual reports to NSF show that significant additional contributions (often totaling 50 percent or more of the original grant) are being tendered, usually by industry partners. As part of its belief that solid career paths for technicians begin with strong instruction in science, mathematics, and technology at the secondary level, the ATE program encourages its grantees to contribute to the preparation of future middle and high school teachers. It also stresses activities that aim to enhance the diversity of the scientific and technical workforce, as well as those that use new technologies to improve teaching and learning. All centers and projects are required to include sound evaluations and to disseminate widely the best of their results.

ATE Projects and Centers Through 1998



Advancing Technological Education

But the impact of the ATE program reaches far beyond its basic educational strategies. The program is clearly creating synergy between the academic and private sectors; it is bringing together key audiences and challenging them to build new solutions to both old and new problems. "You sense a real enthusiasm for what they're doing. They believe they're making a real difference. It's almost like an electric charge," says Lynn Barnett, who is preparing case studies of selected ATE projects and centers in order to single out the practices that work best.

Most importantly, however, notes Luther S. Williams, NSF's Assistant Director for Education and Human Resources, "ATE opens the door to high-skill, technical occupations for all students—including a large fraction of students who were previously left out." Williams believes the success of the program can be traced to its multitude of effective partnerships, its grounding in rigorous instruction in the fundamental concepts of science and engineering, and its model curricula that lay out articulated pathways from high school to community college and beyond. He adds, "This effort is strengthening the science and technology workforce as a whole by injecting new skills and perspectives. That's why it is attracting so much attention."

ATE Projects and Centers, by Disciplinary Focus, through 1998

Agriculture	4
Aquaculture	1
Biotechnology	18
Chemical technology	11
Core science and mathematics for technical programs	22
Electronics, instrumentation, laser and fiber optics	12
Engineering technology (general)	12
Environmental technology	19
Geographic Information Systems (GIS)	8
Graphics, multimedia	7
Information technology, telecommunications	16
Machine tool technology, metrology	3
Manufacturing, industrial technology	34
Marine technology	4
Multidisciplinary or general science and technology	43
Transportation	2
TOTAL	**216**

> "This effort is strengthening the science and technology workforce as a whole by injecting new skills and perspectives. That's why it is attracting so much attention."
>
> Luther Williams
> National Science Foundation

Technical Perspectives

What are skilled technicians and what do they do?

In the words of management consultant Peter Drucker, technicians are "highly skilled workers who also possess a substantial amount of formal knowledge, formal education, and the capacity for continuous learning." Although other industrial nations have formal classifications and established systems for training such workers, notes Drucker, in the United States there are myriad job definitions and educational avenues to technical careers. Depending on their field of specialization and the industry in which they work, technicians can be found operating machines or laboratory or field equipment; collecting samples; performing tests or experiments; recording and analyzing data; troubleshooting, calibrating, servicing, or repairing equipment or processes; or educating other users of equipment. They also communicate detailed, firsthand knowledge about particular technologies to other professionals, such as scientists and engineers, who depend on or design for those technologies. Often they must interface with the public, as well. This mix of duties means that technicians need not only technical competence but also good interpersonal skills.

For example, computer technicians typically install hardware and software; connect wiring systems for networking and communications; maintain, troubleshoot, and repair computer equipment and related communication systems; and provide technical support to users of hardware and software. Hazardous materials technicians typically monitor a workplace's environment and workers for unsafe exposure to hazardous materials; calibrate, operate, troubleshoot, and repair sampling and monitoring equipment; handle, store, and dispose of hazardous materials; follow and apply local, state, and federal environmental regulations; assist in the design and implementation of safety and health plans; maintain records; and respond to hazardous materials releases and follow appropriate procedures for cleanup and decontamination.

"Manufacturing technicians," says Jack L. Waintraub, director of the **New Jersey Center for Advanced Technological Education**, "troubleshoot, design, and prepare for the production of cost-efficient, state-of-the-artproducts." Like other technicians, they apply their scientific and technical know-how and use their own judgment and experiences in operating, fixing, and improving the machines, processes, and information flow that serve the mission of their organization.

Michelin—the automotive tire company and a partner of the **South Carolina Center for Advanced Technological Education**—relies on workers like John Dove, a maintenance technician, to keep its 1,150-worker production plant in

Anderson, South Carolina, humming. Dove, 36, is a "troubleshooter," one of two technicians who must fix any of 85 to 100 machines when they malfunction. Working unsupervised, they decide for themselves when and how to most effectively respond to a problem, except when a "priority machine" breaks, which can stop the production line. Then "we are expected to give an answer in 20 minutes," Dove says. Different machines exhibit different problems, and because the production line runs continuously, each day

brings new challenges. Breakdowns can occur in the computer network as well as in the production machinery; Dove needs to know electronics, mechanical engineering, and networking. In the highly competitive tire industry, says Joseph McMullen, one of Dove's supervisors, "If the line shuts down, you see money flying out the window."

Such workplace realities have helped shape the ATE program's philosophy of technical education. At its foundation stand five "pillars":

One, students should learn sound knowledge of the field as industry practices it.

Two, students should be grounded in the core science and mathematics that underpin their technological field.

Three, the learning environment should replicate the workplace. (For example, a team-taught multidisciplinary curriculum exposes students to different knowledge areas and perspectives while modeling teamwork.)

Four, students should graduate from two-year programs prepared not only to succeed in their first job but also to be lifelong learners.

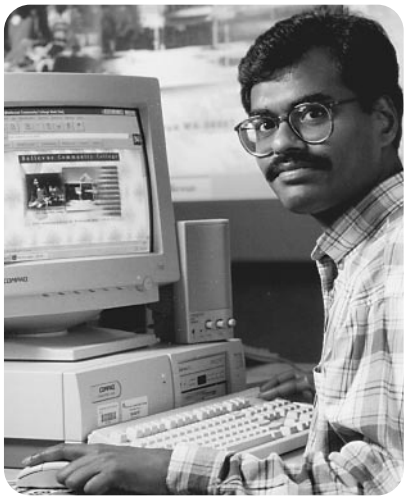
Five, traditional students should be able to move seamlessly from high school to community college and—depending on their interest—into the workforce or on to four-year degrees, and adults preparing for new careers should be able to move quickly through courses into a highly skilled job.

To glimpse the synergy that these pillars are creating in technological education, we will focus here on just two of the many areas that the ATE program serves: information technology and environmental technology.

New Designs for Advanced Information Technology

Along with 16 projects, the ATE program supports two centers devoted to information technology education—one in Washington State and the other in Massachusetts. A closer look at the history of these two centers can illustrate how the ATE program is restructuring technical education.

The **NorthWest Center for Emerging Technologies,** located at Bellevue Community College, is reformulating information technology education with the help of two successive three-year ATE center grants totaling $5 million. The center counts Boeing, Microsoft, US West, Siemens, the Washington Software Alliance, and the State of Washington among its major partners. Since NSF announced its first award to Bellevue in 1995, the center has developed a set of skill standards for eight career clusters in information technology, overhauled its curriculum, and signed partnering agreements with more than 25 high schools and institutions of higher education across the state.



With the world's leading software provider and the world's largest aerospace company both headquartered nearby, Bellevue is positioned to feed an exploding demand for well-qualified workers in information technology. Jean Floten, the college's president, describes how the center got its start. "[Industry] said they wouldn't be interested until we demonstrated we were good users of the technology ourselves." So Floten hired Neil Evans, formerly chief information officer at Microsoft, to turn the center and its staff into a modern, high-tech organization. But it was not until the NSF grant became public that area companies began to commit as partners, contributing cash, personnel, and other in-kind support.

Boeing had made some earlier contributions, but stepped up to do much more. The ATE award

Networks!

The central southern region of Mississippi has not been the same since Computer Sciences Corporation—one the largest providers of information services in the world—and other industry giants such as WorldCom, Mobilecom, and Skytel arrived in the mid-1990s. Many of the information technology employers in the area used to stage their own training courses until "they were competing with each other," explains Robert Landrum of Jones County Junior College in Ellisville.

Landrum and his colleague Catherine Cotten researched the problem and discovered that the state's two- and four-year colleges were not doing enough to educate their students for careers in information technology. In 1997, they received an ATE grant to remedy the problem. Under their project, **Network Training for Educators**, the college is building a statewide infrastructure to provide education and training in network technology for two-year college and secondary school instructors. Instructors from around the state come to the campus for intensive four-week workshops designed to help them teach information technology. Intensive is the operative word: some workshop participants claim that it is the toughest four weeks of their academic lives. Not only is the training rigorous, but in order to receive a full stipend for attending the workshop, a participant must take and pass, at an official testing center, one of the examinations to become either a Novell- or Microsoft-certified network administrator. So far, an impressive 70 percent of the 150 participating middle school, high school, and community college instructors have become certified.

Landrum and Cotten have developed a new degree program in local area network management, which is now offered at the campus, and they have designed a complementary curriculum for use at the secondary level. Since many of their students plan to become elementary or secondary teachers after they graduate, teacher preparation has been given significant emphasis. The project is helping to prepare these future teachers to introduce, teach, and maintain information technology systems in the schools.

From 20 students, the program has grown to over 200. About 25 percent are from racial or ethnic minority groups—representative of the proportion in the area—and 60 percent are women. Starting salaries for new graduates are in the high $20,000s to low $30,000s—an excellent starting wage for the region. Landrum believes they are turning out top-notch graduates. "How can you have an average placement rate above 95 percent year after year if you're not?"

By sharing their curricula and experience with other ATE grantees, the Jones County project team exhibits the spirit of cooperation that characterizes the "ATE family." For example, the team has begun acting as a mentor to a younger ATE project at Diné College, a tribal college serving the Navajo Nation in northeastern Arizona and northwestern New Mexico. Landrum, Cotten, and two associates have traveled to Arizona to visit the project site and have shared their instructional materials with the Diné College team, which is developing a program to educate students to maintain computers and computer networks, largely to meet needs within the Navajo Nation. Likewise, the project leader from Diné has traveled to Mississippi to learn more about Jones County's facilities and programs and to attend one of the four-week workshops on computer networking. Through such cooperative efforts, the ATE program aims to maximize projects' effectiveness and build a larger community pursuing common objectives.

Advancing Technological Education

also caused Microsoft—with nearly 15,000 employees in the Puget Sound area—to take notice. Each company pitched in a million dollars. "We're contributing time and money so [the center has] the resources it needs to be able to provide us the kind of top-caliber talent we're looking for," says David Pritchard from Microsoft. Adds Boeing's Dianna Pressely, "Information technology is very important to the Boeing Company. We employ people who . . . apply computing technology across the board so we can keep the competitive advantage in the aerospace industry."

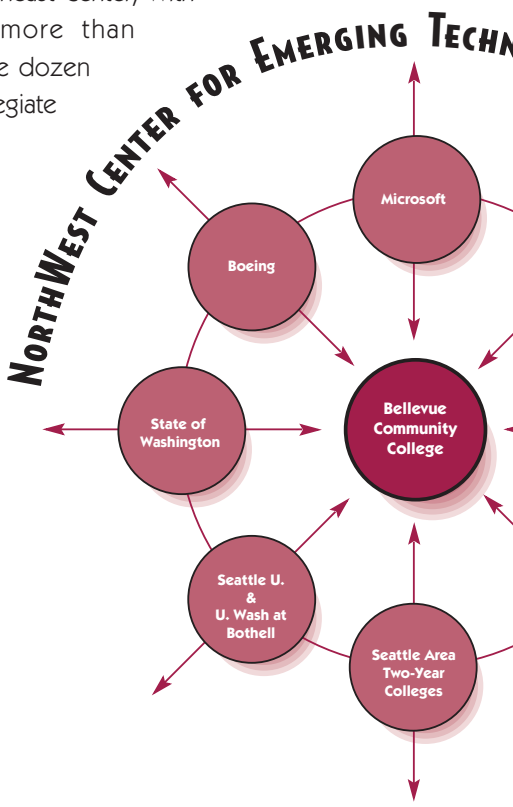
In the few years that the center has been operating, it has launched a full-scale plan to redesign information technology education and assist schools, colleges, and industry across the nation. Its elaborate skill standards for occupations in information technology have been validated by industry leaders and educators and endorsed by major professional societies.

Besides serving as the basis for new courses and curricula at Bellevue, the skill standards are being used to develop an information technology Tech Prep curriculum at the high school level. This curriculum is being tested in the regional Tech Prep consortium of schools that partner with the NorthWest Center; and it will link with Bellevue's new associate's degree program in information technology, which will itself link with university degree programs to create a model "2+2+2" curricular structure spanning the high school, community college, and university levels. The Tech Prep consortium has also developed a presentation to help parents of secondary school students sort through the options for college study and become aware of the educational paths to careers in information technology and other high-tech fields.

By April 1998, Bellevue had more than 400 students enrolled in information technology programs; its two-year college partners had 2,400. Center officials estimate they have reached out to more than 25,000 students through presentations at high schools, community fairs, and other settings. With major publishers on board to disseminate the center's products to educational institutions and industry, its increasing impact on a national level seems assured.

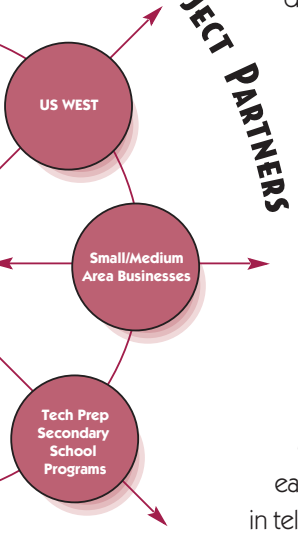
The **Northeast Center for Telecommunications Technologies** got its start in 1997 when employers and educators from New York and New England joined forces with Springfield Technical Community College in Massachusetts to create a program that would prepare a new generation of telecommunications technicians.

The astounding expansion of the Internet, the passage of telecommunications reform laws, and advances in communications technologies have all contributed to the unprecedented growth of the telecommunications industry in recent years. The Northeast Center, with its more than three dozen collegiate and high



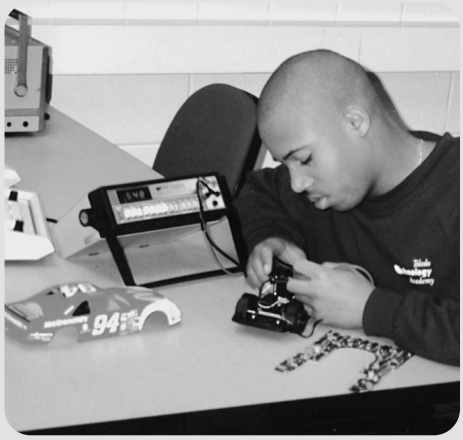
school partners, has set out to meet the educational challenge resulting from the industry's growth, so that the United States can maintain its global advantage in telecommunications. Although just a year old, the center has lined up an impressive set of partners from industry, including Bell Atlantic, IBM, Texas Instruments, and Time Warner Cable, along with virtually all key government entities in the region, including the New England Board of Higher Education, the two major unions representing communications workers, and several trade associations.

The center did not have to start from scratch, but instead grew from several NSF-funded education projects focusing on computer networking and optics technologies. In designing new educational materials and curricula, it has also been able to draw from, and complement, the ongoing Next Step program.



Launched in 1996 by NYNEX (now Bell Atlantic), the International Brotherhood of Electrical Workers, and the Communications Workers of America, Next Step allows qualified employees to earn associate's degrees in telecommunications technology in a curriculum jointly designed by management and labor.

Virtual Vision



With the help of a 1997 ATE grant, Daytona Beach Community College is creating a virtual classroom for introductory classes in electronics, computer-aided design, civil engineering, and computer programming. This new learning environment is just the first step in the college's plans to accommodate different learning modalities and the diverse schedules and lifestyles of "nontraditional" students (those older than the "traditional" age of 21), who constitute about 60 percent of community college enrollment nationwide. "Our current population is composed of more mature students with significant personal responsibilities that limit their ability to follow a traditional college schedule," reports project director Bob Williams.

The **Virtual Classroom Environment** project permits students to access their courseware at any time and from any place through the Internet, through CD-ROMs, and through video-based courses distributed with the help of WCEU, the local PBS affiliate. The virtual environment encourages students to work at their own pace; to benefit from the presentation of course material in multimedia; to study on campus, at work, or at home; and to "attend class" when they have the time—morning, noon, or night.

The virtual classroom gives students the freedom to interact with faculty at any time or place—not just in lectures or laboratories. Williams explains, "The teacher can focus less on content delivery and spend more time tailoring the materials needed by individual students, and play a greater role as learning facilitator, evaluator, mentor, coach and counselor." Project staff are also developing and implementing interactive curriculum materials, and they plan to provide training to secondary school teachers in the use and development of interactive computer-aided instruction.

According to Williams, the project is inspiring and mobilizing faculty, staff, and students from all over the campus. In fact, it has made such an impact that the college has recently chartered a challenging new direction for the future: to transform itself into a national leader in distance learning. "The ATE grant has become a catalyst for revolutionary change across the institution that would have otherwise taken many more years to develop," he concludes.

Advancing Technological Education

The center's director, James Masi, is quick to note that its rapid start-up has been assisted by advice it received from existing ATE centers and by the growing expertise in technician education that the program has fostered. "[Although] this center would have been possible without the NSF, it wouldn't have had the direction and the motivation it has," he says.

One indication of the NorthWest and the Northeast centers' progress and the ATE program's cachet could be seen early in 1998, when both colleges were among the first five institutions to be designated as "Mentor Colleges" in the new, well-publicized Working Connections grant program sponsored by Microsoft and the American Association of Community Colleges. The two community colleges will be responsible for mentoring other Working Connections grantees as they attempt to implement new educational programs in information technology.

Resources for Environmental Technology Education

The ATE program also supports two centers focusing on environmental technology education—one in Oregon and the other in Iowa—in addition to a related center for marine technology education and more than 15 associated projects.

Declining populations of Pacific salmon and shrinking old-growth forests are forcing economies in the Pacific Northwest to shift toward more sustainable methods of managing the environment. The **Northwest Center for Sustainable Resources**—coordinated by Chemeketa Community College in Salem, Oregon—is a model for collaboration in addressing these regional and national problems. The center was funded by the ATE program in 1995 and renewed in 1998, for a total of $5 million. It encompasses more than 100 partners, primarily in Oregon, Washington, and northern California. Among them are Oregon State University, the University of Washington, California Polytechnic State University, several high schools and school districts, the Weyerhaeuser Company, Native American tribal confederations, the U.S. Forest Service, and the U.S. Fish and Wildlife Service.

Under the Sea

The great seas of the Earth cover more than two-thirds of its surface but often seem oceans apart from our daily experience. In reality, however, they are much nearer: the majority of the world's population lives within 100 kilometers of a coast. Oceans affect weather and climate; they provide food, minerals, and fuels; and they are a major venue for recreation and transportation.

In 1997, Monterey Peninsula College in California, along with its partnering institutions, competed successfully for an ATE center grant. The **Marine Advanced Technology Education Center** set out to improve the education of people who are interested in ocean-related occupations and to meet the needs of the workforce and employers in those fields.

Marine technology is multidisciplinary and intersects with many other technological areas such as environmental management, transportation, and construction. Marine technicians apply their multifaceted science and engineering skills to the understanding and use of the marine environment. They work in the open ocean, coastal regions, estuaries, rivers, swamps, lakes, and laboratories. According to the center, marine technicians have, in the past, been recruited to help with the design, construction, testing, or repair of such diverse projects as the transoceanic fiber-optic cable network, astronauts' tools used to repair the Hubble space telescope, the Shasta Dam water control system in California's Central Valley, swimmer delivery vehicles for the U.S. military's Special Operations Forces, equipment used in marine aquaculture, and aquatic entertainment devices for amusement parks.

According to its director, Nicole Crane, the center is providing the kind of leadership to reshape marine technology education that will meet the demands of the future. The increasing use of computers and advanced technologies, the growing complexity of equipment such as remotely operated vehicles, a more international perspective, and a greater demand for environmental monitoring, assessment, and cleanup will continue to influence the education of marine technicians and their work assignments in the coming years.

The center emphasizes intensive collaborations that focus on developing a variety of products and services, including courses and curricula; online exchanges for students, technicians, educators, and employers; student internships and school-to-work experiences; on-demand courses for practicing technicians; and faculty development workshops. The center is focusing on areas of marine technology for which there is a growing demand that is not currently being met by the existing educational system.

Bringing Together Western Technology and Native American Culture

Historically, Native American lands have been neglected, and native tribes have not had the resources and expertise to gain a foothold on cleanup and the prevention of further pollution. At least that was the case until Mesa State College in Grand Junction, Colorado, along with partnering tribal colleges in 10 states, won an ATE project grant in 1994 to develop an environmental technology program that effectively places technical education in the context of the rich cultural history of native people, while bolstering the connection they have traditionally had to the earth and its resources. According to Frank Morgan, a cultural consultant, the project aims to produce technicians "who have training in both Western technology and cultural ways, who respect relationships in the environment, and who can suggest technological solutions appropriate to the tribal world."

Together, the Native American colleges involved in the ATE project have set out to do dramatically more to help tribes measure, analyze, and respond to environmental risks on their lands through their own technologically educated environmental workforce. The **Environmental Technology Education Transfer to Native American Tribal Colleges** project is using existing resources to create and disseminate an interdisciplinary associate's degree curriculum in environmental technology for tribal and other colleges that educate Native Americans. This curriculum focuses on technologies used for environmental monitoring, site assessment, solid waste management, and pollution prevention—the technologies most relevant to the environmental issues facing native tribes. Students are developing analytical skills that lead to well-paying jobs on or near tribal lands while furthering their connection to their cultural heritage and benefiting the environment.

The project is also sponsoring professional development opportunities for faculty, designing instructional materials, and implementing a novel equipment rotation program so that all the partnering colleges—regardless of their individual resources—can benefit from proper instructional and experimental instrumentation.

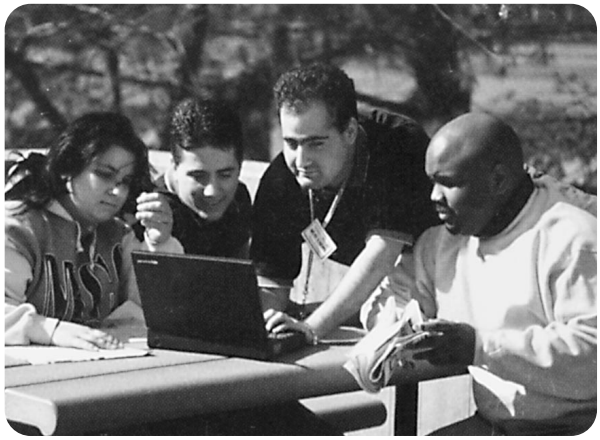
Through the center, these diverse groups are improving education about agriculture, fisheries, and forest and wildlife management by emphasizing how ecosystems can be sustained by carefully balancing resource use with conservation. Wynn Cudmore, the principal investigator on the grant, explains the center's philosophy: "Rather than managing for a single commodity like salmon or Douglas fir trees, we recognize that the management unit needs to be the entire ecosystem. To operate in this new world of ecosystems management, students need a whole new set of skills. They need to be effective communicators. They need higher math skills. And they also need to understand how to use a scientific approach."

In an efficient division of labor, six community colleges in Oregon, Washington, and California have each taken the lead in developing materials and programs for one of the center's six focus areas—agriculture, fisheries, forestry, wildlife, environmental science, and geographic information systems (GIS). Other colleges in the region then test and modify the core programs. Internationally recognized research organizations have also assisted the center in developing curricula that incorporate higher levels of science and mathematics in response to employers' demands. Students now learn more biological and physical science, advanced data

collection and analysis, and how to use cutting-edge tools, such as GIS and other computer-aided technologies, in the context of mapping and monitoring complex ecosystems.

To advance program development in grades 9 through 12, the center has pioneered a series of "summer institutes" for high school teachers, which allow the teachers to gain field experience, learn about the latest developments in natural resources research and pedagogy, and connect with natural resources specialists in their communities. The institutes are offered over a three-year cycle, with an in-depth session the first summer and followup meetings during the next two summers. The center intends these summer experiences for teachers, along with additional year-round support, to translate into comprehensive, coordinated sequences of natural resources courses and activities for secondary students. This effort especially benefits students in Oregon, where Natural Resources Systems is one of six career-related "endorsement areas" for the Certificate of Advanced Mastery offered at the high school level. The center also sponsors a similar series of summer workshops for college faculty.

The center's headquarters at Chemeketa Community College provides leadership by coordinating activities across sites and serving as a forum for partners to share innovative ideas. An electronic network allows partners and others to exchange and disseminate information on environmental education that it collects from regional, national, and international sources.



In the 1980s, the Eastern Iowa Community College District began developing courses to teach technicians how to interpret and apply government environmental regulations for area businesses. The effort, however, was fragmented until the college district won a three-year ATE center grant in 1994, which served to draw together a range of related efforts into the **Advanced Technology Environmental Education Center**, located in Bettendorf, Iowa.

The center—which has since received a three-year renewal grant—developed partnerships with the Hazardous Materials Training and Research Institute (operated by two Iowa community colleges), the University of Northern Iowa, and the Partnership for Environmental Technology Education, a huge consortium that networks environmental education programs nationwide. The end product of this alliance is a nationally recognized authority on environmental education to lead development of instructional materials and curricula and provide professional development for high school and two-year college educators through a prestigious annual fellowship program. The summer fellows program, which revolves around field work, has involved over 80 educators from two dozen states in its three years of operation, and has been judged so successful that in 1997, the center won an award widely recognized in the field for "excellence in creating innovative teacher learning opportunities."

Advancing Technological Education

"I was motivated to authorize the Advanced Technological Education program by the need to improve community colleges' science, math, and technology education programs. I wanted to make the resources of the NSF, long available to our nation's four-year institutions, also available to America's community college students."

Rep. David Price (D–N.C.)

The center is assisting two-year colleges and high schools that want to create or improve environmental education programs. It helps them use communications networks and instructional technologies more effectively, meet the needs of diverse learners, and apply teaching and curriculum standards for environmental education. Toward this end, the center has undertaken the task of defining 11 occupations in environmental technology, identifying the skills required for each, and designing academic programs that convey these skills.

Catherine Almquist, leader of an ATE project in environmental technology and an associate dean at Trident Technical College in South Carolina, attests to the effect that the center is having on the field: "When someone from a two-year college wants to know what's going on in environmental education, they always contact the Iowa center first."

Like other ATE centers, the Iowa center works closely with ATE projects in its field. For example, it has produced two textbooks for the Preserving the Legacy project, which is overseeing the development of a series of seven textbooks and 15 videos covering topics in environmental technology. As a complement to its own faculty fellowship program, the center also conducts the Curriculum Problem Solving Network for the Faculty Associates in Science and Technology (FAST) program, which is led by the Partnership for Environmental Technology Education and funded by the ATE program. Over two years, FAST has placed 80 community college instructors with a business, national laboratory, national park, or government agency in a four- to eight-week summer program to work on environment-related projects. The Curriculum Problem Solving Network provides important followup activities for these faculty associates and gives them a forum to discuss current issues in instruction.

Looking Ahead

Even though the ATE program is just five years old, it is already mature enough for participants and outsiders alike to see that it is improving the caliber of technical education nationally. In 1997, an outside committee of experts reviewed the program and reported, "ATE breaks new ground for NSF. It introduces a new community of faculty, institutions, and groups heretofore not touched by NSF programs." So far, about 40 percent of program funds have been awarded to institutions new to NSF support. The relatively large number of first-time grantees makes the program a high-risk venture, but to date, this investment seems to have paid off. In February 1998, a *Washington Post* editorial singled out the ATE program as a catalyst for "well-designed collaboration[s] between companies and community colleges … [which] has launched some 200 such partnerships over five years."

In selecting grantees, NSF applies its system of merit review, in which independent experts from academia and industry review proposals, rate their quality, and provide constructive feedback (anonymously) to the authors. NSF program officers expect the products of ATE projects and centers to align with respected standards, such as the National Science Education Standards, the mathematics standards issued by the National Council of Teachers of Mathematics, and voluntary industry standards. Efforts are also made to ensure that the centers and projects help students develop the competencies identified by the Secretary's Commission on Achieving Necessary Skills (SCANS) in the influential 1991 Department of Labor report *What Work Requires of Schools*. As noted earlier, several of the centers and projects have themselves spearheaded the development of skill standards in their fields.

In addition, each center and large project is required to undergo periodic review by a committee of experts, who advise on a range of issues and make recommendations for improvement. These committees both assess the progress of grantees and assist in disseminating information about their work. Through the Evaluation Center at Western Michigan University, NSF helps identify intern-evaluators for some ATE centers and projects.

When a poll was last taken at an ATE conference for principal investigators in November 1996, the six existing centers estimated that they had formed partnerships with more than 450 community colleges, involving more than 1,000 college faculty. Since then, the ATE program has added five new centers and 79 projects. The impact on faculty and students has surely grown dramatically. **The Maricopa Advanced Technology Education Center** in Arizona, which concentrates on semiconductor manufacturing education, provides one concrete example: When the Maricopa center's grant was awarded in 1996, 34 community colleges and technical schools were either offering or developing programs in semiconductor manufacturing, and about 1,000 students were enrolled in these programs. By 1998, the number of colleges had increased

Advancing Technological Education

> "There is a sense that the nation's neglect of technician education is being addressed. Faculty are changing priorities, recognizing they must teach skills which lead to careers."
>
> Arnold Packer
> Johns Hopkins University

to 81 and the number of students had quadrupled, owing to the recruitment and curriculum development efforts that the Maricopa center undertook in collaboration with two major consortia of semiconductor manufacturers, SEMATECH and the Semiconductor Industry Association. In 1998, the center also distributed over 500 copies of its award-winning career awareness video "A Fab Way to Work" to high schools, thereby introducing approximately 7,500 students to career possibilities in semiconductor fabrication.

Many of the faculty who have participated in ATE projects and centers feel their careers have changed for the better. "We cannot go back to teaching the way we taught before," declares Susan Johnson, a mathematics instructor at Greenville Technical College, who benefited from professional development offered by the South Carolina ATE center in Columbia.

Oliver Stewart, Asha Nelson, and Chris Cornelius also cannot go back. Stewart, the Queens, New York, software technician, has developed skills and confidence through his ATE-supported experience. He not only found "a great first job where I feel very comfortable," but he has received other job offers, including one for $65,000 per year. Nelson, the grandmother of five, had an earlier career in social work, but switched to software when Seattle's information technology industry exploded. Her earlier training was narrow and resulted in few transferable skills. Nelson's Bellevue degree has made her so eager to expand her skills that she recently turned down a higher paying job because she felt the work was too limiting.

Cornelius, the manufacturing technologist, plans to continue working while going on to a four-year program at the University of Dayton. All of the degree credits he earned at Sinclair Community College will transfer to his four-year degree program, in keeping with the ATE program's philosophy. "You can go anywhere with an education," he proudly remarks.

Norman L. Fortenberry, director of NSF's Division of Undergraduate Education, sums up: "We're very impressed with what the ATE centers and projects have accomplished in so brief a time. They truly are reformulating technical education. In a decade, I'd like to think that we will be able to look back and say that technician education has changed in the U.S., and NSF has been a leader in this effort."

SYNERGY SNAPSHOT: Two-Year Colleges on the Move

Two-year colleges play a unique role in the higher education system. They offer open admissions and lower tuition, and work closely with local employers. They provide preparation for transfer to four-year institutions, for direct entry to the workforce, and for lifelong learning. They serve not only traditional students on their way to first full-time jobs, but also experienced workers returning to college to upgrade their skills or retool for new careers. All of these missions are congruent with the goals of the ATE program, making for the productive partnership that NSF has forged with two-year institutions.

In 1996, there were nearly 1,500 two-year colleges in the United States, with a total enrollment of approximately 5.5 million full- and part-time students. This enrollment accounted for about 45 percent of the nation's undergraduates—up from 31 percent in 1970. More than 60 percent of the students attending two-year institutions were enrolled part time, as compared with 30 percent of students attending four-year institutions.

Community colleges are funded primarily by state appropriations (43 percent), tuition (22 percent), and local funds (19 percent). Tuition at public two-year institutions is much lower—$1,633 per student, on average—than at most public four-year institutions, where the tuition averages $3,243.

Community college students tend to be older than the typical college student. The average age is 32. While 61 percent of the four-year college population is less than 25 years old, only 50 percent of the two-year college population is. One out of every 10 community college students already has a bachelor's degree. African American students make up 12 percent of two-year enrollment, which is slightly higher than their proportion (10 percent) in four-year institutions. Latinos, who account for only 6 percent of four-year college enrollment, make up 11 percent at the two-year level. Native Americans account for approximately 1 percent of the enrollment at both types of institutions.

Graduates of two-year colleges are more likely to be employed than those that hold only a high school diploma. In 1996, their respective unemployment rates were 3.3 percent and 4.7 percent for those 25 years and older. Two-year college graduates also earn higher salaries on average. For women, a two-year postsecondary degree makes a difference of over $6,800 in median annual income, and for men, a difference of almost $5,700.

Sources: College Board. 1998 *Trends in College Pricing 1998.* Available online at http://www.collegeboard.org/press/cost98/html/981007.html.

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Links to the centers' home pages can be found on the World Wide Web at **http://www.ehr.nsf.gov/ehr/due/web/ate/atelist.htm.**

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For more information on the Advanced Technological Education program, phone NSF's Division of Undergraduate Education at 703/306-1668 or NSF's Division of Elementary, Secondary, and Informal Education at 703/306-1620, or send e-mail to undergrad@nsf.gov. Information may also be found at EHR's Web site, http://www.ehr.nsf.gov.

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