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FACILITATING AN UNDERSTANDING OF ADVANCED TECHNOLOGICAL EDUCATION TARGETED RESEARCH NEEDS

Liesel Ashley Ritchie, Ph.D.

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The National Science Foundation (NSF) Advanced Technological Education (ATE) program supports targeted research regarding "technician education, employment trends, the changing role of technicians in the workplace, and other topics that advance the knowledge base needed to make technician education programs more effective and more forward-looking" (NSF Solicitation 07-530 p. 10). In 2007 The Evaluation Center was funded to facilitate dialogue between researchers, two-year college educators, and other appropriate stakeholders by developing and conducting a workshop with the goal of defining research topics that would most benefit ATE project and center principal investigators (PIs) and their staff. The primary outcome for the Targeted Research Design Challenge Workshop was to be an increased understanding of ATE targeted research needs from a variety of stakeholder perspectives (e.g., researchers, ATE PIs, business/industry, and NSF personnel). That workshop was conducted in Baltimore, Maryland, on February 5-6, 2008.

This paper builds on the Baltimore workshop. Its purpose is to enhance understanding of research needs for the ATE program and issues surrounding technician education, especially in community colleges. The paper explores various perspectives of four primary groups of stakeholders with an interest in learning more about "what works and why" with respect to technician education.[1] These stakeholder groups are (1) NSF ATE program officers and the EHR directorate, (2) ATE projects and centers – as well as their faculty and administrators, (3) researchers in four-year colleges and other research settings, and (4) business and industry groups that employ the types of technicians produced in programs supported by the ATE program[2] (see Figure 1). Each group brings different, yet often related research questions to the table.

Although this paper is intended to be just one means to encourage and improve research efforts in the ATE program, we anticipate the paper's findings can be used by the respective stakeholder groups for several purposes, including these:

- Dissemination to the STEM community, especially those in two year colleges, to assist in their technician education planning
- Planning for research within current projects and centers
- Use in proposal planning by preparing proposals to NSF for conducting ATE project- and center-based research studies
- Revision of the annual program solicitation
- Use by NSF for panel reviews

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[1]Details about the methods used to convene and conduct this workshop during which these perspectives were obtained are presented later in this paper.

[2]Given the time line and initial scope of work, the workshop process relied on participants from ATE projects and centers to represent a broad business/industry perspective. Future efforts should attempt to include participants from business and industry.

Hopefully, this work also will lead to future collaboration on publications and presentations about this topic.

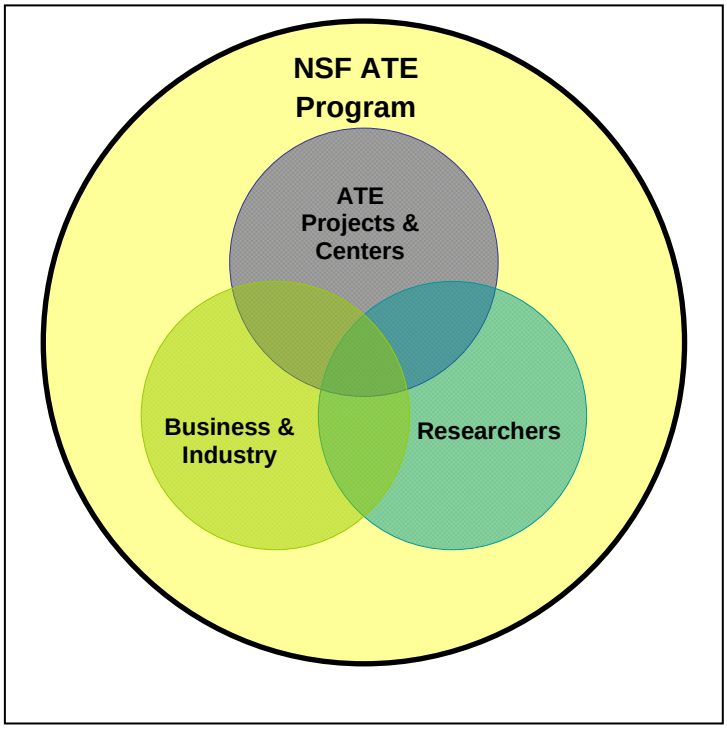

Figure 1. Toward an Integration of NSF ATE Stakeholder Research Interests

BACKGROUND

In 1992, the Scientific and Advanced Technology Act established a national program to improve the education of technicians in advanced technology fields by involving the nation's 2-year colleges. In response to this Congressional mandate, the National Science Foundation initiated the Advanced Technological Education program to educate professionals in science, technology, engineering, and mathematics (STEM) fields to serve emerging needs of business and industry. Since its inception in 1994, ATE funding approaches $300 million, awarding about $50 million in 2007-08. Currently, the ATE program supports approximately 33 centers and 200 projects that primarily focus on technician education to improve the number and quality of technicians to serve business and industry needs. The program invites its grantees to employ 4 primary methods to conduct this work: program improvement activities, professional development for educators, curriculum and educational materials development, and targeted research.

For several years the ATE program has solicited research grant proposals to understand why projects work, with whom, and under what circumstances. As announced in the 2007-2009 solicitation, the ATE program will support targeted research regarding "technician education, employment trends, the changing role of technicians in the workplace, and other topics that advance the knowledge base needed to make technician education programs more effective and more forward-looking" (NSF 07-530, p. 10). NSF is especially interested in learning more about the effectiveness of work currently being done by ATE projects and centers in community colleges. The research studies solicited by ATE are essential to continued improvement of the program and to accomplish the technician education objectives set forward for this program. ATE program officers note that research in technological education also should inform stakeholders about what elements of successful projects might be generalized to other contexts beyond ATE projects and centers.

In addition, given its substantial investment, NSF has a strong interest in investigating the effects of its programmatic attempts to increase and improve (a) the quality and diversity of students engaged in technician education in the United States, (b) the quality of these education programs, and (c) the collaborative partnerships between business/industry and education institutions charged with technician education. It desires to know the extent to which its funding efforts have been successful, which programmatic efforts have been most fruitful, and what programmatic changes are most likely to yield the greatest benefits.

To date, a limited number of targeted research proposals have been submitted; and fewer than five projects have been recommended for funding in this priority area. At the June 2007 ATE program evaluation advisory panel meeting, participants identified a need for NSF and other stakeholders to articulate specific lines of inquiry required in technician education more clearly. Doing so requires a more complete understanding of research needs in this arena. Following the advisory panel meeting we proposed and were funded to enhance the science education community's and ATE's understanding of research needs and encourage additional targeted research in the ATE program.

PERSPECTIVES ON CONDUCTING RESEARCH IN TECHNOLOGICAL EDUCATION

In this section, we first provide a summary of research questions and proposal topics gleaned from the Baltimore workshop across each of the four aforementioned stakeholder groups. We then explore the various perspectives of each stakeholder group in more depth, again primarily using information gathered and provided for during this workshop.

As presented in Table 1, questions and proposal topics are aligned across columns to represent the most apparent overlap in areas of research interest between (among??) stakeholders. Where questions are not aligned across columns, there are gaps or limited overlap in research interests; this is highlighted in bold. Red cells indicate the most obvious divergence in research interests across stakeholder groups. As discussed

in more detail later in this paper, the research interests of business and industry are most directly related to a limited number of research questions associated with the quantity and quality of available technicians. The greatest number and scope of questions, as well as the most detailed questions, were generated by the ATE PI stakeholder group. Questions raised by NSF in its formal solicitation of proposals tend to be broad and limited in number. The researcher interests and proposal topics listed in the far right column are presented in more detail later in this section (see D – Researchers).

Table 1. ATE Program Stakeholder Groups and Their Interests in Targeted Research

NSF Questions	ATE PI Questions	Business and Industry Questions	Researcher Interests and Proposal Topics
What are the future trends of the roles of technicians, and how can technician education stay abreast of rapid advances in the field?	What definition of a technician can industry and educators agree upon? How can those involved with the ATE program define and validate a common technical skill set in the workplace(s) served by ATE projects and centers? **What is the current/-desired ratio of technicians to entry-level workers and engineers by technological field?** **What will be the demand for technicians over the next five years?** **What are employer perceptions regarding the supply of qualified technicians? What roles do they expect community and technical colleges to play in satisfying this demand?** **How can the data required to address the aforementioned questions be collected easily to encourage employer participation and response?**	What definition of a technician can industry and educators agree upon? How can those involved with the ATE program define and validate a common technical skill set in the workplace(s) served by ATE projects and centers?	Project VIII (Anderegg & Badway): Building and Enhancing Capacity for Technician Education Research Across Community College ATE Leaders and Experienced Community College Researchers – *This project will engage ATE center PIs and university and community college researchers in prioritizing and strategically reflecting upon technician education research needs, challenges, and next steps.*

NSF Questions	ATE PI Questions	Business and Industry Questions	Researcher Interests and Proposal Topics
	How do technician educators know if they are producing the right quantity of highly skilled technicians for current needs? In the next five years? Are there ways to work within and across industry sectors to involve ATE projects and centers in the earliest stages of conversations associated with emerging technologies? What models exist for involving technician educators earlier in the planning for future and visioning process(es??)—working with industry to anticipate new trends that provide adequate lead time to create new programs, introduce new technology, and better prepare faculty in the new technologies before industry need is greatest?	Are there ways to work within and across industry sectors to involve ATE projects and centers in the earliest stages of conversations associated with emerging technologies? What models exist for involving technician educators earlier in the planning for future and visioning processes—working with industry on anticipating new trends that provide adequate lead time to create new programs, introduce new technology and better prepare faculty in the new technologies before industry need is greatest?	
Which components of technician education programs work (or don't work), with whom, why, and under what circumstances?	What definition of a technician can industry and educators agree upon? How can those involved with the ATE program define and validate a common technical skill set in the workplace(s) served by ATE projects and centers? **How do technician educators know if a program is providing a better worker?** **If the technicians provided by ATE program activities are noticeably better than those from other programs, or with other experiences, in what**	What definition of a technician can industry and educators agree on? How can those involved with the ATE program define and validate a common technical skill set in the workplace(s) served by ATE projects and centers?	Project I (Anderson & Welch): Strategies for Improving Recruit-ment, Retention, and Placement – *The principal focus of this project is twofold*: *the overall national technician workforce education system pipeline and the individual technology (ATE) projects*. Project II (Hull & Glover): Individual Differences in Technological Proficiency and Work Readiness – *The*

NSF Questions	ATE PI Questions	Business and Industry Questions	Researcher Interests and Proposal Topics
	way or ways are they different? To what extent are these differences attributable to the ATE technician education program? **How can we measure what our students know and can do in terms that are translatable to an industry perspective?** **In what ways can research expertise assist in identifying meaningful and appropriately normed benchmarks in these areas? From what particular cohort groups can these benchmarks be meaningfully derived?** **In what ways can research expertise assist in determining and evaluating success against meaningful quantitative benchmarks for improvement in areas like these? How can the impacts of projects and centers toward achieving these benchmarks be evaluated effectively?** **In what ways can research expertise assist in determining the short- and long-range qualitative impacts of projects and centers on student success factors (e.g., grades, job success, job growth, and similar measures)?** What are the effectiveness, value, and efficacy of ATE programs in increasing the	What are the effectiveness, value, and efficacy of ATE programs in increasing the numbers of technicians trained and available? What are the effectiveness, value,	*purpose of this pilot study is to discern variation in core psychological variables common to students as they enter two-year technical education programs.* Project IX (Magura): Research to Define and Measure Effectiveness of ATE Centers/Projects – *This research proposes to develop measurable criteria of effectiveness for ATE centers/projects across the range of ATE priority areas (i.e., materials development, professional development and program improvement).*

NSF Questions	ATE PI Questions	Business and Industry Questions	Researcher Interests and Proposal Topics
	numbers of technicians trained and available? What are the effectiveness, value, and efficacy of ATE programs in improving the quality of the technicians trained and available? **How effective are new, more systemic educational programs in improving the numbers, skills, and retention of technicians in the education pipeline?**	and efficacy of ATE programs in improving the quality of the technicians trained and available? **What are the effectiveness, value, and efficacy of ATE programs in improving business results?** **What are the effectiveness, value, and efficacy of ATE programs in improving business results?** **What are the effectiveness, value, and efficacy of ATE programs in improving communi-cations and collaborations across business and industry groups?** **What are the effectiveness, value, and efficacy of ATE programs in improving business capability to respond quickly and effective-ly to emerging workforce needs?** **To what extent do ATE programs focus**	

NSF Questions	ATE PI Questions	Business and Industry Questions	Researcher Interests and Proposal Topics
		attention on faculty development in areas of business and industry needs? With what levels of success?	
Which educational strategies have proven most effective in improving student learning in these specific high technology fields? Can these strategies be translated to [applied to?] other fields of technology?			
Across multiple technology fields, what impacts have strategies such as project-based learning, particular recruiting and retention strategies, and remote laboratories had on the effectiveness of technician education programs? What are the reasons for these impacts?	**What is the appropriate mix and subsequent effectiveness of online and classroom learning for technical coursework/programs?** **What models of blended instruction provide both cost-effectiveness and improved learning? What is the "right" blending proportion?** **Are simulations as effective as hands-on labs? To what degree are they better/worse than traditional "classroom-lab" combinations in improving learning? To what factors are those differences attributed?** **What are the most appropriate metrics to measure effectiveness, impact, return on investment, and project/program success factors in associated with new Web and**		Project VI (Horvitz & Zinser): Identifying the State of Online Instruction in ATE-Funded Technical Education Programs at Community Colleges – *This study is a first step toward providing key stakeholders with information to make decisions regarding the allocation of resources to instructional innovations that appear to hold out the promise of increasing student access, enrollments, and degree completion of these programs.* Project VII (Yarnall & Haertel): Developing Scales for Classifying Innovative ATE Instructional Materials – *This project focuses on developing and pilot testing rating tools to permit*

NSF Questions	ATE PI Questions	Business and Industry Questions	Researcher Interests and Proposal Topics
	telecommunications vehicles for career information and instructional content delivery? **What are the issues surrounding anonymity and privacy?**		*comparing and contrasting different innovative instructional materials: case-based, problem-based, and simulation-based tools.*
How can stakeholders in technician education (e.g., community colleges in collaborations with business and industry, government, economic development groups, four-year institutions, secondary schools, and professional societies) develop meaningful and mutually beneficial partnerships?	**What are characteristics of effective partnerships and collaborations?** **How are effective partnerships and collaborations developed?** **How are effective partnerships and collaborations sustained over time?** **What are the fundamental barriers and elements essential to genuine HS-CC-4-year college articulations? Is it possible to identify successful models or elements of successful models that can be replicated?** **What are the most effective models of ATE Center Advisory Boards? What roles do these groups play in the efforts of ATE projects and centers?** **Are there other models of advisory boards, groups, or panels beyond the ATE program—perhaps elsewhere in NSF—from which ATE projects and**		Project III (Rogers & Schall): Framing Research to Develop Successful Articulation Models Between Two- and Four-Year Technology Programs *– This proposal is for a planning grant to identify the areas of research required to develop models that can be replicated to promote the articulation of students from two-year to four-year technology programs.*

NSF Questions	ATE PI Questions	Business and Industry Questions	Researcher Interests and Proposal Topics
	centers might learn? Conversely, how might the work of ATE advisory boards inform the efforts of other such entities?		Project VIII (Anderegg & Badway): Building and Enhancing Capacity for Technician Education Research Across Community College ATE Leaders and Experienced Community College Researchers – *This project will engage ATE center PIs and university and community college researchers in prioritizing and strategically reflecting on technician education research needs, challenges, and next steps.* Project X (Welch & Anderson): Assessing and Improving the Sustainability of ATE-Supported Projects and Centers – *The overarching goal of this proposed research is assessing and improving long-term program impact.*
What model educational programs and industry partnerships prepare students for sustained success in a technician career (as opposed to training for a specific job)?	Industry continues to move toward multi-skilling and higher degree requirements in technical jobs (a four-year technician?)—what successful two-year or four-year program models exist within or outside the educational provider community to better address this need? To what degree are they effective?		

NSF Questions	ATE PI Questions	Business and Industry Questions	Researcher Interests and Proposal Topics
What are the characteristics of the employees who adapt most readily to an evolving techno-logical work environment? What educational strate-gies develop such characteristics?			Project II (Hull & Glover): Individual Differences in Techno-logical Proficiency and Work Readiness – *The purpose of this pilot study is to discern variation in core psychological variables common to students as they enter and exit two-year technical education programs.*
	What roles do projects and centers serve in the economic development arena, given their respective disciplines/fields? How can the effectiveness of these roles be evaluated? What types of workforce data are needed to evaluate the effectiveness and efficacy of ATE project and center activities? **Can ATE projects/centers provide evidence of leadership or influence in convincing potential employers to hire students from the programs they support? What evidence would be sufficient?** **What roles do ATE projects and centers play in increasing employment opportunities for technician level students? What evidence would be sufficient to evaluate the effectiveness and efficacy of these contributions?**	What roles do ATE projects and centers serve in the economic development arena, given their respective disciplines/fields? How can the effectiveness of these roles be evaluated? What types of workforce data are needed to evaluate the effectiveness and efficacy of ATE project and center activities?	Project IX (Magura): Research to Define and Measure Effectiveness of ATE Centers/Projects – *This research proposes to develop measurable criteria of effectiveness for ATE centers/projects across the range of ATE priority areas (i.e., materials development, pro-fessional development and program improvement).* Project X (Welch & Anderson): Assessing and Improving the Sustainability of ATE-Supported Projects and Centers – *The overarching goal of this proposed research is assessing and improving long-term program impact.*

NSF Questions	ATE PI Questions	Business and Industry Questions	Researcher Interests and Proposal Topics
	How can the data required to address the aforementioned questions be collected easily to encourage employer participation and response?	How can the data required to address the aforementioned questions be collected easily to encourage employer participation and response?	
	What are the effectiveness, value, and efficacy of ATE programs in changing negative perceptions of technology programs? **What are the impacts of the ATE program (projects and center activities) on other influential groups—i.e., counselors, parents, other faculty, and peers?**		Project V (Henderson & Fynewever): Identifying the Impacts of ATE Centers on Their Home Institutions: An Exploratory Study – *This project will identify the undocumented and, perhaps, unanticipated impacts (both positive and negative) of mature national ATE Centers on their home institutions.*
	What are the models of effective mergers of occupational and academic programs that offer new approaches to technician education (high school, community college, and four-year) and alternatives to the constant tensions between these types of programs? What are essential elements contributing to the success of these mergers? **What research has been done to assess the importance of general education/liberal education to the success and effectiveness of graduates in the workplace? If so, how might this research be replicated for**		

NSF Questions	ATE PI Questions	Business and Industry Questions	Researcher Interests and Proposal Topics
	more technologically oriented education? State Career Technology Education (CTE) offices are emphasizing the need for "greater academic rigor" in CTE programs. To what extent has there been a similar thrust at two- and/or four-year institutions? What were the origins of this emphasis? What is the anticipated impact of this new/renewed emphasis? What research has been done on comparing the effectiveness of the integration of general education/liberal education disciplines with technical courses in terms of course integration versus program integration? Many universities are beginning to offer four-year technology programs. Typically, the technical core in two- and four-year programs is the same or very similar. What research has been done to compare the success and effectiveness of these graduates in the workplace? Industry continues to move toward multi-skilling and higher degree requirements in technical jobs (a four-year technician?)—what successful two-year or four-year program models		

NSF Questions	ATE PI Questions	Business and Industry Questions	Researcher Interests and Proposal Topics
	exist within or outside the educational provider community to better address this need? To what degree are they effective?		

In the following sections we address technological education research from the standpoint of NSF followed by research questions posed by representatives from ATE projects and centers. We then review ATE-related research questions that are of interest to business and industry, as described by ATE project and center representatives. Finally, we describe efforts to engage experienced researchers in conducting research in technology education, examining research questions of interest to individuals in four-year colleges and other research entities interested in partnering with two-year colleges. In this section we summarize ten research topics recently recommended for funding under the auspices of a single "umbrella" proposal intended to enhance targeted research in the ATE program. At the conclusion, we describe ways in which the research foci of these different stakeholders are similar, as well as divergent, and provide recommendations for meeting needs identified by the various stakeholders.

A. *NSF ATE program.* NSF has made a substantial investment in technological education since the mid-1990s. The creation of the targeted research track reflects a desire to know much more about the results of this investment—the products and productivity of projects and centers, the issues they face, and proven strategies for accomplishing program objectives. These interests extend well beyond the numbers of students involved in the program or the types and numbers of materials developed, for example. As the program has grown, so has its need for different forms of data on program impacts.

It is apparent that NSF personnel have given considerable thought to the types of research they are seeking to fund and have made considerable investments of time and other resources to advance this goal. The most recent ATE solicitation (NSF Solicitation 07-530) offers a number of suggestions for research questions of interest to the program:

- What are the future trends of the roles of technicians, and how can technician education stay abreast of rapid advances in the field?
- Which components of technician education programs work (or don't work), with whom, why, and under what circumstances?

- Which education strategies have proven most effective in improving student learning in these specific high technology fields? Can these strategies be translated to [applied to] other fields of technology?
- Across multiple technology fields, what impacts have strategies such as project-based learning, particular recruiting and retention strategies, and remote laboratories had on the effectiveness of technician education programs? What are the reasons for these impacts?
- How can stakeholders in technician education (e.g., community colleges in collaborations with business and industry, government, economic development groups, four-year institutions, secondary schools, and professional societies) develop meaningful and mutually beneficial partnerships?
- What model education programs and industry partnerships prepare students for sustained success in a technician career (as opposed to training for a specific job)?
- What are the characteristics of the employees who adapt most readily to an evolving technological work environment? What education strategies develop such characteristics?

Dr. Salinger posited additional questions and potential research topics for investigation from his own reading and reflections on these matters (personal communication, December 16, 2007). His suggestions were diverse, as he noted the possibility of exploring issues associated with increasing understanding of

- Ways in which ATE projects and centers develop successful relationships with employers or college administrators to develop and sustain technical programs
- How ATE projects and centers interact with incumbent workers and displaced or retiring workers
- The case for (or against) hands-on courses in various technician disciplines across the ATE portfolio of projects
- The role of online courses and learning in technical education, including perspectives of business and industry on this topic
- Successful practices in marketing technical careers to students among ATE projects and centers
- Successful practices in attracting more women into emerging technology fields among ATE projects and centers
- Practices being developed or used by ATE projects and centers explicitly to help students with either physical or learning disabilities become successful technicians

- Mentoring processes between ATE centers and projects that lead to the establishment of new viable sustainable programs at community colleges

B. ATE projects and centers. The contexts in which ATE projects and centers operate likely influence their perspectives on research and their capabilities to conduct research. We sought input on these contexts and their perspectives about research from two experienced center directors (Faber & Zdravkovich, 2008).

Input from Faber and Zdravkovich suggests that ATE PIs tend not to distinguish between evaluation and research and use these terms interchangeably. Because research and evaluation serve different purposes but use common tools (e.g., surveys and interviews), this slippage in language can lead to misunderstandings and even inappropriate actions. For example, in discussing the viability of research, Faber and Zdravkovich report that project and center PIs are concerned that "increasing evaluation costs decrease dollars allocated to other objectives perceived as equally or more important." Here their concerns do not seem be stated in terms of evaluation squeezing out money for research, but rather that research as a form of evaluation (or vice versa) is already intruding on more important project work. If research efforts are viewed as a type of evaluation and evaluation costs are viewed as detracting from the work of the project, then certainly PIs will be unlikely to either propose their own research efforts or agree to engage with others who solicit their involvement.

A second stated concern regards project longevity versus the interests of research. Projects and centers are funded for relatively short periods of time (e.g., three or four years) and consistently have a substantial list of intended outcomes to achieve in that time period. Their ambitious agendas and short durations make it difficult to focus on general issues that extend beyond the life of an individual project. For example, longitudinal studies beyond the life of project or center funding are generally not feasible.

Third, PIs articulate what they consider to be serious "constraints" associated with conducting research in the ATE context. Among these are "multiple partners; regional focus of centers versus [the] tighter focus of projects; differences in data collection systems and outputs; … and [the importance of] credit and continuing education delivery ; ; ; to [their] customers [and] differences in these components and data collection systems." Additional issues include PI concerns that the "time, resources, and expertise incurred in seeking some of these answers [i.e., conducting research] by [projects and centers] . . . are limited and insufficient." PIs also note that "long-term follow-up is difficult due to the intermittent nature of community college student enrollment and employment patterns."

Fourth is the challenge that education and workforce development organizations typically do not use the same metrics to measure success, impact, or the efficacy of particular programs/approaches—data collection systems, lack of agreement on common research issues, and staffing often work counterproductively. Additionally, the

ultimate customer—the employer—often has a much different, more practical set of metrics to evaluate the value-added component of education and workforce development programs.

Fifth, "the range of topics for possible research efforts is very broad and often over-imposing" for projects and centers. This daunting notion of research may be the most immediate challenge.

With the aforementioned issues in mind, ATE project and center representatives describe two overarching forms of research needs: workforce/workforce development and topics related more specifically to the education arena. These issues are intertwined, rather than necessarily distinct elements. Notably, the research questions posed by this stakeholder group are similar to those presented by NSF. A primary difference is the specificity suggested by the PIs and what might be referred to as the contextualizing comments accompanying their need for information. In the following sections we address ten areas of research interests identified by a convenience sample of ATE PIs. These include (1) meaningful employment outlook information, (2) outputs evaluation, (3) benchmarks, (4) economic and workforce development systems, (5) institutional impacts, (6) perceptions of technical education, (7) effective articulation agreements, (8) pipeline improvements, (9) effective partnerships and collaborations, and (10) models of ATE center advisory boards.[3]

1. Meaningful employment outlook information. As various industries and employment sectors adapt to their competitive challenges, the question of what defines the nature of the 'technician' ATE projects and centers are preparing may need to be revisited in order to reach some meaningful consensus on the expectations for both the quality and quantity of the technician product. Various reports, skill standards, certification examinations, and similar information inform the work of the projects/centers. However, regional or local needs and realities often differ from these national perspectives. Employer faith in the validity and value of these products is questionable. These issues give rise to questions such as the following:

- What definition of a technician can industry and educators agree upon? How can those involved with the ATE program define and validate a common technical skill set in the workplace(s) served by ATE projects and centers?
- What is the current/desired ratio of technicians to entry-level workers and engineers by technological field?
- What will be the demand for technicians over the next five years?

[3]Specifically, activities such as curriculum development, faculty development, creation of partnerships, development of articulation agreements, and enhancing the educational pipeline are deemed essential to the success of ATE centers.

- What are employer perceptions regarding the supply of qualified technicians? What roles do they expect community and technical colleges to play in satisfying this demand?
- How can the data required to address the aforementioned questions be collected easily to encourage employer participation and response?

2. Outputs evaluation. The term "outputs," as used by the ATE PI stakeholder group, refers both to quantity and quality of technicians developed and produced by their program activities. Although current evaluation efforts provide data about effective placements and in limited instances information about the satisfaction of employers with graduates, there is no information identifying specific program elements that result in success in the workplace. Questions associated with this type of evaluation include these:

- How do technician educators know if they are producing the right quantity of highly skilled technicians for current needs? In the next five years?
- How do technician educators know if a program is providing a better worker? (Privacy issues make it very difficult for a company to provide employee-specific information. Are there methods to address these sometime conflicting needs?)
- If the technicians provided by ATE program activities are noticeably better than those from other programs or with other experiences, in what way or ways are they different? To what extent are these differences attributable to the ATE technician education program?
- How can we measure what our students know and can do in terms that are translatable to an industry perspective?

3. Benchmarks. ATE projects and centers often are asked to establish quantitative and qualitative goals against which their success and efficacy can be measured (e.g., diversity, gender, credit/continuing education balance, enrollment and completion percentages). Questions/claims arise with respect to the extent to which the measures associated with these goals are meaningful, as well as accurate.

- In what ways can research expertise assist in identifying meaningful and appropriately normed benchmarks in these areas? From what particular cohort groups can these benchmarks be meaningfully derived?
- In what ways can research expertise assist in determining and evaluating success against meaningful quantitative benchmarks for improvement in areas such as diversity, gender, credit/continuing education balance, enrollment and completion percentages? How can the impacts of projects and centers toward achieving these benchmarks be evaluated effectively?
- In what ways can research expertise assist in determining the short- and long-range qualitative impacts of projects and centers on student success factors (e.g., grades, job success, job growth, and similar measures)?

4. Economic and workforce development systems. Economic development officials frequently cite the increasing importance and advantages of an adequately trained workforce in their efforts to attract and retain businesses in their states or regions. ATE projects and centers tend to refer to their value in this process in attracting new business/industry/-government facilities, in retraining incumbent workers, and in developing new programs of study to respond to these needs. Questions pertinent to these issues include those listed below:

- What roles do projects and centers serve in the economic development arena, given their respective disciplines/fields? How can the effectiveness of these roles be evaluated? What types of workforce data are needed to evaluate the effectiveness and efficacy of ATE project and center activities?
- Can ATE projects/centers provide evidence of leadership or influence in convincing potential employers to hire students from the programs they support? What evidence would be sufficient?
- What roles do ATE projects and centers play in increasing employment opportunities for technician level students? What evidence would be sufficient to evaluate the effectiveness and efficacy of these contributions?

Often, new directions and new technologies are very proprietary; this represents a challenge for anticipating emerging needs for technical education as indicated by these questions:

- Are there ways to work within and across industry sectors to involve ATE projects and centers in the earliest stages of conversations associated with emerging technologies?
- What models exist for involving technician educators earlier in the planning for the future and visioning process—working with industry on anticipating new trends that provide adequate lead time to create new programs, introduce new technology and better prepare faculty in the new technologies before industry need is greatest?

5. Institutional impacts. Questions about the impacts of ATE program activities on community college campuses where they reside seem to have increased in recent years. ATE PIs—particularly center directors—are interested in having a better understanding of these impacts and how their efforts may have influenced their institutions and other departments with which they interact.

- What are the “internal” impacts of ATE projects and centers on their institutions (community colleges where they are based)?

6. Perceptions of technical education. Most ATE centers are focused on highly technical programs with different levels of academic sophistication. Moreover, these programs

are frequently isolated from the general education/liberal education programs and faculty on campuses—in spite of the fact that each program contains a general education core. Similarly, ATE projects with their foci on technical education operate in environments where perceptions linger that the rigor associated with this type of training or education is not as great as in academic tracks. In this context, a number of challenges are associated with implementing ATE programs; these are evident in the following questions posed by ATE PIs:

- What are the models of effective mergers of occupational and academic programs that offer new approaches to technician education (high school, community college, and four-year) and alternatives to the constant tensions between these types of programs? What are essential elements contributing to the success of these mergers?
- What research has been done to assess the importance of general education/liberal education to the success and effectiveness of graduates in the workplace? How might this research be replicated for more technologically oriented education?
- State Career Technology Education (CTE) offices are emphasizing the need for "greater academic rigor" in CTE programs. To what extent has there been a similar thrust at two- and/or four-year institutions? What were the origins of this emphasis? What is the anticipated impact of this new/renewed emphasis?
- What research has been done on comparing the effectiveness of the integration of general education/liberal education disciplines with technical courses in terms of course integration versus program integration?
- Many universities are beginning to offer four-year technology programs. Typically, the technical core in two- and four-year programs is the same or very similar. What research compares success and effectiveness of their graduates in the workplace?
- Industry continues to move toward multi-skilling and higher degree requirements in technical jobs (a four-year technician?)—what successful two-year or four-year program models exist within or outside the education provider community to better address this need? To what degree are they effective?

7. Effective articulation agreements. Development of articulation agreements has long been a focus of the ATE program. Efforts to do so include arrangements between high schools as well as with two- and four-year institutions. This is now an integral part of the work of projects and centers; indeed, as reported on the 2008 survey of ATE program grant recipients, 49 percent indicated involvement in establishing articulation agreements (Gullickson & Wingate 2008). However, articulation among high schools, community colleges, and four-year colleges/universities continues to be problematic in some technical program areas and in some regions. ATE PIs indicate an interest in answers to the following research questions:

- What are the fundamental barriers and elements essential to genuine HS-CC-4-year college articulations? What are the successful models or elements of successful models that can be replicated?

8. Pipeline improvements. A variety of project/center objectives and activities involve increasing the number of students interested in technical careers and the quality of preparation of those students (e.g., secondary and postsecondary robotics competitions, summer camps for targeted populations, partnership programs with community education groups, career awareness activities, Web-based and telecommunication delivery tools, new education programs, summer internships). Among questions related to pipeline improvements that are of interest to ATE projects and centers are those about recruitment:

- What are the effectiveness, value, and efficacy of ATE programs in increasing the numbers and skills of technicians?
- What are the effectiveness, value, and efficacy of ATE programs in changing negative perceptions of technology programs?
- What are the impacts of the ATE program (projects and center activities) on other influential groups—i.e., counselors, parents, other faculty, and peers?
- What are the most appropriate metrics to measure effectiveness, impact, return on investment, and project/program success factors associated with new Web and telecommunications vehicles for career information and instructional content delivery? What are the issues surrounding anonymity and privacy?

Additional questions are associated with retention:

- What is the appropriate mix and subsequent effectiveness of online and classroom learning for technical coursework/programs? What models of blended instruction provide both cost-effectiveness and improved learning? What is the “right” blending proportion?
- Are simulations as effective as hands-on labs? To what degree are they better/worse than traditional "classroom-lab" combinations in improving learning? To what factors are those differences attributed?
- How effective are new, more systemic education programs in improving the numbers, skills, and retention of technicians in the educational pipeline?

9. Effective models of ATE center advisory boards. The role of ATE center advisory boards is very important, yet there is limited information regarding effective models and different roles of these groups. Following are the primary research questions:

- What are the most effective models of ATE center advisory boards? What roles do these groups play in the efforts of ATE projects and centers?

- Are there other models of advisory boards, groups, or panels beyond the ATE program—perhaps elsewhere in NSF—from which ATE projects and centers might learn? Conversely, how might the work of ATE advisory boards inform the efforts of other such entities?

10. Effective partnerships and collaborations. The primary mission of ATE centers is strengthening the quality and quantity of the workforce in a particular disciplinary area in the assigned geographic region. The importance of the ATE centers to regional economic development officials often is seen as increased potential to attract and retain new businesses in their states or regions. As previously noted, projects and centers often cite their roles in this process with respect to retraining incumbent workers and developing new programs of study to respond to these needs. Yet, there are limited data and empirical research to inform center directors in efforts to pursue the most effective approaches to developing effective partnerships and collaborations. These research questions are related to these issues:

- What are characteristics of effective partnerships and collaborations?
- How are effective partnerships and collaborations developed?
- How are effective partnerships and collaborations sustained over time?

C. Business and industry. The "ultimate customers" of the ATE program are business and industry—the employers and future employers of technicians throughout the United States. As previously stated, NSF designed the program to (1) produce higher quality technicians and (2) improve the technical skills and employability of general science, technology, engineering, and mathematics (STEM) technicians. The ATE program also is intended to improve the quality of the educators who prepare them, as well as enhance the skills of the incumbent workforce. Given this, it is helpful to integrate the perspectives of business and industry in the potential research questions regarding workforce development.

Our focus here is technician education in the context of the ATE program, impacts of the program on business and industry, and possible research interests from business and industry that may be associated with the program. The nature and timing of the current project did not afford primary data collection activities involving these parties; however, we do have two readily available sources of information that lend to the discussion at hand.

The first source of information on business and industry research needs we cite here is a 2006 report prepared for NSF by Gullickson et al. that assesses the value added by the ATE program to business and industry.[4] Conducted as part of efforts to evaluate the overall ATE program, the Gullickson et al. (2006) targeted study was intended to

[4]Funds for this research were provided under NSF REC #0315385. The report is available at www.wmich.edu/evalctr/ate.

> . . . assess both the impact and effectiveness of the program . . . . [The evaluation was] designed to address the accountability of the ATE program in terms of its impact on the business and industry workforce. Specifically, this 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 (p. iii).

The findings of this report are briefly summarized below, with a focus on their relevance to possible ATE targeted research topics.

As defined by evaluators during the course of the project, the term "value added" included the following general benefits to business and industry: (1) the numbers of technicians trained and available, (2) the quality of the technicians trained, (3) improved business results, and (4) reduced costs for businesses (Gullickson et al., 2006, p. iii). Based on site visits to 24 businesses in 9 locations (5 locations were affiliated with the ATE program and 4 were not), overall findings indicated that "the ATE program adds value to collaborating businesses and industries" (Gullickson et al., 2006, p. iv) in each of the four aforementioned ways. Although results of the study reveal that "the extent to which the colleges serve industry is heavily dependent on local context and collaborative arrangements" (Gullickson et al., 2006, p. v), findings suggest that collaborations between business and industry that are initiated by industry tend to add more value and are generally more beneficial than those instigated by community colleges.

The second source of information regarding business and industry research needs is the ATE project and center PIs whose research interests tend to reflect not only their needs, but also those of business and industry. These perspectives were presented in Section B under the topics "meaningful employment outlook information," "economic and workforce development systems," and "pipeline improvements." Perhaps these are the most basic research questions shared by ATE PI stakeholders and business and industry representatives:

- What definition of "technician" can industry and educators agree upon? How can those involved with the ATE program define and validate a common technical skill set in the workplace(s) served by ATE projects and centers?
- What are the effectiveness, value, and efficacy of ATE programs in increasing the numbers and skills of technicians?
- What roles do ATE projects and centers serve in the economic development arena, given their respective disciplines/fields? How can the effectiveness of these roles be evaluated?
- What types of workforce data are needed to evaluate the effectiveness and efficacy of ATE project and center activities?

- How can the data required to address the aforementioned questions be collected easily to encourage employer participation and response?
- Are there ways to work within and across industry sectors to involve ATE projects and centers in the earliest stages of conversations associated with emerging technologies?
- What models exist for involving technician educators earlier in the planning for future and visioning process—working with industry on anticipating new trends that provide adequate lead time to create new programs, introduce new technology and better prepare faculty in the new technologies before industry need is greatest?

As previously discussed, the metrics used by business and industry are not necessarily comparable to those employed in the education arena. Moreover, "Employer faith in the validity and value of" nationally based skill standards, certification examinations, and similar types of information is "questionable" in the context of local and regional needs **(**Faber & Zdravkovich, 2008**)**. Clearly, for business and industry, key research questions are those that address the quantity and quality of the available technician workforce and the resultant impacts on their productivity and financial bottom line. In this light, business and industry have a vested interest in more fully understanding the extent to which the ATE program and its projects and centers are effective in (1) increasing the numbers of technicians trained and available, (2) improving the quality of the technicians trained, (3) improving business results, and (4) reducing costs for businesses. Embedded in these general areas of research interest for business and industry are questions associated with how involvement in the ATE program affects the following: (1) communications and collaborations across business and industry groups, (2) capability to respond quickly and effectively [to emerging workforce needs], (3) quality of education, (4) numbers reached through the program, (5) attention to faculty development in areas of business and industry needs, and (6) matters of financial needs and impetus (Gullickson et al., 2006, p. iv).

D. Researchers. In September 2007, NSF funded The Evaluation Center at Western Michigan University (DUE-0702981) to engage a group of researchers affiliated with universities and research/evaluation organizations to conduct research and evaluation studies of the efficacy of the ATE program. The primary components of the project involved (1) identifying individuals, groups, and institutions that have capability and interest in technician education research; (2) facilitating awareness of ATE program activities by informing researchers about the program, its funded projects and centers, and expectations of those conducting research about the program; (3) initiating communication between researchers and ATE PIs; and (4) conducting a targeted research design challenge workshop for researchers to facilitate development of preliminary proposals and explore possibilities for additional collaborations. The ultimate objectives of the project are to define research topics that most likely would benefit ATE program stakeholders, stimulate the development of fundable research proposals, and develop a network of researchers who are knowledgeable about

technician education and interested and willing to work collaboratively with funded ATE projects and centers to address publishable research questions of interest to the technician education community. These goals are intended to provide high quality research support of continued improvement in technician education.

To address the aforementioned goals and objectives, the WMU team worked collaboratively with NSF ATE personnel, PIs, and representatives from other NSF divisions to develop a list of well-qualified individuals with experience researching issues associated with technician education. From an original pool of 50, 35 people were contacted and invited to attend the annual ATE PI Meeting (October 17-19, 2007) so that they could be exposed to the ATE program in a dynamic, interactive setting. An additional 5 researchers learned about the project and independently contacted us regarding participation. The project provided travel expenses for 11 researchers, most of whom were not previously familiar with the ATE program. Other researchers and stakeholders attended at their own expense or had already planned to attend the conference.

Prior to the meeting, participants were directed to information about ATE project and center activities, previous research and evaluation findings, and were provided a series of thought-provoking questions for consideration including those posed in the NSF solicitation. Researchers were assigned the task of developing some initial thoughts on possible targeted research topics to discuss with other conference attendees. WMU personnel developed an agenda designed to facilitate introductions between researchers and ATE PIs, project staff, and other meeting attendees. We also provided suggestions for attendance regarding general conference sessions and panel discussions that might be particularly pertinent to researchers (e.g., the opening plenary session of the conference, the showcase and welcome reception where they were able to learn more about ATE center activities and had an opportunity to network, a discussion session entitled Targeted Research for Technicians).

On the last day of the meeting, WMU personnel facilitated a debriefing session to systematically collect and document the ideas and impressions of researchers regarding possible areas for more detailed investigation at the subsequent targeted research design challenge workshop. This session was attended by NSF personnel and other interested parties not part of the original set of invitees. At the conclusion of this session, 27 individuals expressed interest in participating in the workshop to further pursue research in technological education. Subsequently, an additional 8 researchers contacted us and expressed interest, which resulted in a total of 35.

The initial goals of the workshop were to produce a list of recommendations regarding critical research topics that would offer a set of priorities for consideration by NSF and researchers submitting targeted research proposals to the ATE program. Following the October PI meeting and subsequent dialogue with NSF personnel, these goals evolved somewhat to include working sessions to advance proposal development and discussions regarding the most appropriate and timely ways to submit proposals. In

early November 2007, we sent a follow-up e-mail message to individuals who had expressed interest in participating in the design challenge workshop. The message also requested that researchers submit one- to two-page research abstracts by December 10, 2007. These abstracts provided information regarding topics researchers believed should be addressed, who might be involved in the research (individuals/their organizations), and offered initial designs for proposed research and evaluation studies that they considered to be responsive to the ATE program's call. This call for submissions to be sent to WMU personnel yielded 13 abstracts from 9 teams of researchers based in academic and research institutions across the country.

Individuals familiar with the ATE program, as well as NSF program officers, reviewed the proposals and provided written feedback to WMU, which subsequently was shared with researchers. Notably, there were some differences in comments among reviewers—primarily between individuals not affiliated with NSF and NSF program officers. These discrepancies primarily emerged with respect to issues of utility or applicability of research results in community college settings. In sum, initial drafts of research ideas fell short of serving NSF and community college priorities. In an effort to address these concerns, we invited three ATE center directors to attend the targeted research design challenge workshop and speak about the research needs of community colleges and address issues raised by NSF program officers.[5]

In February 2008, 28 individuals—including 17 researchers who had submitted proposal ideas—attended the workshop in Baltimore, Maryland. The agenda was designed collaboratively to provide a framework for interaction among researchers, ATE PIs, and NSF personnel to explore topics of mutual interest and benefit to technician education. Agenda items included elements suggested by researchers based on feedback following the October meeting as well as recommendations from ATE program officers and members of the ATE program evaluation advisory committee.

One of the most immediate and tangible outcomes of the workshop was the development of an "umbrella" proposal to NSF, submitted for review in mid-April 2008 and recommended for funding in July 2008. This proposal is a major commitment on the part of NSF to "jump start" interest and involvement in ATE-based research. The proposed work represents the efforts of more than 20 researchers from 8 institutions, with the University of Colorado's Institute of Behavioral Science (IBS) providing coordination and oversight for implementing the research. This collaborative endeavor involves conducting 10 diverse yet interrelated studies ranging from 1 to 2 years in length. The proposal encompasses 3 broad categories that are central to the ATE program's mission: (1) research on program improvement activities, (2) research on curriculum and materials development activities, and (3) research on crosscutting

[5]Two of these individuals, Dennis Faber and Vera Zdravkovich, were able to participate, and the panel was facilitated by Dr. Nick Smith.

issues in technological education. Collectively, these research efforts represent various technical features, including scale or instrument (survey) development and piloting, model development and definition, and workshop and support materials development.

Considerable variation in topics and approaches was presented by the research teams. This is consistent with the broad reach of the ATE program, which supports materials development, professional development, and program improvement. The emphases of ATE projects and centers further reveal the breadth of the program's disciplinary support, ranging from information and biorelated technologies to manufacturing and engineering technology. Additional foci include electronics and photonics, advanced materials (polymers, nanotechnology, microsystems), chemical technology, energy technology, and environmental technology, to name a few (Ritchie, Gullickson, & Wygant, 2007). Clearly, activities funded by the ATE program offer myriad opportunities to examine various aspects of technological education. Most of the proposed research—six of the nine funded proposals[6]—examines issues associated with two well-defined ATE activity categories: *program improvement* and *curriculum and educational materials development*. Employing these familiar terms frames the research in the context of NSF/ATE priorities. To incorporate the remaining proposals that did not fit so easily into these established activities, a third category defined as *crosscutting research* addresses questions that are explicit and implicit in the ATE program's central goals. The following sections provide an overview of each of the three categories—research on program improvement activities, research on curriculum and materials development activities, and research on crosscutting issues in technological education—and briefly summarize the questions that will be addressed by the proposed umbrella project.

1. *Research on program improvement activities.* The annual ATE program evaluation survey defines a program as a sequence of classes, laboratories, and/or work-based experiences that lead students to a degree, certification, or an occupational competency point. Program improvement is intended to "increase the relevance of technician education to modern practices and assure an increased number of students entering the high performance workplace with enhanced competencies" (NSF 07-530, 2007, p. 6). ATE program improvement requirements include expectations that efforts will produce enhanced curricula; involve employers; produce an improved program that leads students to an appropriate degree, certification, or occupational competency; increase the pool of skilled technicians; and induce an increased proportion of students who enroll to complete programs.

Three research teams will examine the following aspects of ATE program improvement processes: student recruitment, retention, and placement; factors influencing technological proficiency and work readiness; and models of articulation agreements

[6]Originally, ten studies were proposed in the umbrella proposal, one of which was not recommended for funding and is not included in this paper.

between two- and four-year institutions. The intent of these studies is to provide findings to inform ATE program improvement efforts; however, results also have implications for the broader technological education community. The focus of each project is outlined below.

Project I: Strategies for Improving Recruitment, Retention, and Placement – Despite growing market demand for technicians and other technically trained workers with associate degrees, insufficient numbers of students are being recruited into technology programs. Gershwin (2005) noted that by 2020 there will be a shortage of 14 million postsecondary workers; a very large share of these can be educated at community colleges. The Department of Labor (2007)[7] described the STEM pipeline, especially in community education, as very inadequate. ***The principal focus of this project is twofold*: *the overall national technician workforce education system pipeline and the individual technology (ATE) projects***. STEM or technology education pipelines in community colleges essentially consist of the following elements: recruitment, retention, articulation, placement, and retraining—each of which is considered in this study. In addition, this team will analyze diversity, because research has found that unique intervention programs may be needed for underrepresented groups. Whenever possible, age groups and disability groups also will be distinguished statistically to capture trends in retraining and reentry into the labor force. ATE projects and technology programs can be made more effective with tools for monitoring the recruitment, retention, and placement of their students. The proposed project will compile relevant knowledge and identify tools that ultimately will yield improved effectiveness.

Project II: Individual Differences in Technological Proficiency and Work Readiness – Technicians and the education programs that prepare them play a vital and central role in the American workforce. However, little empirical information is available about abilities possessed by the individuals who enroll in technological education programs and the effects programs have on preparing them for work. ***The purpose of this pilot study is to discern variation in core psychological variables common to students as they enter two-year technical education programs.*** The project also will reassess the same students on exit (or after 18 months) to examine changes in ability over time. This information will assist ATE in understanding how to improve recruitment, retention, curriculum development, and so on and assist students and career counselors in making more informed choices regarding careers in which students might ultimately find the most satisfaction and success.

[7] This report was prepared for the U.S. Department of Labor, Employment and Training Administration by Jobs for the Future (2007, April). *The STEM Workforce Challenge: The Role of the Public Workforce System in a National Solution for a Competitive Science, Technology, Engineering, and Mathematics (STEM) Workforce.*

Project III: Framing Research to Develop Successful Articulation Models Between Two- and Four- Year Technology Programs – Although several studies have been done recently on articulation between two-year and four-year institutions, they have not focused on technology programs. It is unclear whether the findings are valid for such programs or if additional factors promote or inhibit successful articulation. ***This proposal is for a planning grant to identify the areas of research required to develop models that can be replicated to promote the articulation of students from two-year to four-year technology programs.*** It is anticipated that the models developed will be applicable to diverse academic environments and identify support needed from industry, government, and accrediting bodies to improve articulation in technical education.

2. Research on curriculum and materials development activities. Materials developed by ATE-funded projects and centers should "affect the learning environment, course content, and experience of instruction for students preparing to be science and engineering technicians

and for their teachers" (NSF 07-530, 2007, p. 7) Modes of distributing ATE materials include print, audio/video, CD-ROMs, online/Web-based training, and mixed media used to convey the content and instruction of activities, modules, and courses. Summaries of the two funded studies in the umbrella proposal that focus on activities related to materials development are presented below.

Project VI: Identifying the State of Online Instruction in ATE-Funded Technical Education Programs at Community Colleges – Community colleges have the highest growth rate in online course offerings among postsecondary institutions over the past five years, yet little data are available on how online technologies are used in these institutions' technical education programs, how much is spent on them, and what kinds of impacts these technologies are having on preparing students for careers in technical fields. Given the significant costs associated with developing and delivering online instruction, decision makers in two-year institutions and funders of such education programs (e.g., NSF) should be interested in such data. This research involves an online survey research project that will begin to systematically address these questions. ***This study is a necessary first step toward providing key stakeholders with information to make decisions regarding the allocation of resources to instructional innovations that appear to hold out the promise of increasing student access, enrollments, and degree completion of these programs.*** External stakeholders—technical employers and four-year universities—also need valid data on the effectiveness of online instruction. These possible benefits need to be weighed carefully against the realities of the pedagogical efficacy of online instruction for technical learning domains and the associated costs of these instructional approaches.

Project VII: Developing Scales for Classifying Innovative ATE Instructional Materials – Since its inception, the ATE program has supported the development of innovative

instructional materials for technician education in many different fields. NSF seeks to understand when and why these instructional materials succeed and fail in community colleges and how to generalize this knowledge to support broader use and dissemination. ATE project and center directors want to know when to use such materials and how to support instructors using them. Learning science researchers have described why and under what circumstances specific innovative and technology-infused instructional materials support student learning in specific domains (Blumenfeld et al., 2000; Savery & Duffy, 2001; Jonassen, 1999; Bransford & Schwartz, 1999; Schwartz et al., 1999). Typically, these analyses describe core features of innovative instructional materials: their specific learning tasks and goals, measurement approaches, and contextual factors that support implementation.

Based on this theory and research, this project proposes to develop a set of scales for use by multiple stakeholders, designed to support focused analysis on a single instructional program and comparison or differentiation among multiple types of instructional materials. These types of instructional materials were selected as a starting point because they collectively represent ATE's long-standing effort to offer technology students learning activities with more context and complexity. For example, case-based instructional materials are based on problem cases gathered from workplaces; problem-based instructional materials encourage students to develop skills to solve complex problems with little instructor guidance; and simulation-based tools provide a way to experience multiple possible outcomes and problem approaches while learning. ***This project focuses on developing and pilot testing rating tools to permit comparing and contrasting different innovative instructional materials: case-based, problem-based, and simulation-based tools.*** These rating tools can be used by researchers, evaluators, and ATE PIs to review and communicate the effectiveness or feasibility of implementing specific instructional strategies in specific program contexts. The scales are intended to help researchers define promising areas for extending theoretical understanding of instruction in technician education, to help evaluators focus on core benchmarks for performance, and to help ATE PIs convey the value of their work to community college and industry audiences. The results of this research will establish a foundation for future researchers, evaluators, and ATE community leaders to review and discuss ATE's innovative instructional materials and their implementation.

3. Research on crosscutting issues in technological education. This body of research addresses central goals of the ATE program: (i) strategies for prioritizing technician education research needs and addressing associated challenges, (ii) measuring the effectiveness of technician education, and (iii) sustainability, or the notion that activities will continue in some form once NSF funding has been significantly reduced or ended (e.g., see NSF 07-530, 2007, p. 6-7, 9).

Project V: Identifying the Impacts of ATE Centers on Their Home Institutions: An Exploratory Study – The ATE program has been evaluated regularly in recent years (see http://www.wmich.edu/evalctr/ate/). As is appropriate, these evaluation efforts

have focused on how well the funded projects and centers are meeting the goals set out by the original legislation that founded the program and in the subsequent NSF RFPs. Recent work, however, has concluded that once funding expires, ATE projects and centers do not sustain several aspects of these goals (Welch & Gullickson, 2006). In particular, those activities that are not otherwise valued by the home institution as part of the "normal" workload for faculty and staff significantly decline once NSF funding is not renewed. ***This project will identify the undocumented and perhaps unanticipated impacts (both positive and negative) of mature national ATE centers on their home institutions.*** This research will involve analysis of existing data (WMU Annual ATE Survey) and in-depth case studies at three ATE centers.

Project VIII: Building and Enhancing Capacity for Technician Education Research Across Community College ATE Leaders and Experienced Community College Researchers – With limited opportunities and finite resources to conduct research, it is extremely important that clear and meaningful priorities be set to guide future ATE research investment decisions. Prioritizing research based solely on the harried, day-to-day lives of working professionals may or may not lead to logical decisions. There is a serious void among academic researchers in knowing what needs to be studied and among community college practitioners about how rigorous studies should be carried out. Yet, an understanding of the importance of an active role for community college professionals in conducting research is not widespread. A deliberate, unified conversation involving community college leaders, practitioners, and researchers familiar with the field is needed to create a meaningful research agenda for the ATE program. ***This project will engage ATE center PIs and university and community college researchers in prioritizing and strategically reflecting on technician education research needs, challenges, and next steps.*** Two key goals will guide the project design team, dialogues with participants and key stakeholders, and dissemination efforts to identify the critical research and implementation challenges and priorities to be addressed in strengthening the implementation and impact of technician education in the United States, and to recognize the most promising frameworks and strategic approaches for building an actionable, joint researcher-ATE practitioner research capacity in technician education.

Project IX: Research to Define and Measure Effectiveness of ATE Centers/Projects – Currently, there are no generally accepted common metrics or methodologies to measure the effectiveness of ATE activities. Instead, grantees tend to report their effectiveness in particularistic ways. ***This research proposes to develop measurable criteria of effectiveness for ATE centers/projects across the range of ATE priority areas (i.e., materials development, professional development, and program improvement).*** The study will develop two main types of measures: "effectiveness for central goals" and "effectiveness in process." ATE's central goals are to produce more science and engineering technicians to meet workforce demands and to improve the technical skills and general STEM education

preparation of these technicians and their educators. It is important to develop standardized measures of effectiveness in process as well, because they may serve as plausible proxies for central goal achievement, as intermediate outcomes toward central goal achievement and/or as interim measures of effectiveness when there has been insufficient time as yet to realize central goals. The study will develop a comprehensive set of potential program accomplishments and innovations in the following nine areas: students and incumbent workers, faculty, two-year institutional culture change, industry, community, high school–four-year institution interaction, collaborations with other two-year institutions, national/regional impact, and dissemination.

Findings from the proposed research have the potential to place the assessment of effectiveness for this important federally funded program on a firmer scientific basis. Results of the study will allow NSF to better understand variations in the success of its ATE grantees and to apply an objective effectiveness measurement strategy to the ATE and similar programs in the future. This could be used to demonstrate return on investment in the ATE portfolio to Congressional stakeholders. Findings also will assist ATE projects and centers in meeting demands for accountability and support their requests for continued NSF and other funding. Finally, technician educators will be able to identify the most effective programmatic innovations to assist them in improving their own models and in disseminating evidence-based ATE programs regionally and nationwide.

Project X: Assessing and Improving the Sustainability of ATE-Supported Projects and Centers – An underlying goal of NSF-supported projects is that their reform efforts will continue in some form once the NSF funding has stopped or is significantly reduced. This continuation is called sustainability—sometimes residual impact—and is one indication of the impact of the ATE program. Although much has been written about how to ensure sustainability of federally funded efforts (Bailey et al., 2004; Klentschy, 2007; Lawrenz & Keiser, 2002), there is little general research on the topic (Cuban, 2007) and even fewer studies that actually have attempted to measure it (Moursand, 2005; Welch & Gullickson, 2006). ***The overarching goal of this proposed research is assessing and improving long-term program impact.*** Using a collaborative process involving university researchers, ATE center directors, and NSF program officers, this 18-month project will address questions about sustainability in the ATE context. Among other topics, researchers will investigate the meaning of sustainability, appropriate indicators for determining the residual impact of ATE projects and centers, and the sustainability of projects and centers that are no longer receiving ATE funds.

The intellectual merit of this research and its impact lies in the goal of the ATE program—to improve the education of technicians in high technology fields. Given this, it is imperative that efforts to achieve this goal continue after federal funding ceases. Research is needed to better understand how this can be accomplished and how that knowledge can be transferred to those involved in technician education.

Collectively, this body of research represents an approach that includes interpretive, qualitative research methodologies and engages practitioners in reflecting on data collected under more quantitative research approaches (Wayman & Stringfield 2006). The opportunity for synergy throughout implementation of the projects is further enhanced by the different disciplinary backgrounds and professional experiences of the researchers. The involvement of individuals from science education, mathematics, engineering, technical education, educational psychology, sociology, and evaluation—and the inclusion of collaborators and advisors from community colleges and industry—set the stage for producing research that takes into account the skills, knowledge, and real-world experience required to more fully understand technological education. An additional benefit is the participation of individuals who are very familiar with the ATE program and NSF and researchers who are relatively new to the arena of technical education. The perspectives of the latter provide fresh lenses through which to examine long-standing activities and traditions, while the former help ground these new ideas. Moreover, the involvement of individuals who are beginning their careers affords an opportunity to interact with and learn from more seasoned researchers. This will help ensure that there will be a cadre of researchers prepared to continue these lines of inquiry in the future.

These research efforts begin to address the scope and diversity of issues inherent in the ATE program. Findings from these studies will offer important benefits to science and society at large by advancing the knowledge base to make technician education programs more effective.

TOWARD AN INTEGRATION OF ATE STAKEHOLDER RESEARCH INTERESTS AND NEEDS

Integrating the research interests and needs of ATE projects and centers, business and industry, researchers from 4-year colleges, NSF, and other stakeholders is an ongoing process. Specifically, building a bridge between researchers and the ATE practitioner community is a key challenge in the program's efforts to encourage and support targeted research. Researchers involved in technological education research must understand the importance of exercising caution as they navigate the distinct cultures of community colleges and universities, recognizing historically based differences in the missions and education orientations of these institutions. As Cohen (2005) notes, instead of having research "done to" them, ATE PIs seek research "done for" them. Particularly in this exploratory phase, university-based researchers must avoid giving the impression to community college educators that "we're from the university and we're here to help you." These individuals have vast experience and knowledge in their own right, and the expertise that abounds in community college settings must not be underestimated. Close collaboration and consultation with educators and administrators from community colleges is critical to ensuring success in this research arena.

There are a number of limitations in the process by which we attempted to engage various stakeholder groups in advancing our understanding of the research needs for

the ATE program. Many of these limitations were primarily a function of limited time and, to a lesser degree, resources with which to convene the workshop. An evaluation of the workshop processes revealed five main points among participants who responded (n=6):

1. The recruitment process was not understood clearly by the researchers. It did not cast a wide net, and it was recommended that recruitment of researchers should be done through organizations such as AERA and NARST.
2. Attending the ATE PI conference was a valuable experience for the researchers. Most of them did not have suggestions for improvement.
3. Some researchers developed their research ideas on their own, while others involved groups of researchers. Some had a complete proposal prepared, while others had only the idea papers. People were at very different stages.
4. The process could have been improved by sharing existing research and research questions that were of interest to ATE practitioners early in the process.
5. Some researchers thought that the initial feedback from reviewers, including NSF personnel, was helpful; others felt strongly that the feedback was not helpful. It was suggested that there be more "back and forth" interaction about the research ideas and that more structure be required.

The greatest area of concern with respect to the workshop was a lack of understanding associated with how the various research components would be submitted to NSF. Given the fact that the development of these proposals was outside the regular submission cycle, it was not feasible to submit each research project for review. Ultimately, it was decided that the most efficient way of handling the situation was to develop a single "umbrella" proposal for consideration, using one research idea from each of the ten research teams represented at the workshop. As noted in the evaluation, "Respondents were very positive about NSF's determination and support to conduct high quality research on the ATE program. The respondents were pleased to be a part of this initiative, but were not pleased with the [initial processes used to develop] the umbrella proposal."

In the event there are future efforts of this type, the details of the umbrella proposal requirements should be planned in advance. Specifically, issues associated with who and what institution will take a lead role—and what that role will be—should be addressed from the onset using a collaborative, consensus-driven approach that includes representation from each research or project team.

We believe that the efforts associated with this project in the past 12 months have served as an important step toward enhancing understanding of the research needs for the ATE program and issues surrounding technician education, especially in community colleges. As might have been anticipated, given the complexity of the challenges associated with understanding the efficacy of technical education, our attempts have generated many additional questions that have yet to be addressed and answered. First

and foremost, additional dialogue with and among the key stakeholder groups is necessary to ascertain the extent to which the issues voiced across all the groups are really the same, but just articulated differently. If in fact the issues presented in Table 1 that were raised by the four different stakeholder groups—NSF ATE program officers and the EHR directorate, ATE projects and centers, researchers in four-year colleges and other research settings, and business and industry groups—are different, what are the key differences and their implications for the viability of ATE-based research? If, on the other hand, the issues and research questions are actually similar in one or more areas, does this provide some direction for encouraging studies or developing special support groups?

Next, what incentives are there for ATE PIs and their staffs to engage in research (or facilitate others' research efforts)? There are, of course, many types of incentives for different people in different settings. However, it seems apparent that funding will play an important role in helping to encourage participation in research-related activities at the project and center level.

There is considerable interest in continuing to pursue these questions and the dialogue that was formally begun just one year ago. More researchers now are aware of the opportunities to conduct studies in this arena, and we now have more information about specific topics in which other stakeholders are interested. We also know much more about the perceived challenges involved with engaging in advanced technological education research at community colleges. Continuing and expanding the stakeholder dialogue that was formally begun a year ago will be critical to maintaining the momentum generated in the past several months. Of perhaps more importance will be moving forward with the implementation of the recently funded research and learning not only the results of the studies, but also documenting and understanding the challenges and successes in doing so.