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Institutionalization and Sustainability of the National Science Foundation's Advanced Technological Education Program

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In response to the 1992 Scientific and Advanced Technology Act (SATA), the National Science Foundation (NSF) initiated the Advanced Technological Education (ATE) program to promote systemic reform of the nation's science, technology, engineering, and mathematics (STEM) education. The Act gave community colleges the central role for the implementation of the ATE program.

The study summarized here analyzed the influence of the ATE initiative on the nature of STEM programs in community colleges; on the formation of partnerships; and on the characteristics of the colleges in which they were located. It also examined the steps taken to promote the sustainability of the ATE reforms and innovations once the NSF funding had ceased or been significantly reduced.

The Advanced Technological Education Program

The mission of the ATE program is to improve science and technology education at secondary schools and associate-degree-granting colleges; to encourage college outreach to high schools for recruitment purposes; and to improve the educational opportunities of postsecondary students by creating comprehensive articulation agreements between two-year and four-year institutions.

The Scientific and Advanced Technology Act specifically endorsed the following activities: the development and use of exemplary educational materials, courses, and curricula, and their introduction in new educational settings; the preparation and professional development of college faculty and secondary school teachers; the provision of internships and field experiences for students, faculty, and teachers; and the broad dissemination of exemplary educational materials and pedagogical strategies that have been developed through previously funded ATE awards. These activities are implemented through two major formats. ATE *centers* are intended to collaborate with two-year and four-year colleges, universities, secondary schools, and industries; provide models and leadership for other projects; and act as clearinghouses for instructional methods and materials. ATE *projects*, more limited in scope, focus on one or more activities, including curriculum and educational materials development, program improvement, professional development for educators, technical experiences, and laboratory development.

More than 450 ATE grants have been awarded to community colleges. At the beginning of 2003, there were 21 centers and large-scale dissemination projects, and approximately 200 smaller projects receiving ATE funding from the NSF.

Description of the Study

Study Sample and Methodology

The Community College Research Center closely examined six ATE projects and four national centers between October 2000 and January 2002. Information was collected by researchers through two- or three-day visits to each of the sites, as well as through information available on the ATE website and the websites of the individual projects and centers. We were assisted by an advisory board consisting of a community college president, a former principal investigator of an ATE center (not one of those included in our sample), and an expert on technological innovation and diffusion.

We examined the major activities of the ATE projects and centers in five broad areas:

(1) The development, implementation, and dissemination of curriculum and other instructional materials;
(2) Professional development of college faculty and secondary school teachers;
(3) Efforts to strengthen science, technology, engineering, and mathematics (STEM) education in high schools and to increase the numbers of high school students in STEM postsecondary programs;
(4) Articulation and transfer agreements between the two-year and four-year institutions; and
(5) Partnerships with industry.

Conceptual Framework

We considered the sites in light of two broad classes of problems that the NSF is trying to solve through its ATE program. The first is the absence of an adequate curriculum and a shortage of professors and students for technical programs in community colleges; solutions would involve increasing the available curricula, professors, and students. We refer to these activities as *output-oriented*. The second problem concerns the environment that leads to these shortages; solutions involve changing that environment. Since this perspective emphasizes the institutional processes of curriculum and professional development, we call them *process-oriented* solutions.

We were also specifically concerned with the ability of the centers and projects to meet ATE's goal of having a significant and permanent influence on their host colleges and on the system of STEM education in general. Thus, we considered the *institutionalization* of the initiatives—the extent to which their activities were becoming incorporated into the normal, ongoing activities of the college. We also considered *sustainability*—the extent to which the major ATE activities would continue after the period of funding.

Of course, some ATE projects may not have been successful and therefore should not continue—a normal and expected result of a program designed to encourage risk-taking and innovation. Also, some ATE activities may be aimed at solving one-time problems and, once they are solved, activities can cease. For example, a new technology arises for which there is no curriculum; once that material is prepared and disseminated, additional resources and effort may not be necessary. Still, if the ATE activities lead to internal changes within the colleges so that the ATE innovation in effect becomes a standard procedure, the goal of having a strong influence on the host college has been achieved.

Study Findings

Accomplishments of the ATE Sites

The ATE projects have developed new curricula for scientific and technical fields. In most cases, these curricula reflect an emphasis on a strong academic content in occupational education, which is one of the ATE program's central tenets. Some of the sites we studied were also experimenting with modularized curricular strategies that potentially can provide more learning benchmarks and flexibility to a student's educational program. ATE grantees have also created professional development opportunities to help faculty learn to use the new curricula. Further, they have successfully engaged technical faculty in the development of the ATE curricula and, in many cases, technical faculty have used the ATE materials in their classes. The participation of these faculty, combined with the strengthened curricula, is evidence that ATE is making progress in reforming technical education in community colleges.

Some of the sample sites have worked to break down traditional interdepartmental barriers. In some cases, academic faculty members joined technical faculty in curriculum development. Colleges seeking to increase collaboration developed both formal and informal structures that brought together faculty and administrators from diverse parts of the college.

Industry has strongly supported ATE sites by providing equipment, advice, internships, and jobs for graduates. Further, many ATE grantees have worked closely with employers and industry associations in the creation and design of curriculum, skill standards, and professional development to gain access to knowledge about the latest technological developments and skill requirements in the industries.

Finally, the ATE initiative has promoted significant inter-institutional collaboration. Work with high schools, among the sites that we studied, has been particularly impressive, and changes in the high school curriculum have been noteworthy. Grantees also made use of faculty from four-year colleges for curriculum and professional development. These relationships, if they are sustained, can strengthen the environment in which STEM education takes place.

Strategies and Sustainability

Determining whether a center or site has an output-oriented or a process-oriented perspective enabled analysis of the strategic alternatives employed by the sites, and also permitted investigation of the institutionalization and sustainability of their activities. We found that, so far, ATE projects and centers have emphasized output-oriented strategies such as the development and dissemination of new curricula and efforts to recruit high school students. Process-oriented strategies were less developed. In most of the colleges, ATE activities concentrated on occupational and technical courses and were implemented within the traditional structure of the community college, not challenging the tension between technical and academic organization and instruction. Except in some high schools, ATE projects and centers had not influenced the content or pedagogy of academic courses.

Thus, ATE has promoted a reform of technical courses rather than a more broad-based integration of academic and technical instruction. We also found that transfer was not a priority in the ATE sites. While ATE technical curricula had stronger academic content, in many cases those courses were still not transferable. Moreover, we noted a trend towards short-term or non-credit courses, which usually are nontransferable as well.

Over the long run, process-oriented approaches that influence the basic operations and environment of the colleges are more likely to be institutionalized. Those centers and projects that have concentrated primarily on output-oriented strategies may have a more difficult time sustaining their gains. Nevertheless, sustainability is certainly possible without institutionalization; programs

or centers could continue to seek additional outside funding once the NSF grants expire.

It is not surprising that output-oriented strategies have been more common. The sharp division between academic and technical instruction is one barrier in the way of innovative approaches to the education of STEM personnel, and that division is long-standing and well established. Moreover, there is no consensus among faculty members at many community colleges, particularly academic faculty, that this division should change. It is easier, therefore, for ATE staff at a college to avoid this conflict and focus on changing the content of technical courses or even short-term or non-credit courses, where they are likely to meet much less resistance.

Even the enthusiastic involvement of industry may limit the depth of reform. While industry associations tend to support broad educational innovations, the short-term firm-specific interests of particular employers may not always be consistent with the broader educational goals of the ATE.

Additionally, we found that the process of awarding the grant money created incentives for output-oriented rather than process-oriented approaches. Soft money operations within educational institutions tend to operate at the margins of those institutions, and are therefore relatively weak tools for bringing about internal substantive or organizational change.

This does not mean that ATE centers and projects cannot bring about process-oriented reforms. Indeed, in our sample, we have seen important progress. With a ten-year record of widespread reform of STEM education, the NSF may have the opportunity to shift the emphasis. Indeed, in the last few years, through the design of its RFPs, the NSF has sought to strengthen reforms that would be considered process-oriented. In particular, it is encouraging more attention to transfer and articulation and program reform, as opposed to materials development. The RFP-specified focus of the regional centers, the latest type of center provided for by the ATE program, explicitly calls for efforts to change programs and systems. Thus, we would expect to find more widespread attempts to pursue process-oriented strategies among more recently established centers and projects.

Recommendations and Conclusion

It is important to emphasize that while we selected a variety of centers and programs to study, the sample is small and not necessarily representative. Moreover, the ATE program is evolving, so our comments refer to the situation that existed when we observed the sites between 2000 and 2002.

In principle, the NSF would like to see the innovations and reforms that it funds institutionalized and sustained once ATE funding ends. We argue, though, that the optimal level and nature of institutionalization and sustainability depends on the underlying problems that the ATE activities are trying to solve. Thus, our first recommendation is that in planning for ATE projects and centers, *the applicants and the NSF staff need to be clear about the problem to be solved*, or more specifically, about the circumstances that stand in the way of solutions and improvements.

For example, the education system creates and disseminates instructional material, organizes professional development, and develops partnerships with business and other educational institutions. Why are these normal organizational processes not adequate without additional ATE resources? Possible problems include the following: (a) insufficient appropriate instructional materials; (b) a lack of adequate academic content in the existing materials; (c) no instructors who can develop appropriate instructional materials; (d) no instructors to teach existing appropriate instructional materials; (e) no distribution channel for these instructional materials; (f) a shortfall in the number of students who come to technical programs in the college; (g) too few technology/occupational students who go on to advanced STEM programs; (h) general education programs that do not connect theory to application; and (i) the organization or cultures of colleges thwarting the introduction of innovative material or pedagogies. Different causes imply different solutions, and the nature of those solutions will, in turn, influence the most appropriate level and nature of institutionalization and sustainability.

The first recommendation suggests a second one: *design incentives that will promote broader programmatic and organizational innovation*. The underlying characteristics of the ATE initiative tend to promote a particular type of solution—an output-oriented approach. In many cases, this approach may be the most appropriate solution, but special provisions will need to be made in situations where the NSF and college staff judge that a different type of approach is needed. Though a trend towards more flexibility is already evident in the evolution of the ATE RFPs, the ATE operators at the college level also need to make special and conscious efforts to achieve process-oriented changes when necessary.

For example, in some of the projects and centers, ATE staff sought to bring about deeper change within the host colleges, particularly through breaking down the divisions between academic and technical education. Gaining support from four-year colleges can help to create an environment more conducive to cooperation between academic and technical faculty in community colleges. The involvement of industry organizations is particularly important, since they tend to have a broad view of the needs of industry. However, the interest of industry organizations is difficult to sustain, and conflicts can arise between the broad educational goals of the ATE and the firm-specific interests of individual employers.

Therefore, the ATE grantees, and their partners in four-year colleges and industry, need to engage in a broad discussion about articulation and transfer to baccalaureate-granting institutions. The optimal

solution would be a two-year degree that would provide the immediate skills sought by employers and also serve as the first two years of a bachelor's degree. This model requires a willingness of educators to rethink the nature of prerequisites for upper-division courses and of employers to take a broad view of the types of skills that they are seeking. The ongoing discussion of the increasing educational requirements of modern innovative workplaces, sometimes referred to as high-performance work organizations, suggests that the tension between immediate work preparation and preparation for additional education should be diminishing.

Third, we believe that there is a need for several types of *new research explorations*. The division between technical and academic instruction in colleges is an important barrier to more thorough reform of technical education, and resistance from faculty, staff, and college constituencies persists. Similarly, improving articulation and transfer is made difficult by disagreements about the amount of academic or general education courses needed for terminal occupational degrees as opposed to transfer-oriented programs. A broad research agenda is needed to explore the best ways to combine academic and technical instruction, both to meet the needs of the job market and to prepare students for subsequent education. Such a research agenda should also be of interest to other programs within the NSF.

This study also clearly suggests the need for research that tracks the experience with ATE activities after the end of, or significant reduction in, NSF funding. Studying a sample of post-funded projects and centers could provide useful findings, such as identifying which activities, if any, continue; exploring the nature of the relationship between NSF-funded projects and centers and the colleges (institutionalization); and identifying what, if any, alternative funding sources were attained.

The NSF and ATE grantees need to continue to work towards a better understanding and measurement of the outcomes of the project. Our study has looked at outcomes—institutionalization and sustainability—that are intermediate in the sense that they are means to an end—more and better educated STEM technicians—rather than the end itself. While our analysis can tell us a great deal about the program process and the potential mechanisms through which it might work, more evidence of the eventual program effects is needed. We may find that different types of institutionalization lead to different types or levels of outcomes. Studying outcomes in a program as diverse and decentralized as ATE is extremely complex. The program's characteristics make a straightforward experimental design difficult, especially at this early stage of the program's development. Nevertheless, considerable progress can be made through a better and more comprehensive understanding of the changes that the ATE initiative has brought about in the country's system of STEM education. Most projects and centers have their own evaluators, and one step might be to work towards greater standardization of their efforts and more communication among them.

The National Science Foundation's Advanced Technological Education program has an impressive record of accomplishment, particularly in the influence that it has had on curriculum and professional development, and on bringing together community colleges, universities, high schools, businesses, commercial publishers, and other groups in a unique initiative to improve the education of STEM technicians. The ATE program now has a solid base on which to promote a stronger focus on broader organizational and cultural change. The NSF, in its management of this initiative, is already moving in that direction. We suggest that this shift can be further strengthened by a more explicit understanding of the barriers that the program is trying to overcome and by carefully tracking the experience with, and effects of, overcoming those barriers.

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