The National Science Foundation's Advanced Technology Education Program

Final Evaluation Report

The Evaluation Center
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November 29, 2006

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Advanced Technological Education
Final Evaluation Report

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Abstract

This report describes the basis from which the ATE program was created and conducted and the evaluation work that has shadowed this program for the past seven years. It traces the program's work and reach to community colleges and others since the beginning of the ATE program. It analyzes ATE solicitations to show linkages between the program guidelines and program productivity and then describes this evaluation's design and data collection methods to show why and how evaluative data were collected. The following evaluation findings both describe and judge the program in various respects.

Findings from the evaluation show that the program is healthy and well run. Nearly a fifth of the nation's two-year colleges have been funded at least once by this program, and those funds have resulted in substantial productivity in funded and collaborating institutions and organizations. Major strengths of this program are evident in its materials development, professional development, and program improvement products. Large numbers of students and teachers have participated in this program—taking courses and graduating or otherwise being certified. Business and industry have collaborated with colleges in developing and conducting these programs with perceived substantial benefits from that involvement.

Multiple strands of evaluative information describe and confirm that the program produces important outcomes of good quality. Though consistently positive, these findings are highly dependent on testimony/feedback as a primary quality assurance mechanism. We believe additional project/center-based direct evidence of program effectiveness and quality would strengthen claims of quality and provide important information for program improvement. Suggestions are made that we believe will improve the ATE program; these suggestions are viewed as small changes designed for incremental improvement.

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Executive Summary

The Advanced Technological Education (ATE) program is a response to the need to improve U.S. competitiveness in the world economy by increasing the quantity and quality of technicians in strategic advanced technology fields. In 1999, The Evaluation Center at Western Michigan University was awarded a grant from the National Science Foundation to evaluate the ATE program. A second grant was awarded in 2002 to continue and expand the evaluation. A central feature of the evaluation was an annual survey of ATE grantees. In addition, the evaluation included site visits; targeted studies on the value added to business and industry, materials development, professional development, and sustainability; issues papers focused on collaboration, dissemination, materials development, professional development, program improvement, recruitment and retention, sustainability, advisory committees, and evaluation; and three separate metaevaluations. About 40 reports focused on various aspects of the ATE program evaluation are available from The Evaluation Center's Web site at www.wmich.edu/evalctr/ate/. This final evaluation report presents a broad-brush summary of the program, its achievements, and its likely impact, framed around the four primary evaluation questions, as discussed below.

To What Degree is the ATE Program Achieving its Goals?

The ATE program essentially has two long-term goals: to increase the nation's capacity to provide advanced technological education and to increase the number and quality of skilled technicians in the workforce.

There is evidence that the program has made significant strides toward ***increasing the nation's capacity for advanced technological education*** in terms of increasing the number of technical education programs and improving their quality; providing professional development to increase the knowledge and skills of technical educators; creating, improving, and disseminating instructional materials; and establishing collaborative partnerships to support technical education. Over the course of the 2000-2005 evaluation period, ATE principal investigators reported the following achievements:

- 19,000 courses and 3,000 programs were developed or improved with ATE funding at almost 5,000 locations.
- More than 80,000 participants took part in more than 5,500 ATE professional development activities.
- More than 5,200 materials were developed, including about 1,650 courses, 2,500 modules, and 1,000 other materials. Of these, about 135 courses, 560 modules and 500 other materials were published commercially.
- From 2000 to 2005, between 80 and 90 percent of grantees reported collaborating with business and industry and/or other education institutions. The average grantee reported

approximately a dozen or more collaborations with education institutions and even more with business and industry.

The ATE program has demonstrated some success in terms of providing the necessary ingredients for ***creating a larger, more skilled technical workforce.*** ATE principal investigators reported the following achievements during the 2000-2005 evaluation period:

- An estimated 130,000-190,000 students took at least one ATE-supported technological education course, with more than 32,000 completing programs of study.
- More than half of those completing programs had already been part of the technical workforce.

Together these indicators provide good circumstantial evidence that in addition to adding to the sheer number of technicians, it has raised the overall skill level of that segment of the workforce. However, we cannot state definitively that the ATE program has led to "more skilled" technicians in strategic advanced technology fields.

Is the ATE Program Making an Impact and Reaching the Individuals and Groups Intended?

The ATE program targets current and prospective technicians, technical education students, secondary and postsecondary teachers, prospective teachers, and business and industry decision makers. NSF also seeks to increase the participation of women, underrepresented minorities, and persons with disabilities in advanced technology areas through ATE program activities. The program's institutional target has been two-year colleges.

The annual survey data, along with grant award data, confirm that the program is reaching its primary targets:

- Approximately two-thirds of the 32,000 individuals who reportedly completed ATE programs of study were at the associate level, one-third were at the secondary level, and fewer than 1 percent was at the baccalaureate level.
- 345 institutions received ATE funding, including 200 two-year colleges. This amounts to the program directly funding 17 percent of the 1,157 community and technical/vocational colleges in the U.S. The remaining funding was distributed to secondary schools, 4-year colleges and universities, professional societies and associations, and a small number to business and industry.
- Annual survey findings show that the typical ATE project and all centers reach multiple education institutions to bring materials, program improvement, and professional development opportunities to them. Annually from 2000 to 2005, the typical (median) individual ATE grantee collaborated with five or more other non-ATE education institutions. Those data suggest that the majority of this country's community colleges have been impacted in one or more ways by the program.

However, demographic data show minimal gains in terms of increasing the rate of participation of women and minorities in technology fields.

How Effective is the ATE Program When it Reaches its Constituents?

Evaluative evidence focused on three areas or categories of work: materials development and dissemination, professional development efforts, and program improvement–student engagement. Evidence of program productivity in all three areas is very strong. This productivity shows in the large numbers of materials, courses, and curricula developed; the numbers of participants who engaged in professional development efforts; and the numbers of students who engaged in courses and completed programs.

Evidence of program quality in each of these areas is also very positive although not always substantive. In terms of materials development, (a) the large majority of materials subjected to external expert review were rated as at least satisfactory, (b) local and regional use of these materials indicates the materials are valued by educators, and (c) a small proportion of materials received national distribution through commercial publishers. Certainly the large numbers of colleges and secondary schools taking advantage to study and revise their programs is direct testimony to the effectiveness of the ATE program. Concomitantly, the student data show that these institutions are engaging large numbers of students and graduating them or otherwise certifying them for technician work. The large numbers of articulation agreements and increasing numbers of students making use of them indicates schools have developed effective paths for pursuing these educational opportunities. Both professional development providers and participants of these programs have expressed strong satisfaction with the nature and quality of these education programs, although little follow-up evaluation has been conducted to confirm professional development effects in terms of participant use and changes to their instruction and student learning.

Are There Ways the Program Can Be Significantly Improved?

The evaluation evidence suggests that ATE is functioning very well. Yet, our evaluation reports consistently have identified ways in which we evaluators believe the ATE program and its projects and centers can be improved. For example, the most recent briefing papers have suggested specific actions related to evaluations, needs assessments, focus on student recruitment, and cross-institution articulation agreements. Those suggestions for change as well as the few highlighted below build on the program's recognized strengths.

Our analyses and experience lead us to conclude that the program will benefit most through incremental changes to the annual solicitation for proposals. Project operations are guided by their proposals and proposals are heavily influenced by the suggestions provided in the solicitations, so changes to the solicitation are likely to result in changes in the projects.

We encourage changes to make these solicitations speak more directly to standards and other procedural specifications that can aid applicants in achieving desired outcomes (e.g., National Science Education Standards for Professional Development). Including such standards may help applicants better understand what is expected of them and make them aware of viable tools for their planning.

We also encourage emphases within solicitations that couple project/center processes to needs assessment information. In addition to perceived needs for improving formal needs assessment practices for planning, principal investigators report other areas in which they are challenged (Ritchie, Gullickson, & Coryn, 2006). For example, one current challenge noted is the recruitment of students. These challenges should be areas for discussion and sharing of potential solutions.

Evaluation Lessons Learned

We have presented an array of papers at professional meetings such as the annual meetings of the American Evaluation Association that point to strategies tried and lessons learned. Our most painful (and unpublished) lessons have been relative to developing clear and careful work plans and well-grounded, enforceable contracts to guide those who engage with us in evaluations.

Our most productive lessons learned revolve around new strategies for conducting work. For example, the materials development evaluations clearly show the importance of well-constructed review strategies as an evaluative tool. We believe we learned valuable lessons in the reporting of evaluation findings. Some of our strategies that excerpt and explore well-focused and brief points appear to be much better received and used than longer, better documented work. While there is a trade-off in these matters, we have moved much more toward brief, segmented reporting processes and papers that make their points more quickly and succinctly.

While we knew it intellectually at the outset, the long-term interaction with NSF program officers especially has reminded us about how difficult it is to remain fully objective across a long span of time. Not surprisingly, this evaluation reinforced our expectation that evaluations are more interesting and helpful when the evaluators and evaluatees are all genuinely interested in making the program the best it can be and work toward that objective.

We thank the NSF program staff and all the project/center principal investigators and their staff members for the substantial help we have been given in conducting our evaluation efforts. What we have learned and contributed directly results from the substantial assistance and cooperation provided by all with whom we have worked on this project.

Advanced Technological Education
Final Evaluation Report

This final report for the evaluation of the National Science Foundation's Advanced Technological Education Program summarizes our evaluation efforts and findings spanning 2000 to 2006. It provides a broad-brush view of the program, with sections devoted to (1) the program's background, (2) its overall structure and focus (and changes in these over time), (3) the background for the evaluation, (4) key evaluation questions, (5) evaluation components, and (6) evaluation findings. The report draws on information from the many different components of the evaluation and associated reports from 2000 to 2006. Readers who wish to know more about the specifics of the evaluation methodologies used or findings should refer to the referenced evaluation reports (a complete list of reports is also provided in the Appendix).

ATE Program Background

The Advanced Technological Education (ATE) program is a response to the need to improve U.S. competitiveness in the world economy by increasing the quantity and quality of technicians in strategic advanced technology fields. The importance of such technological education initiatives is clearly developed and described in the National Science Foundation (NSF) document: *Gaining the Competitive Edge: Critical Issues in Science and Engineering Technician Education* (NSF, 1993). As that document indicated, this country has a critical need for trained, professional technicians with unique skills in technology and technological systems. These persons must be educated to serve emerging needs of business and industry and must be able to work on applications that build on theoretical understandings.

> The *Scientific and Advanced-Technology Act of 1992* was intended "to establish a national advanced technician training program, utilizing the resources of the Nation's two-year associate-degree-granting colleges 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 in international trade."

On October 23, 1992, Congress passed the *Scientific and Advanced-Technology Act of 1992* (PL 102-476), which was intended to establish a national advanced technician training program, utilizing the resources of the nation's two-year associate-degree-granting colleges 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 for the technologically advanced global economy.

The following excerpt from the Act identifies the issues that led Congress to pass the law and the purposes it was designed to serve:

(a) FINDINGS- The Congress finds that—

(1) the position of the United States in the world economy faces great challenges from highly trained foreign competition;

(2) the workforce of the United States must be better prepared for the technologically advanced, competitive, global economy;

(3) the improvement of our workforce's productivity and our international economic position depend upon the strengthening of our educational efforts in science, mathematics, and technology, especially at the associate-degree level;
(4) shortages of scientifically and technically trained workers in a wide variety of fields will best be addressed by collaboration among the Nation's associate-degree-granting colleges and private industry to produce skilled, advanced technicians; and
(5) the National Science Foundation's traditional role in developing model curricula, disseminating instructional materials, enhancing faculty development, and stimulating partnerships between educational institutions and industry, makes an enlarged role for the Foundation in scientific and technical education and training particularly appropriate.

(b) PURPOSES- It is the purpose of this Act to—
(1) improve science and technical education at associate-degree-granting colleges;
(2) improve secondary school and postsecondary curricula in mathematics and science;
(3) improve the educational opportunities of postsecondary students by creating comprehensive articulation agreements and planning between 2-year and 4-year institutions; and
(4) promote outreach to secondary schools to improve mathematics and science instruction. (U.S. Congress, *Scientific and Advanced-Technology Act of 1992*, § 2).

As we stated in our 2000 report, "the Act was intended to serve the ultimate goal of improving the competitiveness of the U.S. in international trade by increasing the productivity of the nation's industries, which in turn was to be accomplished by increasing the pool of skilled technicians in *strategic* advanced-technology fields" (Gullickson, Lawrenz, & Keiser, 2000, p. 1). The Act specified that this goal was to be achieved through the improvements in (a) technical and science education at 2-year colleges, (b) math and science curricula at both secondary and postsecondary levels, (c) education opportunities for postsecondary students, and (d) math and science instruction at secondary schools.

The Act emphasized the role of 2-year colleges, stating that "the grant program shall be designed to strengthen and expand the scientific and technical education and training capabilities of associate-degree-granting colleges" (§ 3). The Act further recommended the following strategies for two-year colleges to improve these capabilities:

(1) the development of model instructional programs in advanced-technology fields;
(2) the professional development of faculty and instructors, both full- and part-time, in advanced-technology fields;
(3) the establishment of innovative partnership arrangements that—
(A) involve associate-degree-granting colleges and other appropriate public and private sector entities, and

(B) provide for private sector donations, faculty opportunities to have short-term assignments with industry, sharing of program costs, equipment loans, and the cooperative use of laboratories, plants, and other facilities, and provision for state-of-the-art work experience opportunities for students enrolled in such programs;

(4) the acquisition of state-of-the-art instrumentation essential to programs designed to prepare and upgrade students in scientific and advanced-technology fields; and

(5) the development and dissemination of instructional materials in support of improving the advanced scientific and technical education and training capabilities of associate-degree-granting colleges, including programs for students who are not pursuing a science degree. (§ 3)

ATE Program Overview

> The ATE program focuses on the education of technicians for the high-technology fields that drive our nation's economy.

The National Science Foundation established the ATE program as a mechanism for supporting work in the areas identified as critical for achieving the later outcomes (model instructional projects, professional development, innovative partnerships, state-of-the-art instrumentation, and instructional materials), thereby moving toward the ultimate goals set forth in the Act. The most recent program solicitation (NSF, 2005), summarizes the program as follows:

> With an emphasis on two-year colleges, the Advanced Technological Education (ATE) program focuses on the education of technicians for the high-technology fields that drive our nation's economy. The program involves partnerships between academic institutions and employers to promote improvement in the education of science and engineering technicians at the undergraduate and secondary school levels. The ATE program supports curriculum development, professional development of college faculty and secondary school teachers, career pathways to two-year colleges from secondary schools and from two-year colleges to four-year institutions; and other activities. A secondary goal is articulation between two-year and four-year programs for K-12 prospective teachers that focus on technological education. Additionally, the program invites proposals focusing on applied research relating to technician education. (p. 2)

Figure 1 is our construction of the ATE program theory, based on context in which the program emerged, the design of the program, the salient aspects of its implementation, and the expected/desired intermediate and long-term outcomes.

Changes in Program Focus

The issuance of annual program solicitations is ubiquitous as a means to meet programmatic goals within federal funding agencies such as NSF, the Department of Education, and the National Institutes of Health. These solicitations set parameters for proposal writers and, as such, become the operational definition of the program's intentions. To characterize the evolution of the program's focus, we examined introductory statements concerning its purpose and the program tracks outlined in each annual solicitation.

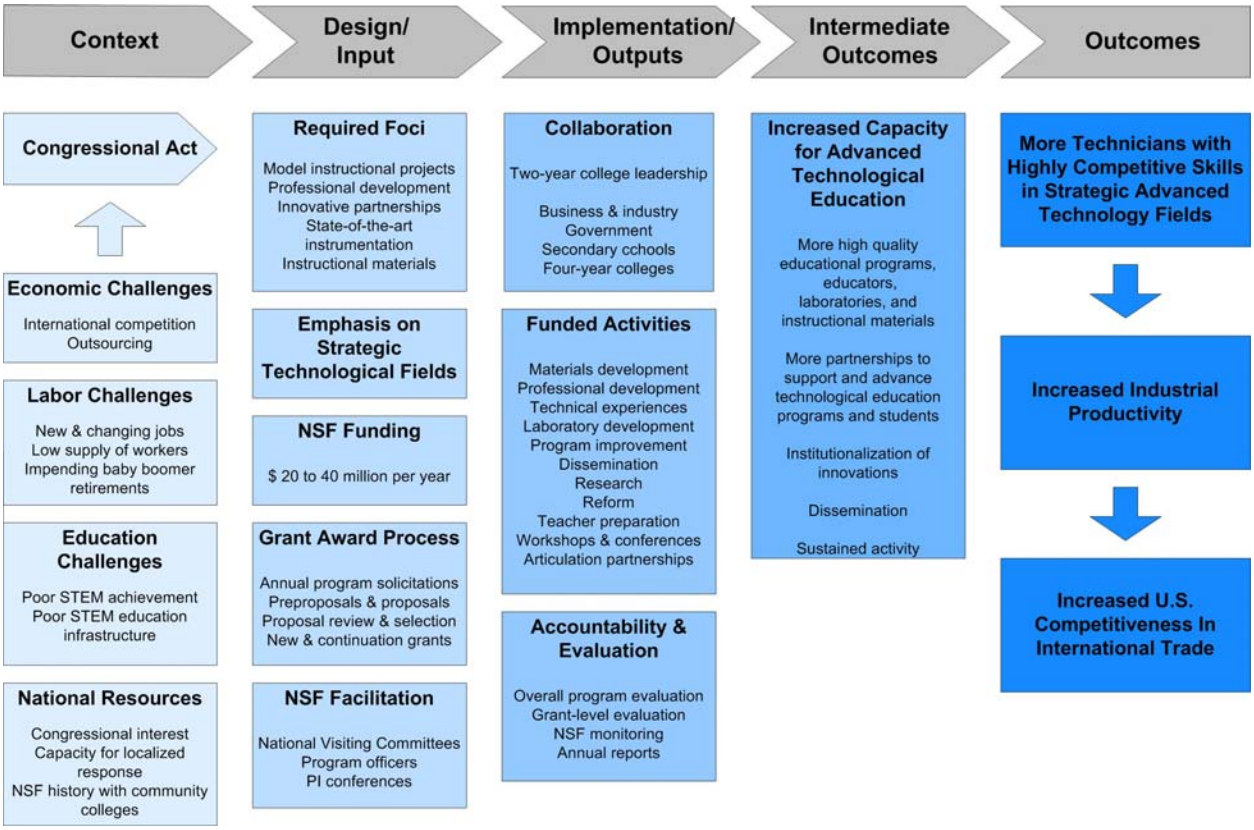

Figure 1. ATE Program Logic

Program Purpose Statements

The beginning of each solicitation contains an introduction or overview concerning the purpose and scope of the program. These program synopses speak directly to the purposes and objectives set forward by Congress and exhibit increasing clarification over the years.

> Early ATE solicitations (1993 through 1996) distilled the legislative intent of the program into a single goal statement: "The purpose of the Advanced Technological Education (ATE) program is to promote exemplary improvement in advanced technological education at the national and regional level through support of curriculum development and program improvement at the undergraduate and secondary school levels, especially for technicians being educated for the high performance workplace of advanced technologies" (NSF, 1993, p. 1). Beginning in 1997, the overall purpose statement was simplified into the following: "The Advanced Technological Education (ATE) program promotes improvement in technician education delivered at the undergraduate and secondary school levels" (NSF, 1997, p. 9). This statement was used until 1999, when it was clarified that the program sought "improvement in the education of

science and *engineering* technicians" [emphasis added] (NSF, 1999, p. 26) That year the solicitation also provided greater clarification regarding what specific science and engineering fields ATE supports, indicating that such fields include, but are not limited to, agricultural technology, biotechnology, chemical technology, civil and construction technology, computer and information technology, electronics, environmental technology, geographic information systems, manufacturing and engineering technology, marine technology, multimedia technology, telecommunications, and transportation technology. (NSF, 1999, p. 26)

Two years later, it was further clarified that "the program generally does not support projects that focus primarily on students who will become health or medical technicians." (NSF, 2001, p.1)

Every annual solicitation has called for partnerships between two-year colleges, four-year colleges, universities, secondary schools, business, industry, and government. Beginning in 1997 the expected inclusion and leadership role of two-year colleges was more explicitly stated: "The program expects two-year colleges to be involved in leadership roles" (NSF, 1997, p. 9). In 1998, it was clarified that "The program expects all projects to include major involvement of two-year colleges" (NSF, 1998, p. 25). From 1999 forward, the expected role of two-year colleges in grant activities has been articulated in the following way: "ATE focuses on two-year colleges and expects two-year colleges to have a leadership role in all projects" (NSF, 1999, p. 26).

> The 1993 through 2005 solicitations show increasing clarity of program focus, evident in increasing specificity in the descriptions of the program's purpose and the types of activities supported.

From 1993 through 1998, the solicitation introductions indicated that ATE would support "curriculum development and program improvement" activities, with general descriptions of each general category. Beginning in 1999, the introductions offered more detailed examples of the type of activities supported.

Since 1999, the solicitation introductions have indicated that "Proposals to the ATE program may aim to affect either specialized technology courses or core science, mathematics, and technology courses that serve as prerequisites or corequisites for specialized technology courses" (NSF, 1999, p. 26). In 2001, this clarification was added:

> The curricular focus and the activities of all projects should demonstrably contribute to the ATE program's central goals: producing more science and engineering technicians to meet workforce demands, and improving the technical skills and the general SMET preparation of these technicians and the educators who prepare them. (NSF, 2001, p. 1)

Overall, the examination of the 1993 through 2005 solicitations revealed increasing clarity of program focus, evident in increasing specificity in the descriptions of the program's purpose and the types of activities supported.

Program Tracks and Subtracks

After the general overview of the program in the solicitations, the specific program tracks (i.e., general categories of program activities and funding) are described. There are major tracks and narrower subtracks. These especially define the character of the program. Table 1 identifies and describes the program tracks and subtracks that have appeared in the 1993 through 2005 solicitations and shows the years they were present in the solicitations. These tracks and subtracks are referenced throughout the remainder of this report.

Table 1. ATE Program Tracks and Subtracks: 1993-2005

Track: Projects	
Materials Development (1993-present)	"Projects that envision major changes in technical education and that result in products such as textbooks, laboratory experiments and manuals, software, videos, CD-ROMs, and other educational products. Products are expected to be widely disseminated through publishers, seminars, workshops, electronic networks, and other appropriate means including conference presentations and journal articles." (NSF, 1998, p. 26)
Professional Development (1993-present)	"Successful projects emphasize content, pedagogy, development and exercise of leadership skills, and opportunities for continuing professional growth. . . . Typical projects for teacher and faculty enhancement include conferences, seminars, short courses, industrial internships, workshops, or a series of such activities." (NSF, 1998, p. 27)
Laboratory Development (1993-2004)	These projects involve the "development of innovative methods for using laboratory and field exercises to improve students' understanding of basic principles for using modern instrumentation, new technologies, or applications of instruments that extend their instructional capability." (NSF, 2000, p. 4)
Technical Experiences (1996-2004)	"Projects providing technical experiences may consist of any combination of activities involving instruction, problem solving, research, product development, and industrial internships. Projects ideally should provide a balance of classroom, laboratory, and field experiences. . . . Student-faculty teams are particularly encouraged to participate in technical experiences and to translate those experiences into meaningful classroom activities that introduce other students to the role of technicians in the workplace." (NSF, 2000, p. 4)
Adaptation & Implementation (1999-2000)	These projects "should involve an innovative use or a significant extension of resources development in other projects." (NSF, 2000, p. 3)
Special Activities (1998-2000)	Special activities include "conferences, workshops, and similar activities that lead to a better understanding of issues in advanced technological education. Typically these are short-duration events and are national or international in scope." (NSF, 2000, p. 5)

Dissemination Focal Points (2000-2001) [Renamed as Resource Centers]	These are "projects that will act as clearinghouses for, and will broadly disseminate, the exemplary educational materials, curricula, and pedagogical practices designed by previously funded ATE centers and projects." (NSF, 2000, p. 5)
Program Improvement (2002-present)	"Proposed activities should enhance a curriculum in multiple ways, producing a coherent sequence of classes, laboratories, work-based educational experiences that revitalize the learning environment, course content, and experience of instruction for students preparing to be science and engineering technicians. The resulting program should constitute a *model* that will be disseminated broadly." (NSF, 2002, p. 3)
Research on Technician Education (2003-present)	"Research studies are separate efforts that grow out of a group of completed projects or from questions that arise through analysis of an issue of priority to ATE." (NSF, 2003, p. 6)
Institution-Level Reform (2005-present)	These are "grants for *planning efforts* leading to *Institution Level Reform of Technician Education (ILRTE).* The planning grants enable institutions to reformulate, streamline, and update the content and pedagogy of technician degree programs at their institutions to meet the emerging needs of employers." (NSF, 2005, p. 7)
Teacher Preparation (2005-present)	"These projects help to prepare a future K-12 teaching workforce that understands the technological workplace and can prepare students to use a variety of approaches to solving real world technology related problems using design processes and principles. . . . Projects must involve both two-year and four-year institutions and should aim to increase the number, quality, and diversity of prospective K-12 science, mathematics, and technology teachers in pre-professional or paraprofessional programs at two-year programs." (NSF, 2005, p. 6)
Track: Centers	
National/Regional Centers for Excellence (1993-1999)	"Centers will serve as national and regional models and clearinghouses for the benefit of both colleges and secondary schools. Model curricula, instructional materials, and teaching methods will be developed at and through these Centers and then disseminated through publishers, seminars, workshops, publications, electronic networks, and other appropriate means. . . . Centers must be cooperative efforts among two-year colleges, four-year colleges and universities, secondary schools, industry, business, and government." (NSF, 1993, p. 6)
National Centers of Excellence (2002-present)	These centers "may vary in size and disciplinary coverage but must have a national impact. In particular, a National Center should bring together a broad array of institutions that offer programs in the area of technology in which the center focuses. National Centers typically engage in the full range of activities associated with ATE Projects." (NSF, 2002, p. 5)

Regional Centers for Manufacturing or Information Technology Education (2000-present)	"These centers are expected to focus mainly on reforming academic programs, departments, and systems to produce highly qualified workers who meet industry's needs within a particular geographic region and who also meet national industry and academic skill standards appropriate for the region's employers." (NSF, 2000, p. 7)
Resource Centers (2002-present)	"A Resource Center should constitute a highly visible source of materials, ideas, contacts, and mentoring in a particular field of technological education . . . . These centers (1) serve as clearinghouses for, and broadly distribute, the exemplary educational materials, curricula, and pedagogical practices designed by previously funded ATE centers and projects and (2) provide support and mentoring for institutions that wish to start or improve educational programs in a particular field of technology." (NSF 02-035, p. 7)
Track: Workshops, etc.	
Workshops, etc. (1993-1997)	These are "special projects such as conferences, workshops, symposia, studies, and other activities that will lead to better understanding of issues in advanced technological education." (NSF, 1997, p. 9)
Track: Articulation Partnerships	
Teacher Preparation in 2-Year Colleges (2000-2004)	These partnerships are "efforts to strengthen mathematics, science, and technology education for prospective middle and high school technology teachers. The program also encourages projects involving opportunities for in-service teachers to become certified in mathematics, science, and technology." "[T]he nation's technological future depends . . . on K-12 teachers who are technologically literate and have been exposed to the advanced technologies used in the modern workplace." (NSF, 2000, p. 8)
Articulation Between Associate's & Bachelor's Degree Programs (2000-2004)	These are "Partnerships in which two-year colleges work with four-year colleges or universities to develop, implement, and evaluate model problems that enable students to make a successful transition from a SMET associate's degree program to a related bachelor's degree program." (NSF, 2000, p. 9)

The labels for the subtracks changed over the years, although changes in terminology do not necessarily reflect changes in content. Appendix A provides an overview of the different labels used over the years.

To discern changes in program focus, other than those evident in the program overviews, we examined the annual solicitations from 1993 to 2005 to identify variations in program tracks and subtracks across time. Figure 2 charts these changes. When it was evident that a track or subtrack's activities were subsumed by another, arrows show when and where those changes occurred.

As suggested by the chart, two characteristics of the annual program solicitation are consistencies in major program funding tracks and increasing specification of subtracks across

Two characteristics of the annual program solicitation are consistencies in major program funding tracks and increasing specification of subtracks across time.

time. The changes made to tracks and subtracks over time are described below. For a general description of the details about the kind of activities covered by these funding areas, please refer to Table 1.

The original 1993 solicitation identified three distinct funding tracks: (1) *Projects*; (2) *Centers*; and (3) *Workshops, Conferences, Seminars, Studies, and Other Special Projects*. The primary focus has been on projects and centers across all years. The dominant categories consistently have been projects and centers. In 1998, the *Workshops* track was subsumed by Projects within a subtrack called *Special Activities*. In 2000, another track focusing on *Articulation Agreements* was created. This track was maintained through 2004 and then subsumed by the *Teacher Preparation* subtrack under Projects in 2005. As these shifts suggest, tracking was employed to organize program work and emphasize particular objectives at different points in time.

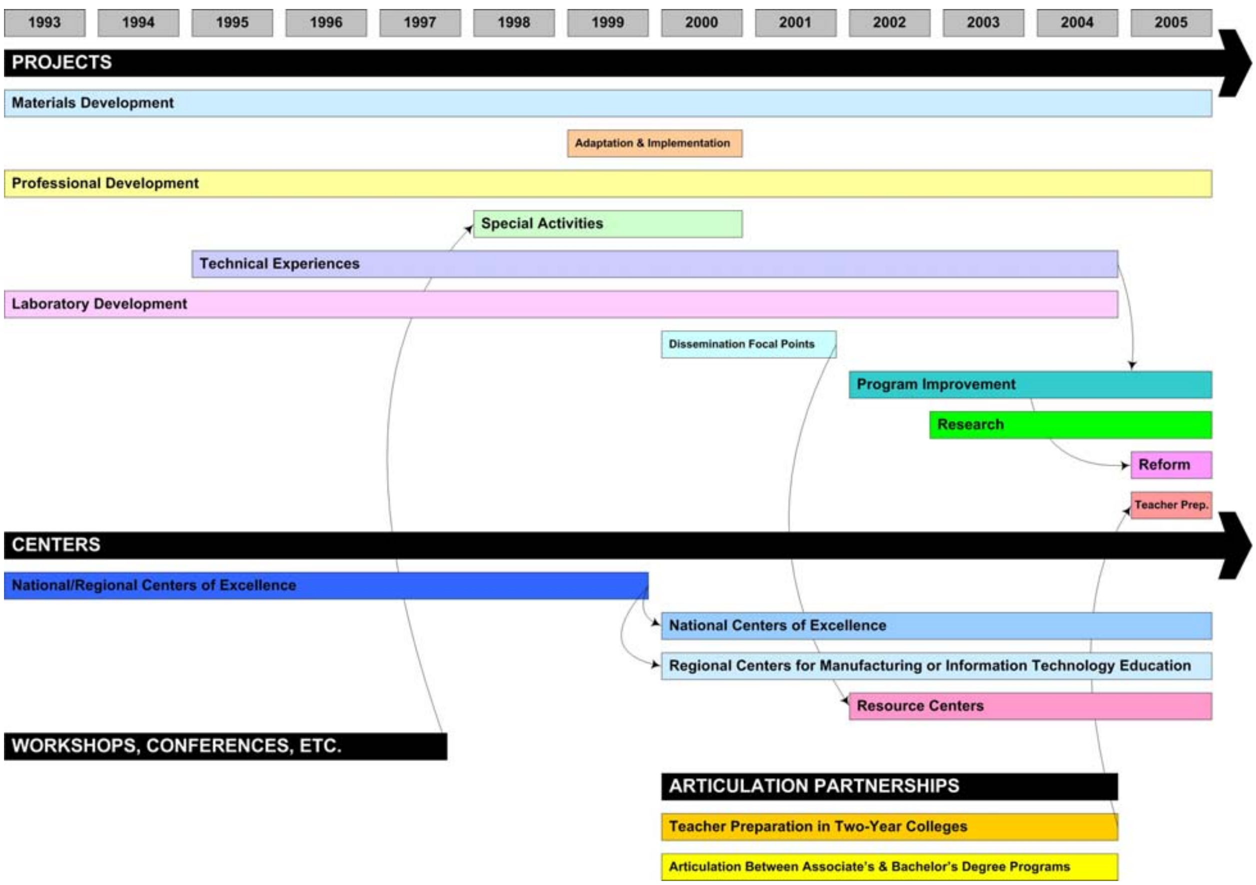

Figure 2. ATE Time Line

While projects and centers have been maintained as the dominant program tracks, there also has been increasing definition of program activities, manifested primarily through changes in subtracks. Some of these subtracks have been long-lived; they always focus on and emphasize specific ATE intentions. *Materials Development* and *Professional Development* have continued as project subtracks since 1993 through the present. Another original project subtrack, *Laboratory Development*, was maintained through the 2004 solicitation. The 2005 solicitation indicated that laboratory development activities would be included under the *Program*

Improvement subtrack, which first appeared in 2002 under Projects and continues to the present. Activities related to *Technical Experiences*, a project subtrack introduced in 1995, were also subsumed by the *Program Improvement* subtrack in 2005, when the Technical Experiences subtrack was discontinued. *Adaptation and Implementation* was introduced in 1998 to encourage the application of resources developed with ATE support. This project subtrack was also present in the 1999 and 2000 solicitations, but not in any subsequent solicitations. In 2000, a new project subtrack, *Dissemination Focal Points*, was introduced, but was not continued after 2001. However, many of the same activities were supported under the new center subtrack, *Resource Centers,* which was initiated the following year. *Research* emerged as a project subtrack in 2003 to expand and refine the body of knowledge concerning technician education that had been generated by ATE-supported activities over the previous 10 years. In 2005, two new project subtracks were created: *Institutional-Level Reform of Technician Education* and *Teacher Preparation. Teacher Preparation* assumed much of the same focus of the *Articulation Partnerships* subtrack called *Teacher Preparation in Two-Year Colleges*, which was in place from 2000 until 2004. Another articulation partnership subtrack, *Articulation Between Associate's and Bachelor's Degree Programs*, was also maintained during this period; its focus on transitioning students in STEM programs from two-year to four-year colleges was integrated into other program tracks (program improvement) in the 2005 solicitation.

As this description indicates, most of the changes happened within the projects track. The centers track experienced far fewer changes. From 1993 through 1999, this track provided funding for *National/Regional Centers of Excellence.* Beginning in 2000, this track was divided into two clearly defined subtracks: *National Centers of Excellence* and *Regional Centers for Manufacturing or Information Technology Education.* As mentioned above, resource centers were introduced in 2002. Serving as clearinghouses and a source of support for institutions initiating or improving technology programs, the program solicitation noted, "only ATE national or regional centers and exemplary ATE projects that have already completed their original grants are well-positioned to become Resource Centers" (NSF, 2002, p. 7). As noted above, the emergence of resource centers occurred at the same time that the *Dissemination Focal Points* subtrack was discontinued, thus shifting but continuing dissemination as a funding emphasis within the program.

Although terminology changed over the years and various program tracks and subtracks appeared and disappeared, overall there has been considerable consistency in types of activities eligible for ATE funding since the program's inception. The introduction of a new subtrack may bring into sharper focus a set of activities that were previously included in another category, as was the case with the separation of national and regional centers into distinct and more clearly defined subtracks. Or, new subtracks can represent an extension and/or broader application of program activities that were part of a preexisting subtrack. For example, the *Reform* subtrack introduce in 2005 seeks institutionwide development and improvement of technician education, which is a much broader task than those previously covered by the *Program Improvement* subtrack. The introduction of the *Articulation Partnerships* track probably represents the biggest change in the solicitations over the years,

Although terminology changed over the years and various program tracks and subtracks appeared and disappeared, overall, there has been considerable consistency in types of activities eligible for ATE funding since the program's inception.

since these types of activities were not specifically mentioned in previous solicitations. This track was eliminated after 2004; only the teacher preparation focus of this track was maintained, but within the projects track.

NSF Staff

An important aspect of any program is the personnel who develop and guide it. In this particular case, the program has been led throughout its lifespan by two NSF staff members, Drs. Elizabeth Teles and Gerhard Salinger, who are permanent employees at NSF (not rotators). Both are seasoned, knowledgeable officers. Their work experiences prior to taking on the ATE program likely have enhanced their abilities to communicate with both the community college constituency and Congress (e.g., at one time Dr. Teles was a faculty member at a community college). More importantly, they and other senior members such as Drs. Corby Hovis and Duncan McBride have formed a homogeneous group that has worked effectively together during virtually the entire life-span of this program. That consistency in staff most certainly has greatly facilitated the consistency in focus that is visible in the annual solicitations.

Evaluation Background

This evaluation of the ATE program was supported by two separate ATE grants. In 1999, NSF awarded The Evaluation Center the initial grant of $1.3 million, which covered the first three years of the evaluation. A second grant for $1.8 million was awarded in 2002 to continue and expand the evaluation work conducted thus far.

It is noteworthy that this evaluation was supported by grants and not contracts. Contracts are essentially work-for-hire agreements in which NSF maintains the right to specify products, outcomes, and time frames. Contractors have the advantage of access to information not available to grantees, such as project “jackets,” which include original proposals and reviewer feedback. However, if a contractor wants to collect data from more than nine sites, he or she must go through a lengthy approval process with the federal Office of Management and Budget. In contrast, grantees are not subject to this requirement Moreover, grantees conduct their work under a set of general expectations, having more discretion as to how best to meet the expectations of the grant and the needs of NSF.

> The stance of the evaluation was to be responsive to meeting the needs of NSF.

When the first grant for the ATE program evaluation was awarded, the Government Performance Results Act (GPRA), which was intended to increase accountability of the federal funding agencies, was an important consideration; and the ATE program was a new format for NSF in that it had been mandated by Congress and was administered across two divisions (DUE and ESIE). The evaluation was a grant housed in REC as opposed to either of the divisions housing the ATE program itself. This administrative organization resulted in a three-person management team for the evaluation, with the ESIE person the communication contact. Because of the uniqueness of the ATE program and the conscientiousness of the program officers, the evaluation had a strong link to the administrators. Additionally, an advisory committee consisting of people from diverse backgrounds was formed and included representatives from 2-year colleges, industry, technician/technical education, and evaluation. As an addition to the formal advisory committee, an evaluation advisory committee also was formed to provide specific advice and assistance in conducting the evaluation. The stance of the evaluation was to be responsive to meeting the needs of NSF. This led to frequent communications and flexible implementation of the proposed evaluation.

Katzenmeyer and Lawrenz (2006, pp. 8-9) describe the history of evaluations employed within NSF. In that history they trace a variety of evaluation strategies that focus on program evaluations. They note that emphases have shifted in evaluation purposes, methods, and intended uses. In the 1960s, evaluations concentrated on the effectiveness of newly developed curricula for helping students learn science. In the 1970s "[e]valuation focused on delivery systems and accomplishing change within classrooms, schools, and districts through comprehensive projects, including major efforts to evaluate these programs." In the 1980s evaluations addressed questions of access and diversity in the pool of STEM professionals. The 1990s saw development of complex evaluations assessing change cultures, interactions between cultures, and changes produced. With the advent of GPRA in 1993 and the more recent No Child Left Behind legislation, evaluation attention has shifted to matters of monitoring and accountability and measuring organizational change.

As those characterizations suggest, NSF program evaluations initially produced assurances that materials developed by funded projects were of good quality and implemented in effective ways. Later evaluations have much more directly focused on quality assurances regarding the NSF programs themselves. This evaluation clearly focused on matters of quality assurance for the ATE program but in doing so also invested much of its focus and effort on formative matters. That is, the intent of the evaluation was to provide evidence as to the quality of work done by the program as a whole; but just as importantly, the evaluators consistently targeted points of interest or concern to assist the program in improving its work and productivity.

Impetus from the evaluation's program officers in REC and ATE as well as encouragement from its national advisory panel led to a strong focus on ATE programmatic efforts. The result was much closer attention to strategies and work of program officers than is typical as well as substantial involvement by key project stakeholders, as illustrated in these examples:

- Early in the evaluation we assessed the ATE proposal review process and provided feedback to the ATE program.
- Nearly a dozen ATE project evaluators and directors actively participated in determining this evaluation's foci, criteria, indicators, and measures.
- The work of ATE program officers and their engagement with projects and centers was a regular component of the evaluation's annual surveys.
- Annual meetings of the evaluation's advisory panel included participation by key ATE program officers so that evaluation plans, evaluation findings, and implications of these plans and findings could be discussed with them.

As those characteristics and examples suggest, throughout the life of the evaluation a major evaluative emphasis was to provide information that the program officers, funded projects, and STEM educators could use for decision making and improving the quality of their programs, projects, and STEM-related work.

The initial proposal called for the evaluation to provide an in-depth description of the ATE program, highlighting its diversity as well as strengths and weaknesses. This rich description was to be provided through an analysis of grant jackets, a survey of grantees, and site visits. As the evaluation project progressed, it became clear that the jackets really would not be accessible (a consequence of the grant rather than contract relationship), so that portion of the planned evaluation was modified. The NSF program officers also thought it would be useful for the evaluators to observe the ATE proposal review process. This helped inform the evaluators about the program and the criteria used for awarding grants and provided an opportunity for the evaluators to provide feedback on the review process to NSF.

Evaluation Questions

Over the course of the seven-year evaluation, we addressed these four general questions:

- To what degree is the program achieving its goals?
- Is it making an impact and reaching the individuals and groups intended?
- How effective is it when it reaches its constituents?
- Are there ways the program can be significantly improved?

Evaluation Components

In organizing the evaluation we considered the major ingredients for the program, anticipating that those ingredients would help us develop a viable plan of action. Our thoughts along those lines are displayed in the textbox call-out in this section. As that textbox shows, we considered the federal funding side, the recipient or grantee side, and a couple of the intermediary groups (e.g., evaluation). The bolded items in the list identify primary focus points for our evaluation, those aspects for which our project has gathered substantial evaluation information across the time span of 2000 to 2006. The point in displaying the list and the bolded items is to establish that there is more to the program that we did <u>not</u> investigate than what we did investigate. That's usually the way it is with evaluations. Each evaluation must judiciously choose points of access and gather data that are expected to be most useful.

Four Major ATE Program Ingredients

1. Program funding
   a. Congressional dictates for the program and NSF program design
   b. Federal dollars
   c. ATE program staff, staffing and program management
   d. ATE annual solicitations
   e. ATE proposal review and funding determination process
   f. ATE facilitation and monitoring of ongoing work
2. Grantee attributes
   g. Submitted proposals for project and center work
   h. Grant work and productivity
   i. Reports (annual and final) to ATE
   j. Evaluation input/participation
3. Intermediaries
   k. AACC
   l. Evaluators (WMU and others)
4. Major players (stakeholders)
   m. Lead program directors (Salinger and Teles)
   n. Center directors, especially long-term directors

Here we provide an overview of the major components of the evaluation, including the annual survey, site visits, issue papers, dissemination, advisory committee, targeted studies, and metaevaluation. More details about the specific data collection and analysis techniques used for each of these components may be found in the evaluation reports associated with the various data collection efforts (all reports are listed in the appendix).

Annual Survey

We surveyed ATE grantees annually from 2000 through 2006. These online surveys collected data from ATE grants that had been operating for at least 1 year at the time the survey was conducted—usually between February and April each year. Response rates ranged from a low of 88 percent in 2000 to 100 percent in 2002. The response rates in other years ranged between 92 and 98 percent.

> Survey response rates ranged from a low of 88 percent in 2000 to 100 percent in 2002. The response rates in other years ranged between 92 and 98 percent.

The development of the survey of ATE projects was a major component of the evaluation. The conceptualization of the survey and the development of items were facilitated by the evaluation advisory group. As part of the conceptualization, a model of the ATE program's theory of action—a logic model—was developed and expanded. This model was linked to outcomes, and indicators of the outcomes were specified. These indicators then were translated into potential survey items. Initially, the items were designed to obtain respondents' perceptions of the quality of various components of the ATE projects. As the development continued, and at the suggestion of NSF staff, the items were modified to be more descriptive and less evaluative—this emphasis on description also is reflected in this final report. In the end, the survey provided information about the operation of the program and about numbers and types of participants, activities, and interactions. The items were related to the theory of action but not quite as originally conceptualized. Instead, the survey was organized into the major components of the ATE program: grantee characteristics, organizational practices, collaboration, materials development, program improvement, professional development, and recruitment and retention. Most of the items were fill-in-the-blank or multiple choice with a limited number of open-ended items. The survey was Web-based. At the time the survey was planned, no commercial Web-based survey programs were available. A decision was made to develop the programming for an online survey system that might be made available publicly in the future. The survey system was effective for the ATE evaluation but never reached the level necessary for public dissemination.

The survey was comprised of eight domains, as depicted in Figure 3. Information for the first three domains—grantee characteristics, organizational practices, and collaboration—were gathered routinely from all respondents. Information pertaining to the next four domains—materials development, professional development, program improvement, and articulation agreements—was gathered just from grantees that engaged in those types of activities. Respondents were expected to complete those sections that matched their grant activities. Information pertinent to the final domain—student and workforce impact—was drawn from questions contained in the program improvement section of the survey. This approach was based on the expectation that the impact of materials and professional development efforts would be visible through assessment of the program improvement efforts.

Generally, the framework for the survey and wording of individual questions remained consistent across years. However, each year small changes were made for specific items. In

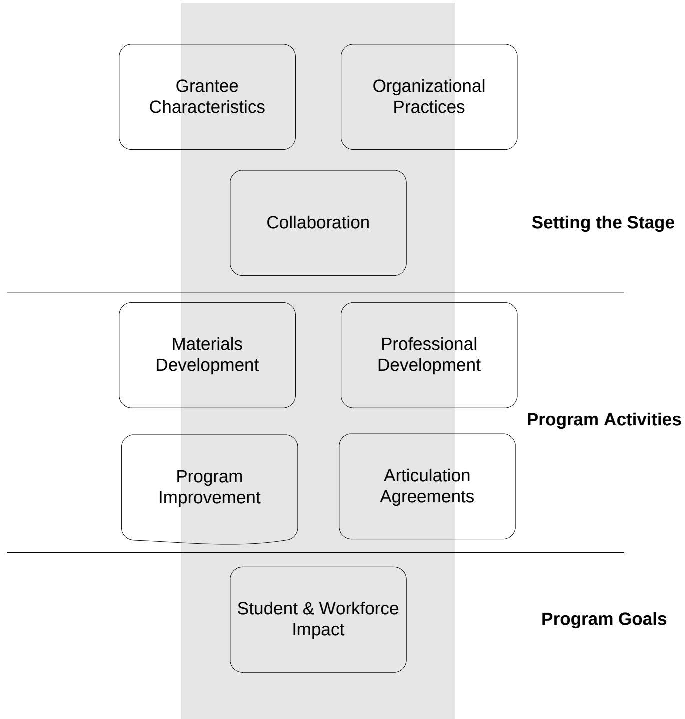

Figure 3. ATE Annual Survey Domains

2004, several organizational changes were made to the survey. Those changes more directly impacted reported results. Three key aspects of those changes include the following:

- Two survey sections labeled “Principal Investigator’s Overview” and “Monitoring” were removed from the survey. The items contained in these sections were either eliminated or moved to a new section called “Organizational Practices.”
- The “Collaboration” section, which was previously optional, became a required section.
- Prior to 2004, the program improvement domain comprised three separate program improvement sections—one each for the secondary, associate degree, and 4-year degree institutions. In 2004, these sections were combined into one “Program Improvement” section, and items regarding workplace training were added to reflect grantee activity in this area.

Site Visits

The second major component of the ATE evaluation was a set of site visits to 13 selected projects. Sites were selected using a purposive sampling technique based on recommendations from NSF, thus ensuring a cross section of project types in the ATE program. To minimize the burden on the sites, visits were usually one full day in length for projects and two full days for centers. Each site received a report that was for its use only.

The site visits were conducted by expert teams of trained site visitors, including evaluation, industry, and education experts. The anecdotal reports from the site visitors indicated they found the survey information to be consistent with what they observed and learned from the local projects.

The site visits were conducted by expert teams of trained site visitors, including evaluation, industry, and education experts. The purpose of the visits was to validate the survey findings; identify sites' major activities and accomplishments; and gather other information pertinent to the issues of collaboration, dissemination, materials development, professional development, program improvement, recruitment and retention, sustainability, advisory committees, and evaluation. As a preparatory step for conducting the visits, the site visitors reviewed survey-based information about the sites. The anecdotal reports from the site visitors indicated they found the survey information to be consistent with what they observed and learned from the local projects. The site visit reports were shared with site personnel and finalized after receiving their feedback.

The original intent was for the site visit reports to be combined to provide a case study of the ATE program. After much discussion with the advisory committee and NSF staff, it was decided that a singe descriptive case study would not be as useful as a series of issue papers, which would synthesize the site visit reports and the survey data along with existing research into documents highlighting the issues surrounding the various aspects of the ATE program. These issue papers are described below.

Issue Papers

The purpose of the issue papers was to synthesize the site visit reports and survey data, along with existing research, into a series of documents highlighting the issues surrounding the various aspects of the ATE program. Nine issues were identified, and the writing of the issue papers was commissioned. The nine issues included collaboration, dissemination, materials development professional development, program improvement, recruitment and retention, sustainability, advisory committees, and evaluation. Once the papers were written, they were submitted to both internal and external review. As a final part of the review process, a meeting was held with the paper authors, reviewers, and NSF program managers to provide guidance in producing the final drafts.

The issue papers were combined into two reports—one focused on seven issues directly related to the ATE program and one focused on the two more management-related issues: evaluation and advisory committees. Both reports had similar introductory chapters that described the ATE program and the issues discussed.

This issue paper process marked the beginning of an ever-increasing push for the evaluation to be of use to STEM educators and evaluators.

This issue paper process marked the beginning of an ever-increasing push for the evaluation to be of use to STEM educators and evaluators as opposed to use only to NSF. The issue papers were research- and topic-oriented and therefore likely to be of more interest to a diverse audience than a report just describing the ATE program, which would have been of more interest to NSF. All nine issue papers were published in a volume of *Advances in Program Evaluation* (Lawrenz, Keiser, & Gullickson, 2004).

Dissemination

The push for products of interest to the field—such as the issue papers described above—also led the evaluation project to produce brochures (focused on materials development, recruitment and retention, and sustainability); a handbook for ATE National Visiting Committees; a guide for conducting site visits; publications in academic journals; and a Web-based system for ATE grantees and others to access the annual survey data. Members of the evaluation team also made several presentations at the annual conferences of the American Evaluation Association and Canadian Evaluation Society. All evaluation reports and products are publicly accessible from The Evaluation Center's Web site.

Advisory Committee

Another result of the issue paper process was heightened interest in the advisory committee process. This interest resulted in a study about the function of advisory committees and clarification of the NSF guidelines requiring advisory committees. The study led to a comprehensive report based on a series of site visits to advisory committee meetings and the development of the above-noted handbook for ATE National Visiting Committees that highlights how to maintain effective advisory committees.

Targeted Studies

Four targeted studies supplemented findings that resulted from the other evaluation components. These studies, described below, focused on the following issues:

- the value added to business and industry
- materials development—the quality and quantity of processes and products
- professional development—quality and impact
- sustainability

Value Added to Business and Industry

This study (Germuth, Gullickson, Lawrenz, & Hanssen, 2006) was designed to address the accountability of the ATE program in terms of its impact on the business and industry workforce. Specifically, the study sought to answer whether and how the ATE program adds value to businesses and industries via the community college-educated technician workforce in the communities served by ATE-funded programs. Data were gathered from business and industry representatives via site visits to 9 locations throughout the U.S. Five ATE sites were selected by NSF program officers who judged the projects successful with regard to the overall mission of ATE. Four non-ATE locations served by colleges that provide programs in similar technologies but had not received ATE funding were chosen as comparison sites. A total of 24 businesses were visited by the study team at these 9 locations.

Materials Development

The materials development study involved three distinct components: (1) an evaluation of a sample of materials produced by ATE grantees (Keiser, Lawrenz, & Appleton, 2004); (2) a description of the development processes used to create four materials that had been judged to be very good to excellent according to the aforementioned evaluation (Appleton & Lawrenz, 2004); and (3) an evaluation of the effectiveness of two materials developed by ATE grantees (Appleton & Lawrenz, 2005).

Because the evaluation of sample materials served as foundation work for the full complement of studies, the review rubric and its criteria were especially important to this work. In the first component, materials were evaluated based on rubrics that first addressed specific expectations, then holistic expectations, and finally provided an overall rating. Industry and content specialists completed one set of specific ratings based on five features: alignment of materials with workplace, application of knowledge, realistic use of technology, rigorous content, and quality performance. Curriculum, instruction, and assessment specialists completed a second set of specific ratings based on six features: instructional strategies, problem solving, integration of general education content, assessment, personal qualities, and diversity**.** All reviewers completed the holistic ratings that focused on industry standards and practices, real world curriculum, workplace competencies, and access to in-depth understanding. The overall rating also was completed by all reviewers. The 5-point overall scale was similar in construction to the rubrics for the specific and holistic components and asked reviewers to rate materials from ". . . will not help students learn . . ." to ". . . will be excellent at helping students learn . . ." (for a full description of the rubric see http://www.wmich.edu/evalctr/ate/ATE%20Rubrics.pdf)

Professional Development

The professional development (PD) study examined the nature of ATE grantees' PD efforts and assessed the value obtained from these activities by participants. The study was conducted in four phases. The first phase involved classifying ATE grants according to the degree to which their materials development and PD efforts were linked and the scope of their professional development activities and then sampling projects based on the resulting classification (Jinkerson & Hanssen, 2004a). The second phase involved validation of the classification system, telephone interviews with PIs for the grants sampled in Phase I, collection of information submitted by grantees as evidence of the effectiveness of their PD activities, and identification of persons to serve as informants for Phase III (Jinkerson & Hanssen, 2004b). Phase III included a validation of the findings from the PI interviews conducted in the previous phase, an assessment of the extent and effectiveness of participants' implementation of ideas and materials received from PD activities, an estimation of the longer term impacts resulting from the PD activities, and an assessment of the types and amount of support provided to participants for their involvement in PD activities (Jinkerson & Hanssen, 2004c). The fourth phase concluded the professional development study by identifying best practices in professional development for community college faculty through a review of the literature and contrasting the cumulative results of the three previous phases including the most successful implementations and most effective programs and activities with those best practices (Jinkerson & Hanssen, 2004d).

Sustainability

The ATE program's sustainability was examined in terms of (a) program funding and reach and (b) continuity of grantee work after completion of ATE funding. Study of ATE funding and reach was initiated by Arlen Gullickson and Paula Roberts and culminated in a report to the project's advisory panel in 2003. That work focused on the funding activities of the ATE program and its reach to ATE constituents. It was updated and substantially expanded by Gullickson and Wingate in 2006. Findings from the update study are provided in this report in the ATE Program Overview and Evaluation Findings sections.

The continuity of grantee work after completion of ATE funding was studied via an online survey of ATE grantees whose funding from NSF had been completed for a year or more. Altarum Institute, Jonathan Morell, project director, conducted this study under subcontract with WMU and submitted his report titled *The National Science Foundation's Advanced Technology Education Program: Tracking and Explaining Sustainability* (Morell, Schröter, & Hanssen, 2005). Review of the report led to a reanalysis of the study's data and a rewrite of the report—*The Sustainability of the Advanced Technological Education Program: An Evaluation* (Welch & Gullickson, 2006). Dr. Wayne Welch, professor emeritus at the University of Minnesota and member of our project's advisory panel, led this *post hoc* work.

Metaevaluation

Our evaluation efforts were scrutinized by external metaevaluators on four occasions. Hartmann and Loizides (2001) evaluated the Web-based ATE evaluation survey system. Migotsky and Stake (2001) evaluated site visits and issue papers. Pucel (2003) evaluated the 2002 and 2003 survey reports. The final metaevaluation by Mark (2006) considered the entire evaluation. Table 2 presents a summary of key metaevaluation findings regarding the strengths and weaknesses of various aspects of the evaluation.

Table 2. Metaevaluation Findings Summary

Focus	**Author/ Date**	**Noted Strengths**	**Noted Weaknesses**
Survey System	Hartmann and Loizides, 2001	• "The survey is an exemplary product that is used appropriately and is subjected to regular and rigorous scrutiny and improvement." (p. 35) • All applicable Program Evaluation Standards (Joint Committee, 1994) were fully addressed, except A4—Defensible Information Sources, which was partially addressed.[a] • 11 of 14 Dillman's (2000) Principles for Constructing Web Surveys were fully addressed; the other 3 were partially met.	• Welcome messages "could be "more motivational" • More clear and user-friendly instructions are needed. • Standard links on all pages are needed. • Logout confirmation is needed. • Some browsers handle the survey better than others. • Recommended monitor settings are not optimal. • Links are not standardized.
Site Visits & Issue Papers	Migotsky and Stake, 2001	• "The site visit part of the evaluation of the ATE program coordinated by The Evaluation Center at Western Michigan University fully met the standards for	• There was "little attention paid to ATE program history and early policy decisions." (p. 21) • "The volume and targeted nature of the

Focus	Author/ Date	Noted Strengths	Noted Weaknesses
		evaluation of educational programs." (p. 19) • "The input writings [for issue papers] have been comprehensive and significant in scope, with clear attention to detail and accuracy. • "Most site people interviewed said the site reports captured the activities and achievements of their projects in a fair and objective manner." (p. 19)	protocols . . . appeared to limit inquiry into the uniqueness of individual sites and interpretations for deeper understanding of the drivers." (p. 19) • "Among other problems examined were: sampling of sites, objections to site visits at centers, lack of time for digesting site data, scarcity of contextual data, too little differentiation between projects and centers, and low priority to policy questions. " (p. 19) • Several sites complained about the "representation of their project work." (p. 19)
2002 & 2003 Survey Reports	Pucel, 2003	• "Project and center directors have found this information to be useful for various purposes" (p. 2) • "The report clearly indicates on page ii that the information provided is largely descriptive and serves as baseline and trend data for tracking ATE program progress. The report does this quite well. Data are presented consistent with the survey, and descriptive interpretations are presented." (p. 4)	• "NSF personnel tend to see this information as useful but not sufficient." (p. 2) • The surveys do not "focus on typical education for work criteria regarding impact of what is produced in terms of the improved ability of technicians to function in the world of work as a result of the new or modified programs." (p. 2) • "The current evaluation does not appear to directly provide information regarding progress toward the overall outcome goals of ATE." (p. 4)
Overall Evaluation	Mark, 2006	• The evaluation resulted in an "impressive list of uses and consequences." (p. 4) • The evaluation was very responsive to the needs of stakeholders, particularly NSF program officers.	• Targeted studies were less useful than the Web-based survey. • NSF's need to comply with GPRA's requirements for "numbers" strongly influenced the evaluation design, possibly taking attention away from more important evaluation questions. • The quest to create a general Web-based survey application was a drain on evaluation resources, but this was not foreseeable. • Some comparison standards used were not appropriate. • Evaluators and program officers had different interpretations of data/findings. • Some survey items were interpreted and reported differently by various respondents, calling into question the reliability and validity of some of the measures.

Evaluation Findings

In this section, we present our findings with respect to the evaluation questions, based on the evidence accumulated over the past seven years.

To What Degree is the Program Achieving its Goals?

As described in the background section, the Act that led to the creation of the ATE program was intended to improve technology-based STEM programs, especially in associate degree institutions, and lead to increased U.S. competitiveness in the global economy through increased industrial productivity due to more skilled technicians in strategic advanced technology fields. We address achievement of goals in a two-step process. We first consider the extent to which the program's implementation has been consistent with recommended actions outlined in the Act. Then we consider the impact/effects of the program on education programs and the larger question of U.S. competitiveness.

Alignment of ATE Program Solicitations With Program Purposes

To assess the alignment of the program solicitations with the specifications of the *Scientific and Advanced-Technology Act of 1992*, we examined the program tracks and subtracks described in the 1993 through 2005 solicitations and cross-checked them against specific actions recommended in the Act to serve its overall purposes. Table 3 summarizes the results of this analysis, showing which program areas (tracks or subtracks) were keyed to which of the five recommended actions. Active subtracks (i.e., those present in the 2005 solicitation) are highlighted. As articulated in the Act, these actions were collectively intended to (1) improve science and technical education at associate-degree-granting colleges, (2) improve secondary school and postsecondary curricula in mathematics and science, (3) improve the education opportunities of postsecondary students by creating comprehensive articulation agreements and planning between 2-year and 4-year institutions, and (4) promote outreach to secondary schools to improve mathematics and science instruction.

As can be seen in this table, every program track serves at least one of the purposes recommended by Congress; most program tracks and subtracks currently in place serve multiple purposes. Conversely, every action recommended in the Act is addressed by multiple tracks and subtracks of project and center work. The call for "professional development of faculty instructors" clearly is served by the *Professional Development* subtrack. Likewise, there is obvious linkage between the call for the "development and dissemination of instructional materials" and the *Materials Development* subtrack. "Acquisition of state-of-the-art instrumentation" was served for many years by the *Laboratory Development* subtrack and then by *Program Improvement.* Although not as obvious, the need for "model instructional programs" is also served by the program improvement category of funding. Resource centers clearly seek to fulfill the Act's requirement that materials not only be developed, but also disseminated. National and regional centers are large-scale efforts that should address all the activities recommended by the Act.

Table 3. Alignment of Act Specifications and ATE Program Tracks and Subtracks

	Actions Recommended by the Act				
	Development of Model Instructional Programs	Professional Development	Innovative Partnerships	State-of-the-Art Instrumentation	Development & Dissemination of Instructional Materials
Track: Projects					
Materials Development					X
Professional Development		X			
Laboratory Development				X	
Technical Experiences		X			
Adaptation & Implementation					X
Special Activities*	X	X	X	X	X
Dissemination Focal Points					X
Program Improvement	X			X	
Research*	X	X	X	X	X
Reform*	X	X	X	X	X
Teacher Preparation		X	X		
Track: Centers					
National Centers	X	X	X	X	X
Regional Centers	X	X	X	X	
Resource Centers					X
Track: Workshops/Conferences					
Workshops	X	X	X	X	X
Track: Articulation Partnerships					
Teacher Preparation in 2-Year Colleges			X		
Articulation Between Associate's & Bachelor's Programs			X		
* These are broad crosscutting endeavors that could potentially advance knowledge/performance/capacity in multiple work categories.					

Overall, there is close alignment between the actions specified in the Act and the program tracks defined in the annual solicitations. The one area that does not seem to be as clearly addressed by a particular funding track is "innovative partnerships" (e.g., between two-year colleges, four-year colleges, business, industry), but this was an expectation put forth of all grantees, regardless of the category in which they were funded. The track that most explicitly supported this type of activity was *Articulation Partnerships*.

NSF Program Monitoring

ATE program officers play an integral role in the implementation of its programmatic efforts. In addition to funding an annual three-day meeting of ATE principal investigators, senior project/-center staff members, and selected participants, the program has supported additional meetings and involvement by centers. NSF, for example, holds a separate luncheon meeting for center principal investigators on the last day of the annual PI meeting. It has held several additional meetings to address topics of concern to centers including a meeting of community college presidents and meetings on evaluation and center sustainability matters. Program support has been provided for centers' displays and participation at the annual meetings of the American Association of Community Colleges and for booklets that describe and promote the work of these centers (e.g., *ATE Centers Impact 2006-2007)*.

To assess the nature and extent of involvement and oversight provided by these officers, we annually included a section in the survey devoted to NSF program monitoring. Across all years, both projects and centers rated their program officers highly in matters of understanding their project work, interacting, and responding to questions—facilitating the PIs and their staff members in conducting grant work. On 5-point rating scales, the average ratings consistently were midway between 4 (agree) and 5 (strongly agree). Center PIs generally tended to rate the program officers more highly than did project PIs; almost never did a center respondent rate the program officer negatively in any aspect of program monitoring work. These findings strongly suggest that program officers have implemented the program in ways expected by the PIs and their staffs—in accordance with expectations set forward in the program's solicitations.

Increased Capacity for Advanced Technology Education

As indicated in Figure 1 (ATE program logic), an intermediate goal necessary to achieve the ultimate outcomes is to increase the nation's *capacity* for providing advanced technology education. This increased capacity is critical in order for more long-term outcomes to be sustained. Capacity for providing advanced technological education is enhanced through the creation of high quality education programs, professional development of technological educators, developing state-of-the-art laboratories, producing high-quality instructional materials, and establishing partnerships to support and advance technological education programs and students. Moreover, these innovations need to be institutionalized along with sustained development and dissemination. Below each component that contributes to increased capacity is discussed in turn, focusing on productivity and quality issues (when relevant information is available).

> From 2000 to 2005, more than 19,000 courses and 3,000 programs were developed or improved with ATE funding at almost 5,000 locations.
> Two-thirds of the programs and 87 percent of the courses impacted by the ATE program were at the associate level.

Education programs. As of 2005, 83 percent of ATE grantees reported being engaged in program improvement efforts. From 2000 to 2005, ATE PIs responding to the annual survey reported that more than 19,000 courses and 3,000 programs were developed or improved with ATE funding at almost 5,000 locations. The report, *ATE Indicators of Productivity: Six-Year Trends 2000-2005***,** (Gullickson, Coryn, & Hanssen, 2006) provides more details regarding annual productivity in the area of educational programs.

Consistent with the ATE program's emphasis on associate-level institutions, the greatest program improvement productivity occurred at the associate degree level. Two-thirds of the programs and 87 percent of the courses impacted by the ATE program were at the associate level.

The study "Assessing the Value Added to Business and Industry by NSF's ATE Program" provides much added detail about college-based education programs serving business and industry. Presented from the viewpoint of the collaborating business and industry informants, four major types of education programs were identified.

1. Consolidated Industry Model: Collaboration with multiple companies in a common industry develops technicians having skills tailored to the various needs of the industry.
2. Retraining/Up-Skilling Model: Collaborating with a variety of companies and consortia of companies typically provides specialized training/education in a targeted technical area.
3. Company Marketing Model: Collaboration with an individual company provides technician education targeted to that company's needs.
4. Mixed-Industry Model: Technician development collaborations are tailored individually with a variety of dissimilar companies in a locale or region.

The four models have unique strengths and weaknesses, but they enjoy many similarities in methodology. For example, all include substantial collaborative arrangements between the companies and the colleges to serve development of technicians, and all provide technician education as course-based opportunities. Consistently these methodological points of commonality were viewed as strengths of the respective models. Even with these points of commonality, considerable variation is in use both within and across these models. One of the perceived strengths of the ATE program was the many ways in which the educators engaged collaboratively with the business and industry representatives to tailor the models to fit local situations.

In concert with survey findings, three site visit conclusions seem most salient. First, regardless of the model employed, companies highly valued community college efforts to serve their needs for improving technician skills. Second, across all sites the effects of instruction reach beyond those taught, affecting others in their companies of employment. Those touched by the courses in a sense infiltrate the companies to change behaviors and practices. Third, a collaborative arrangement between the college and a business or industry is simpler and easier to maintain for long periods when the arrangement engages a single large company or a homogeneous group of companies. When the companies are small and heterogeneous, technician needs can differ substantially from company to company and individual employer requests tend to vary from year to year. Of necessity, technician education for these situations (Mixed-Industry Model) must be broader with training in specialties reliant on small scale programs such as internships, which likely require more intensive work and per-student costs for development and implementation.

More than 80,000 participants took part in more than 5,500 ATE professional development activities between 2000 and 2005.

Professional development. In 2005, a total of 2,195 professional development activities were offered by ATE grantees, including event-based programs (e.g., workshops and conferences), events with follow-up activities, internships, self-study, and other longer term activities. About 40 percent of these were event-based. From 2000 to 2005, grantees reported more than 80,000 participants in the various professional development activities. Most of these participants were educators at the secondary school level (44 percent) or associate degree level (45 percent), with the remaining 11 percent from 4-year institutions.

Pertinent findings from the professional development study (phase III in particular) include these:

Most ATE grantees engaged in professional development are reaching their target audience of 2-year college faculty.

- Improving teaching skills and preparing faculty to teach a specific curriculum are the most common goals of professional development activities.
- Participants attending events (as opposed to longer term programs) are less able to implement the ideas or materials.
- Participant satisfaction is greater for longer-term professional development than event-based activities.

Laboratories. Although development of state-of-the-art instrumentation was an action specifically recommended by the Act and *Laboratory Development* was a subtrack under Projects until 2004, the evaluation did not directly collect data on this aspect of the program. It was the ATE program officers' belief that most work done in this area would be captured by data collection focused on educational program improvement efforts by ATE grantees.

More than 5,217 materials, including about 1,650 courses, 2,500 modules, and 1,000 other materials were developed. Of these, about 135 courses, 560 modules, and 500 other materials were published commercially.

Instructional materials. The development of instructional materials has always been a major thrust of the ATE program. As of 2005, two-thirds of ATE grantees were involved in developing instructional materials. Between 2000 and 2005, grantees responding to the annual survey reported that they had developed 5,217 materials, which included 1,649 courses, 2,508 modules, and 1,060 materials of other sorts. Most of these materials were subject to quality assurance measures, with 70 percent or more of grantees indicating that they "most of the time" or "all of the time" aligned their materials with workforce needs, refer to student and industry standards and guidelines, pilot test materials internally, and field-test materials internally. Less than half of grantees engaged in materials development (between 29 and 45 percent) took more rigorous quality assurance measures, including external field tests and assessing student outcomes.

In 2004, we conducted a separate evaluation of materials developed with ATE support (Keiser, Lawrenz, & Appleton, 2004). Of 65 ATE projects and centers asked to send a copy of their "best" material, 37 (57 percent) did so, with 31 processed for review and 29 sufficiently complete for review. These materials had been developed as full courses, modules, sets of modules, or supplemental materials and covered a broad range of subject areas, including chemistry and biotechnology, electronics and electrical concepts, environmental issues, information technology and computers, manufacturing and automated design, physics, and general engineering.

These materials were subjected to a systematic review by experts from industry, curriculum, and use of technological education materials. Eighteen reviewers were trained on a created set of rubrics for rating the materials. Using this rubric, they rated materials on a scale of 1 to 4 (weak, adequate, good, excellent). Of the 29 materials, 79 percent were judged adequate or better: 7 percent were rated as excellent, 41 percent were considered good, 31 percent were rated as adequate, and 21 percent were judged to be weak.

In addition to the expert review, the two best curricular materials (from those identified above) were selected for an assessment of student outcomes (Appleton & Lawrenz, 2005). One was focused on environmental science and the other on engineering technology. Achievement of students using these materials was compared with achievement of students using traditional materials. After controlling for other variables potentially related to the outcome, significantly higher achievement was found for the ATE-funded environmental science materials. The ATE-funded engineering technology materials were found to be associated with the same levels of achievement as traditional materials.

With more than 5,000 materials produced with ATE support from 2000 to 2005 (which doesn't account for the 5 prior years of the program's existence), it is safe to conclude that the ATE program has led to the production of many more instructional materials for technological education. In many cases these materials provide the first opportunity for colleges to teach the specific topics or courses addressed by the materials. They provide access where no access to these courses or this information existed before. As such, the materials add value to the colleges and schools served.

The two evaluative steps taken to assess the quality of ATE materials produced positive results. The expert reviews provide prima facie evidence that the program produces sound materials. A 79 percent probability of new materials being judged as adequate or better seems particularly good since many of these developers were preparing instructional materials for courses that were new and for which comparable materials were not available as models or building blocks. Also, we know that this was the first major development effort conducted by many of the educators.

The two comparative studies highlighted several facets of the development process. First, it is quite difficult to identify comparable courses for outcome comparison purposes. For many courses it simply was not feasible to construct a test against a predecessor competitor. Second, conducting a comparative field test against competitor materials is extremely time-consuming and expensive. Third, the findings of the study are consistent with the findings of the independent expert reviewers. That is, the two comparative studies resulted in what we would term positive results.

However, the overall review process and the attendant comparative studies have substantial limitations. There are two strong delimiters of the materials review process. First, less than half (43 percent) of the projects provided a set of materials as requested. Second, projects were asked to submit their best material item for review. Even given those substantial limitations, available evidence leads to the conclusion that community college and secondary school access to educationally sound materials has been substantially improved through this program. The positive findings of the comparative studies resulted from comparisons based on materials rated as excellent or very good by the reviewers. Certainly, we cannot say that all ATE-developed materials will fare that well.

Partnerships. From 2000 to 2005, between 80 and 90 percent of grantees reported collaborating with business and industry and/or other education institutions. The average grantee reported approximately a dozen or more collaborations with education institutions and even more with business and industry.

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Articulation partnerships represented a specialized type of partnership between (a) high schools and 2-year colleges and (b) 2-year and 4-year colleges. Articulation partnerships between the latter included those designed to move students toward getting technological degrees OR for teacher preparation in STEM fields. The typical ATE grantee that emphasized partnerships developed multiple articulation agreements. In 2005, there was an average of 20 agreements per grantee for transitions from high school programs to 2-year colleges, 6 per grantee for transitions from 2- to 4-year colleges, and 4 per grantee for transitions to teacher preparation programs at 4-year colleges. In total, more than 2,000 agreements were reported in 2004 and 2005 to address the 3 transition points. As the per-project averages indicate, most agreements (1,479) affected the high school to 2-year college point, and the fewest (87) focused on 2-year colleges as feeder points for teacher preparation in STEM education.

Reports of students articulating under these agreements indicate that 4,455 students articulated in 2004 and 2005. More than half occurred between high schools to 2-year colleges, and the fewest were for teacher preparation.

Virtually all community colleges had ongoing relationships with local businesses and industries prior to the ATE program. Thus, it cannot be said that the ATE program established the idea of such collaborations. Yet, surely the ATE program engaged and expanded these relationships to good use. The various studies reveal a wide array of relationships and purposes served by the collaborations established through the ATE program. For example, the surveys show that those engaged in materials development called on business and industry partners to help create skill standards, assess technician responsibilities, and assure content validity of materials being developed. Site visits add to survey findings to show that those involved in program improvement engaged partners as teachers and collaborators in determining and developing course and program content.

The study on sustainability among projects showed that collaborations persist after ATE funding ceases, though not to the same degree as during funding. Additionally, the purposes identified as important to ATE collaborations persisted after funding ceased. For example, program content was identified as the most prevalent purpose for collaboration in the final year of project funding. That collaborative purpose retained its position of prominence even after funding ceased. This suggests that symbiotic relationships developed through the ATE grant continue to help the local colleges develop their programs in the years following the ATE funding. Whether the sustained relationships represent an increase over these types of activity in place prior to ATE funding or just a return to pre-ATE funding levels could not be determined from our findings.

Dissemination. ATE program guidelines stress that materials development work should be limited to preparing high quality materials for national dissemination. According to the annual survey of grantees, use beyond the local project is much more likely to occur with modules and other materials than is the case for courses. Across the 6 years from 2000-2005, just under 6 percent of the course materials were published commercially and 20 percent were used beyond the project. Nearly three quarters of projects (74%) reported course use only at the local level. Module use was more widespread, with slightly more being used elsewhere than locally. Almost twice as many "other" types of materials were used elsewhere as locally. More than 1,000 modules and other materials were reported to have been published commercially, compared with 135 courses. All these data suggest that national dissemination occurs rarely for courses but much more regularly for modules and other materials. The inference we draw from these findings is that national distribution of "large" products is much less likely to occur than for smaller products that can be accommodated within courses or applied for "niche" uses.

Sustainability. The funding support for the ATE program has remained relatively stable over the period of this project. Two-year, associate degree institutions, were identified as the primary target in the congressional bill calling for NSF to create the ATE program. The data show that the ATE program has consistently given priority to funding this group of institutions through its solicitations and in terms of actual dollars awarded. The materials developed, programs improved, and professional development efforts have emanated from and produced outcomes used directly in the 2-year colleges and in linking work at these colleges closely with secondary schools and to a lesser extent with baccalaureate institutions.

While still funded by ATE, grantees typically report one or more of the following five strategies for sustaining grant activity after ATE funding ends: (1) seeking additional funding, (2) disseminating products, (3) developing/modifying existing products, (4) institutionalizing materials/practices/programs at the host institution, and (5) collaborating with other organizations. Of the five strategies, seeking additional funding was the most prevalent form, with approximately 40 percent seeking additional funding each year.

When the project was no longer receiving ATE grant support, at least initially (i.e., in the following year) PIs viewed their productivity as stable or increasing. Reported stability was greatest for the strategy noted above as point 4: institutionalizing. PIs reported continuity of their work to improve curricula and courses both immediately in the year after ATE funding completed and in following years. At the same time, activities in the other described areas declined but did not cease. This decline without cessation was true for all types of activity. Two specific exemplars were noted in the sustainability study (Welch & Gullickson, 2006):

- Total funding declined by more than 60 percent in the year following completion of the grant and continued to decline sharply in following years. These declines were not appreciably related to grant size.
- PIs reported substantial sustainability of collaborations—about 65 percent of the rate reported in the last year of funding—even several years after funding cessation. The types of organizations involved in collaborative efforts remained stable (e.g., business and industry along with other education institutions were most reported as types of collaboration).

Summary. In 1992 Congress set up conditions under which NSF was expected to create and operate a funding program to serve technician education and produce more and better qualified technicians for the American workforce. The NSF divisions of Undergraduate Education and Elementary, Secondary, and Informal Education teamed up to provide that program. Initiated in 1994 the program continues to the current time. The funding in 2005 was more than three times what it was in the program's initial year (1994), but it remains a small program in federal terms.

Through its annual guidelines (solicitations), the program has developed in a way that is congruent with Congressional expectations. The evidence clearly shows that the program is meeting its federal mandates. The program initially created two main tracks, projects and centers; those two tracks persist in current funding. The program has varied program opportunities within these tracks across time to emphasize particular objectives. It has continued to make community colleges its focal point, but has included a wide array of technology and technicians in its points of emphasis.

The nature of centers funded across years has evolved with more centers funded to serve regional interests and with smaller annual budgets. Typically, centers have much larger annual budgets and routinely have National Visiting Committees that oversee and support their work. Factors such as budget size, scope of work, visibility provided by their National Visiting Committees, and occasional meetings reserved for center participation only suggest that centers are a higher priority for the program.

The program has emphasized program improvement, professional development, and materials development types of activities. These efforts occur in both centers and projects, though the size of individual efforts differs markedly between projects and centers.

Annual solicitations vary from year to year, not in major ways but rather in points of emphasis. The result is that work emphases appear to change across time, but overall priorities remain quite stable. Perhaps the largest change is seen in professional development. There, attention of the program has increasingly shifted toward support for developing new teachers using the community colleges as conduits for teacher preparation in STEM fields. In recent years the

program also has been much more pointed in requiring proposal developers to plan for sustainability and for developing evidence of effectiveness.
Throughout this evaluation's tenure we have solicited information from PIs regarding the support provided by program officers. Consistently, these PIs have informed us that their program officers communicate effectively with them and provided support for their efforts when needed.

In sum, the evidence shows that the program is oriented directly in the way mandated. It is stable but malleable in focusing on specific objectives of interest. These activities have been visible across all years of the program. The solicitations have changed from year to year, emphasizing different activities and aspects of the program. Throughout, however, the solicitations remain true to the stated congressional intent. We conclude that the program has put in place the necessary conditions and strategies to increase the country's capacity to provide advanced technological education.

More Skilled, Advanced Technicians

Between 2000 and 2005 ATE-grantees reported that more than 385,000 students had taken at least 1 course in a 12-month period. Given that ATE-funded projects and centers are likely to serve many of the same students across survey years, the actual number of "unique" students is likely to be somewhere between one-half and one-third of this number (i.e., 130,000-190,000).

An estimated 130,000-190,000 students took at least one ATE-supported course, with more than 32,000 completing programs of study. More than half of those completing programs had already been part of the technical workforce.

In that period, more than 32,000 technical education students *completed* ATE-funded programs of study (e.g., degree or certificate) at the secondary, associate, baccalaureate, and on-the-job levels combined. Slightly more than 20,000 of these students were employed as technicians prior to their enrollment in an ATE-funded program.

The ATE program has reached a large number of students, and the numbers of students reached is increasing annually. The annual funding support for the program and resulting numbers of annual grants awards have nearly doubled since the evaluation began. At the same time, as Figure 5 displays, there has been an almost threefold increase in the total volume of students completing ATE programs of study since 2000 and a nearly equal increase in the number of participating students who were already in the technical workforce prior to entering an ATE program of study.

Individual projects and centers do not break out their costs in ways that provide for determining the precise cost per student reached or graduated. The best figure we could compute is a cost of less than $500 per student (2000-2005)—if all funds were used for student instruction purposes. That, of course, is an overestimate because it does not consider other major work such as materials development, faculty professional development and articulation agreements.

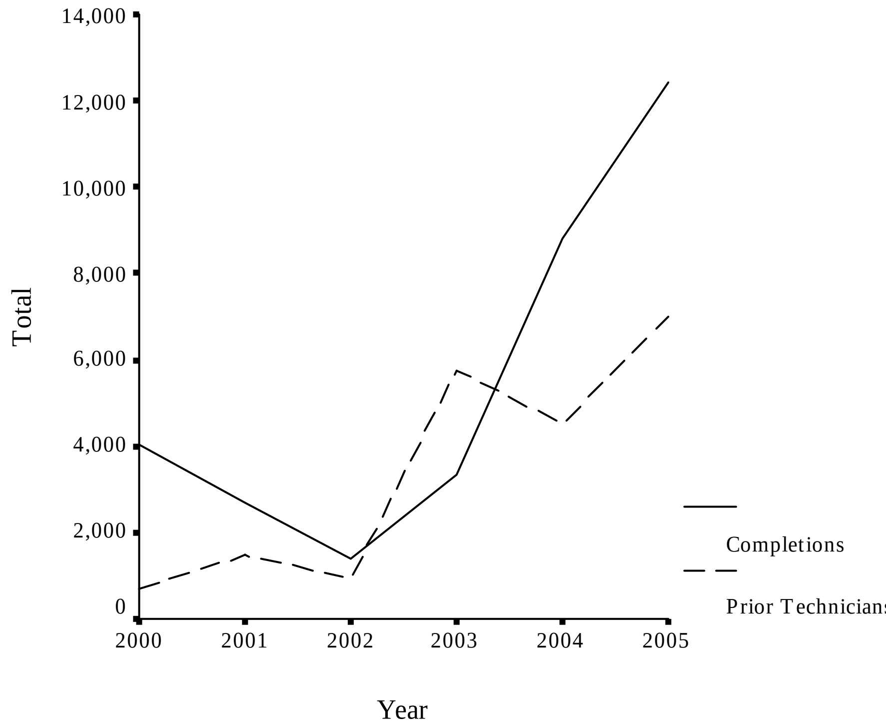

Figure 4. Total Number of Students Completing ATE Programs Annually and Number of Enrolled Students Who Were Technicians Prior to Participation

We anticipate that the articulation agreements will ultimately yield more technicians and greater numbers of STEM students since these agreements “cement” long-term relationships that will encourage enrollment in technical programs for years to come. We do not have indicators of the magnitude of this effect; and we know that many, if not most, of these students would likely have been enrolled in community colleges regardless of the presence of the ATE program and the articulation agreements. Since we have no control or comparison groups, we cannot determine whether or how much student enrollment increased due to ATE.

The case for ATE increasing the numbers of technicians is improved somewhat by the evaluation’s targeted study that focused on the value added to business and industry. It concluded that the ATE program adds some value to collaborating businesses and industries in terms of the numbers of technicians educated/trained and available. Although this finding was positive, most interviewees did not view the ATE program as a major factor in increasing the numbers of technicians to serve their needs. Rather, they spoke most directly and positively in terms of improving the quality of technicians, their own employees and new hires. Consistently, they also reported that their relationships with the ATE program and the quality of ATE-educated technicians made a difference by improving their business results and reducing their business costs.

Altogether, the evidence is not strong that large numbers of students have been attracted to technical programs as a direct result of ATE support. In part this is due to external pressures (e.g., the increasing outsourcing of technical positions to companies overseas); as a result, the huge demand for technicians has declined to some extent. However, ATE's support of colleges has enabled the colleges, especially associate degree institutions, to focus on improving their curricula and linkages with business and industry.

In sum, the evidence gathered is better in terms of arguing the ATE program has improved the skills of technicians. Evidence that more technicians are being educated is less convincing. Certainly, though, the ATE program has demonstrated success in providing the necessary ingredients for creating a larger, more skilled technical workforce—tens of thousands of students have received ATE-supported technological education, with more than 30,000 completing programs of study. More than half of those completing programs had already been part of the technical workforce, suggesting that in addition to adding to the sheer number of technicians, it has raised the overall skill level of that segment of the workforce. These indicators provide good circumstantial evidence of success but not ultimate proof.

Is it Making an Impact, Reaching the Individuals and Groups Intended?

Reach is defined as *the extent to which the program made contact with its target, and other, audience(s)*.

With a focus on preparing "technicians for the high-technology fields that drive our nation's economy" (NSF, 2005, p. 2), the ATE program targets current and prospective technicians; technical education students; secondary, postsecondary, and prospective teachers; and business and industry decision makers. NSF also seeks to increase the participation of women, underrepresented minorities, and persons with disabilities in advanced technology areas through ATE program activities.

In accordance with the congressional act, which indicated intent to improve education in advanced-technology fields through focusing on two-year colleges, ATE's primarily institutional target is associate-degree-granting institutions. The annual solicitations specify that "all proposals are expected to include one or more two-year colleges in a leadership role" (NSF, 2005, p. 4). The leading institutions were expected to create partnerships with other two-year colleges, four-year colleges and universities, secondary schools, business, industry, and government.

Reach to Targeted Individuals

> About two-thirds of the 32,000 individuals who completed ATE programs of study were at the associate level, one-third were at the secondary level, and fewer than 1 percent were at the baccalaureate level.

Approximately two-thirds of the 32,000 individuals who reportedly completed ATE programs of study were at the associate level, one-third were at the secondary level, and fewer than 1 percent was at the baccalaureate level. These data along with grant award data show that the program is focused on and reaching the primary target—students at community colleges—with secondary emphasis of improving programs in secondary schools.

The ATE program also has emphasized pointedly the importance of supporting women and underrepresented minorities. The survey trend data from 2000 to 2005 most directly address these points. A large majority of ATE students are male and white. Males consistently comprised about two-thirds of ATE students from 2000 to 2005. The participation rate of white students dropped about 6 percent (from 66 to 60 percent) over the 6 years. Demographic data show variations from year to year across all racial categories so that whether or not these represent definitive trends can be argued. But, for example, from 2000 to 2005 the numbers of Native American and Hispanics have increased somewhat (5 to 10 percent), while participation by African Americans has held steady.

Overall, these data indicate that, at best, ATE's success is in the total numbers of women and minorities reached but not in changing their rate of participation in technician education during the period we evaluated the program. Even though the ATE program has not succeeded in substantially increasing their rates of participation, the total numbers of women and minorities who have been impacted by the ATE program at community colleges across the country has increased annually; and this number has escalated with the program's increase in funding and concomitant increase in grants to colleges. This almost certainly means that the program has increased the numbers of better qualified women and minorities in the technician workforce.

Reach to Targeted Institutions

> The ATE program directly supported 17 percent (n=201) of the 1,157 U.S. community and technical/ vocational colleges. The typical ATE grantee collaborated with 5 or more non-ATE education institutions, which served to substantially broaden the reach and potential impact of the program.

ATE made 674 awards between 1994 and 2005, an average of 56 per year. By congressional and program mandate, associate degree (two-year) colleges were the expected point of emphasis (e.g., "improve science and technical education at associate-degree-granting colleges"). At less than 60 awards per year, the ATE program could not be expected to reach all the nation's associate-degree-granting institutions during its current lifetime. For example, if only these institutions had been given awards and all awards had been dispersed equally on a "nonmerit" basis, the program could have reached only a small majority (58 percent) of the nation's 1,157 associate-degree-granting colleges. Project funding records show that 345 grants were to *unique* institutions, including 200 two-year colleges. Overall, this amounts to the program directly funding 17 percent (201 of 1,157) of the total United States community and technical/vocational college population. The remaining funding was distributed to secondary schools, 4-year colleges and universities, professional societies and associations, and a small number of awards to business and industry.

The focus on two-year colleges also is evident in overall funding, with 65 percent of <u>all</u> awards going to this constituency, as can be calculated from figures in Table 4. These data show that 2-year colleges were more than 40 percent more likely to receive multiple awards than other funded groups (52 percent of ATE-funded 2-year colleges received multiple awards compared with 36 percent for other groups).

Table 4. Number of Awards by Type of Institution

Number of Awards Per Institution	Type of Institution		Total
	Other	Two-Year College	
1	92	97	189
2	31	53	84
3	11	23	34
4	4	7	11
5	4	8	12
6	1	8	9
7	1	0	1
9	0	3	3
10	0	1	1
13	0	1	1
Total	144	201	345

Other survey data point to a much broader impact than visible just from review of the numbers of ATE grants. Annual survey findings show that the typical project and all centers reach multiple education institutions to bring materials, program improvement, and professional development opportunities to them. Annually from 2000 to 2005, the typical (median) individual ATE grantee collaborated with five or more other non-ATE education institutions. Those data suggest that the majority of this country's community colleges have been impacted in one or more ways by the program.

Considering the logic that the greater the number of institutions reached, the greater the potential for program impact, an important attribute of the ATE program is its continual reach to new institutions. Figure 5 shows that the number of newly funded institutions increases by about 25 per year, and currently is about 40 percent of the awards given annually. This figure also shows that the number of total grant awards per year is increasing more rapidly than the number awarded to newly funded institutions. This indicates that previously funded institutions are having considerable success in competing for new awards after their initial funding. In many instances, subsequent awards are for continuation of the originally funded work. Currently, national and regional centers are eligible for an additional 3 years of funding after the initial award; resource centers may be renewed for an additional 4 years. In other instances, especially when the number of awards made to an institution is larger than 4 across the 12 reported years, there is a strong probability that multiple projects and principal investigators are being funded at the institution.

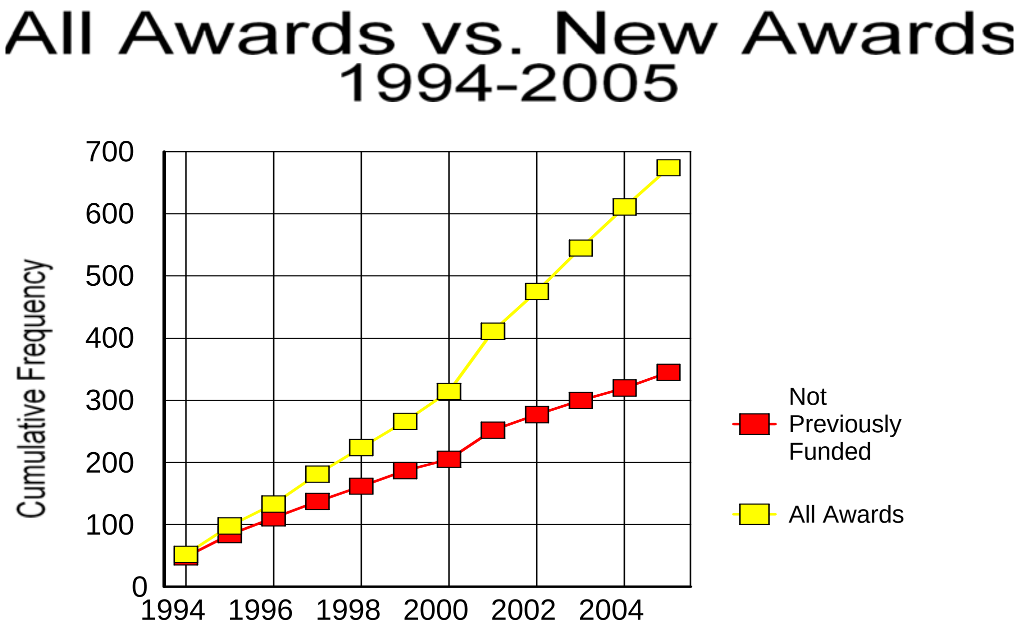

Figure 5. Numbers of ATE Awards Made Annually

In sum, the profile for ATE reach to targeted institutions shows substantial impact, significant remaining need, and continued progress toward meeting the need. There are several points here. First, despite the strong emphasis on funding two-year colleges, the large majority of the nation's community and technical/vocational college population have yet to be directly supported through this program. Second, those that have competed successfully once tend to be highly competitive in future competitions. This is important motivationally for faculty members and host institutions. Third, funded institutions tend to collaborate with multiple other education institutions, which increases the reach of the ATE program. Fourth, a substantial proportion of ATE grants go to never-before-funded institutions. This suggests that ATE regularly is meeting and serving new constituents.

How Effective is it When it Reaches its Constituents?

Evidence collected in our evaluative effort focused on three areas or categories of work: materials development and dissemination, professional development efforts, and program improvement—student engagement. If *effective* is "measured" in terms of productivity, the findings of our evaluation show clearly that the ATE program has been highly productive and therefore effective. The productivity shows in the large numbers of materials, courses, and curricula developed; the numbers of participants who engaged in professional development efforts; and the numbers of students who engaged in courses and completed programs.

Large numbers of new materials have been developed, and these materials have been embedded in secondary and college level courses and programs. Large numbers of educators at both the secondary and community college levels have received professional development instruction in the use of new materials and associated STEM instruction. Certainly, the evidence shows that new courses are being offered and students are being given opportunities to participate in ways that were not possible prior to the ATE program. The large numbers of articulation agreements have opened new avenues for enabling students to transition into new higher education STEM opportunities, and many students are acting on those opportunities. One cannot attend an annual ATE principal investigator's meeting, for example, without being impressed by the numbers of student participants and their testimonies regarding new options and opportunities to which the program has given them access.

Most of our findings regarding materials development indicate good quality and positive effects when the materials reach intended constituents. Our study of developers' best materials found that most (over 80%) are at least adequate for the stated instruction purposes; a minority was rated as high quality. A separate comparative field study of two of the best-rated materials found one to be better and the other to be equal to its competitor.

Survey findings indicate that most materials are used locally and regionally with a small proportion (5 to 12 percent) of developed materials published commercially. Certainly, the local and regional use provides indications that the materials are valued. But national distribution is a stated aim of this aspect of the ATE program. Also, publication by commercial publishers likely serves as a stronger statement of good quality. We would like to see a higher rate of publication success for this program. However, since these ATE projects are developing new materials, typically for new courses and programs, likely by faculty members that have not previously developed curricula for publication, we think the publication rate is reasonable for materials development efforts.

Though strongly positive, our indicators of quality of professional development tend to be testimony-based and secondary sources. Both principal investigators and professional development participants rate the quality of professional development programs highly. In our study of professional development participants, we found that participants claim to be applying lessons learned in their local schools and teaching situations. We did not conduct site visits as part of this study to verify actual implementation at these local institutions. Similarly, some PIs stated that they have conducted studies to assess impact of their professional development work, but there is a paucity of evidence regarding the extent to which professional development ideas and information are actually used and do improve participants' STEM instruction.

One negative attribute of evaluative evidence regards the nature of professional development activities. Most PIs indicate that their professional development efforts are event-based (i.e., information taught or shared at a short-term event). A minority describe their work as process-based where the professional development program is closely connected to participants' work at the local level and spanning a long term (e.g., semester or multiple years). Our review of research, as well as the NCES standards, suggests that event-based professional development is likely to be less effective for participants.

Several strands provide considerable evidence of effectiveness for program improvement efforts. These efforts have resulted in large numbers of courses and programs being developed or revised to better serve STEM instruction and build opportunities for student articulations at the secondary and community college levels. Certainly the large numbers of colleges and secondary schools taking advantage to study and revise their programs is direct testimony to the ATE program's effectiveness. Concomitantly, the student data show that these institutions are engaging large numbers of students and graduating them or otherwise certifying them for technician work. Importantly, the articulation agreement aspect of the program has helped institutions develop and cement paths for future students to take for success in education programs. The 2004-2005 trend data show that more than 4,000 students have used this opportunity, and the numbers participating significantly increased in the second year. Input by business and industry collaborators buttress claims of effectiveness because they report that these collaborations have increased the number and quality of their technicians' improved business results and lowered business costs. Finally, we note that our study of project and center sustainability shows that a high proportion of grantees continue ATE initiated-course and curricular program work in the years following completion of ATE funding.

The above judgments of the program's substantial effectiveness are necessarily tempered by lack of data showing gains in student achievement. There have been few, if any direct comparative studies of course and program effectiveness. As a result, we have no direct data that objectively measure the extent to which students have materially gained knowledge and experience as result of new and improved curricular materials and programs. In these regards we believe that more can be done to gather and provide evidence of quality. However, developing measures that objectively show program-wide improvements in student learning are neither simple nor cheap. For evaluation evidence to be compelling it will require careful attention to design and measures, participation across projects, and long-term commitment. It must be attuned to program expectations so that attention to measuring quality does not detract from the program's capabilities to produce good quality outcomes.

In sum, despite the limitations stemming from a paucity of student achievement data, the multiple strands of evidence point to strong, positive effects of the program as delivered.

Are There Ways the Program Can Be Significantly Improved?

The evaluation evidence suggests that ATE is functioning very well. Yet, our evaluation reports consistently have identified ways in which we evaluators believe the ATE program and its projects and centers can be improved. For example, the most recent briefing papers have suggested specific actions related to evaluations, needs assessments, focuses on student recruitment and cross-institution articulation agreements. Those suggestions for change as well as the few highlighted below build on the program's recognized strengths.

Our evaluation findings show that this program has been exceptionally strong in its attention to the federal mandates and in developing and maintaining the program in ways that are consistent with those mandates. Changes to annual solicitations show careful thought as to intended program goals and steps or mechanisms needed to reach those goals. The continuity and relative stability of the program, even during periods of fiscal constraints and cutbacks for the EHR directorate, show that the program has strong political support. Our survey data about the effectiveness of the NSF program managers and our own personal contact with them leads us to attribute much of the program's success to the strong managerial and organizational skills of the lead program officers.

Our analyses and experience lead us to conclude that the program will benefit most through incremental changes to the annual solicitation for proposals. Project operations are guided by their proposals, and proposals are heavily influenced by the suggestions provided in the solicitations; so changes to the solicitation are likely to result in changes in the projects.

The solicitations that guide applicants in preparing plans speak much more directly to specification and standards pertaining to desired outcomes for technician knowledge and skills than for how outcomes should be achieved. Two examples are shown from the current (NSF 5-530 solicitation):

- "Components of the program improvement process might include: integrating industry standards and workplace competencies into the curriculum." (p. 4)
- "These projects help to prepare a future K-12 teaching workforce that understands the technological workplace and can prepare students to use a variety of approaches to solving real world technology related problems using design processes and principles. (See Standards for Technological Literacy, ITEA [http://www.iteaconnect.org/]." (p. 6)

We view the focus on outcomes as appropriate. But we also believe that the solicitations can improve the viability of the awarded projects by providing guidelines for processes that should be included in the projects in addition to expected outcomes.

We believe the solicitations should emphasize the use of standards in determining what processes to implement and how to implement them. Two examples of standards that would be relevant to ATE projects are the *National Science Education Standards* (National Research Council, 1996) for designing professional development, teaching, and content and *The Program Evaluation Standards* (Joint Committee on Standards for Educational Evaluation, 1994) for designing evaluations. For example, we have noted on several occasions that existing ATE professional development efforts tend to be event-based rather than process-based. Clearly, the ATE program is encouraging the latter, but the program has not made major strides in achieving a strong process-based approach. Mentioning the NSES standards for professional development might help applicants better understand what is expected of them and make them aware of viable tools for their planning.

Mentioning the program evaluation standards might also be beneficial. We have repeatedly encouraged more attention to project/center-based evaluation efforts. We believe that strong local level evaluations can strengthen individual projects/centers and through them improve the program. Our evaluation findings suggest that most projects and some centers engage evaluators that lack experience; focus on the easily obtained data rather than important evaluation tasks; and produce evaluation findings that, while useful, fall well short of producing optimum value. Highlighting the evaluation standards in the solicitation would provide potential PIs with a good source of information about high quality evaluations.

Our second recommendation on how to make improvements is that the solicitation should emphasize carefully relating project processes to needs assessment information gathered by the project. In addition to formal needs assessment used for project planning, existing projects also report a number of areas in which their projects are challenged (Ritchie, Gullickson, & Coryn, 2006). For example, one current challenge noted by many principal investigators is the recruitment of students. These challenges should be areas for discussion and sharing of potential solutions. As an aside and in keeping with our observation that the ATE program is well managed, student recruitment is already on the docket for the next PI conference. We encourage the program to continue to check for challenges and address them as needed.

Evaluation Lessons Learned

We have presented an array of papers at professional meetings, such as the annual meetings of the American Evaluation Association, that point to strategies tried and lessons learned. Our most painful (and unpublished) lessons have been relative to development of clear and careful work plans and well-grounded, enforceable contracts to guide those who engage with us in evaluations.

Our most productive lessons learned revolve around new strategies for conducting work. For example, the materials development evaluations clearly show the importance of well-constructed review strategies as an evaluative tool. The cost trade-offs also show that the review panels can provide strong evidence regarding quality at much lower costs than required for comparative studies of findings. But we acknowledge that review panels cannot be a substitute for making ultimate determinations about the merit and worth of materials in the classroom.

We believe we learned valuable lessons in reporting evaluation findings. Some of our strategies that excerpt and explore well-focused and brief points appear to be much better received and used than longer, more comprehensive work. While there is a trade-off in these matters, we have moved much more toward brief, segmented reporting processes and papers that make their points more quickly and succinctly. We still have much to learn in this regard.

While we knew it intellectually at the outset, the long-term interaction with NSF program officers especially has reminded us about how difficult it is to remain fully objective across a long span of time. One safeguard we have applied with only limited success is the use of metaevaluators to assess our work and help ensure that our evaluation efforts remain unbiased (so that we do not go “native” as Daniel Stufflebeam would say). Advisory panels, when well briefed and given the opportunity to speak freely, can also contribute significantly to objectivity. Yet, going native is such a worrisome aspect of long-term evaluations that we note it needs special attention, not just by the evaluators, but also by those who fund and/or use evaluation findings.

Not surprisingly, this evaluation reinforced our expectation that evaluations are more interesting and helpful when the evaluators and evaluatees all are genuinely interested in making the program the best it can be and work toward that objective.

We thank the NSF program staff and all the project/center principal investigators and their staff members for the substantial help we have been given in conducting our evaluation efforts. What we have learned and contributed directly results from the substantial assistance and cooperation provided by all with whom we have worked on this project.

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Appendix:

ATE Program Evaluation Fact Sheets, Reports, Publications, and Presentations (available from http://www.wmich.edu/evalctr/ate/publications.htm)

Fact Sheets

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