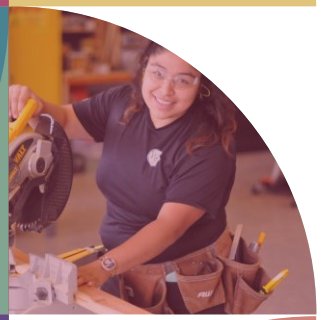
# ATE SURVEY 2024

Findings from the Annual Survey of Principal Investigators in the National Science Foundation's Advanced Technological Education Program

EvaluATE



# CONTENTS



Click any topic to jump to that section.

# INTRODUCTION

The Scientific and Advanced-Technology Act (1992) called for establishing "a national advanced technician training program utilizing the resources of the nation's two-year associate-degree-granting colleges." In response, the National Science Foundation (NSF) created the Advanced Technological Education (ATE) program. The ATE program makes awards ranging from $70,000 to $7.5 million to support an array of initiatives to improve the education of technicians at undergraduate institutions and secondary schools, with an emphasis on two-year colleges. Examples of high-technology fields of interest include advanced manufacturing, biotechnology, energy and environmental technologies, engineering, information technologies, and nanotechnologies.

**This report summarizes data gathered in the 2024 survey of ATE program grantees.** EvaluATE, the evaluation hub for the ATE program, located at The Evaluation Center at Western Michigan University, has conducted this survey annually since 2000. Included in this report are findings about ATE awards (referred to as projects) and their activities and achievements during the 2023 calendar year (and, for budget-related questions, the 2023 fiscal year).

**The 2024 survey was a census of ATE principal investigators (PIs) with active grants (*N*=325). Ninety-six percent of PIs (*n*=312) responded to the survey.** The survey included sections about grantee characteristics and practices, evaluation, collaboration, academic program or course development, educational materials development, instrument acquisition, student services and support, professional development for educators or future educators, professional exchange, research and publications, and ATE program services. Grantees were asked to complete sections that pertained to their work.

Similar survey items are asked year to year. However, readers should exercise caution when comparing the results of the 2024 survey with those of prior years. Changes over time may not necessarily be explained by a meaningful change in advanced technician training programs. In some cases, changes in the wording of survey items and structure may explain changes across time. Additionally, respondents change from year to year, given grant funding cycles and response rates.

Reported numbers of participants, products, and activities throughout this report are rounded to the nearest ten. The *n* that appears with tables and figures indicates the number of respondents for a given item.

*Additional reports based on annual ATE survey data dating back to 2000 are available at atesurvey.evalu-ate.org/survey-resources/. Custom reports may be developed upon request. For more information, contact atesurvey@evalu-ate.org.*

# HOW TO USE THIS REPORT

This report is intended for a broad audience, including ATE project staff, evaluators of ATE projects, those interested in submitting to the ATE program, NSF program officers, and others interested in learning more about advanced technological education. To encourage use of this report and translate findings into action, we have outlined how each of these audiences can use this report.

**ATE project staff.** ATE project staff, including principal investigators (PIs), co-PIs, and others who work on ATE-funded projects, can benefit from this report through an increased awareness of how their project fits into the larger ATE program portfolio. Reading about the activities and achievements of other projects can provide insights about the similarities and differences between their own project and others'. Project staff can use this report to better understand how their project fits amidst the larger framework of ATE projects across the country. Additionally, the survey report can be used to identify potential practices to add to their current project, to or inspire ideas for future projects.

**ATE evaluators.** ATE evaluators can benefit from understanding standard practices for evaluations of ATE projects, including types of reports produced and use of those reports. Additionally, evaluators new to ATE projects may gain insight about the types of data projects are already asked to collect in order to respond to this survey.

**ATE program grantseekers.** For those interested in submitting a proposal to the ATE program, this report provides a sense of what funded projects are already doing. A detailed understanding of ATE activities can benefit proposers in the planning stages, as well as in their final submissions to NSF. Grantseekers might use data from this report either to support the continuation of a common activity or to justify an alternative activity to fill a need or gap in ATE activities. The findings in this report may also inspire ideas for targeted research projects.

**NSF program officers.** The survey report provides a comprehensive overview of the ATE program, allowing NSF program officers to identify larger trends or needs in the ATE program. Additionally, this report can be shared with Congress as evidence of the program's achievements.

**Others interested in advanced technological education.** This survey report is freely available from the EvaluATE website, open to anyone who has interest in advanced technological education. Efforts to increase courses and programs in career and technical education are not limited to the ATE program. Other academic programs or projects intended to advance career and technical education can benefit from understanding ATE project activities.

# ATE GRANTEE AND PROJECT CHARACTERISTICS

As context for the remainder of this report, this section provides basic information about the individuals and institutions that received ATE awards, as well as key characteristics of the funded work, such as types of awards, disciplinary emphases, and nature of activities.

# ATE GRANT TYPES AND INSTITUTIONS

Most ATE grants support projects, and most PIs are located at two-year colleges.

ATE awards fit into four main categories: projects, centers, targeted research, and conferences and meetings. The ATE program has special funding tracks for institutions new to the program and for organizations developing plans for national centers. **Ninety percent of ATE grants were for projects (including a variety of subcategories of project types).** Among the 281 project grants, 70 were designated for institutions new to the ATE program, and 3 were coordination network grants. Of the 21 centers, 11 identified as national centers, 3 as regional centers, and 7 as support or resource centers.

The majority of ATE grants support **projects**.

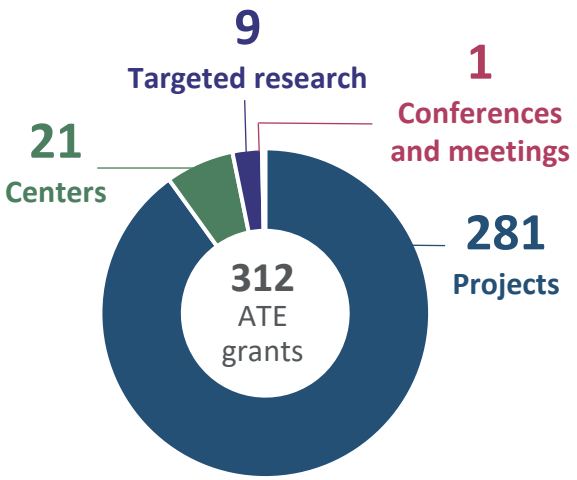



Figure 1. Types of ATE grants awarded (*n*=312)

Most ATE grantees are located at **two-year colleges**, followed by **four-year colleges and universities** and **nonprofits**.


Figure 2. ATE grant recipient institutions (*n*=312)

The ATE program solicitation states that the "program focuses on IHEs that award two-year degrees in advanced technology fields and expects these IHEs and their faculty to have significant leadership roles on all projects" (NSF, 2021). Accordingly, most ATE grants are located at two-year colleges. The 236 grants awarded to two-year colleges supported 222 projects, 13 centers, and one targeted research grant. Most (78%) of the 9 targeted research projects are located at four-year colleges.

**Unless specified, all types of grants—projects, centers, targeted research, and conferences—are referred to as *projects* in the remainder of this report.**

# ATE PROJECT DISCIPLINES

## The majority of ATE projects are in the areas of advanced manufacturing technologies, information and securities technologies, and general advanced technological education.

In alignment with the broad aim of the ATE program to improve the education of science and engineering technicians, the disciplinary emphases of ATE grantees are diverse.

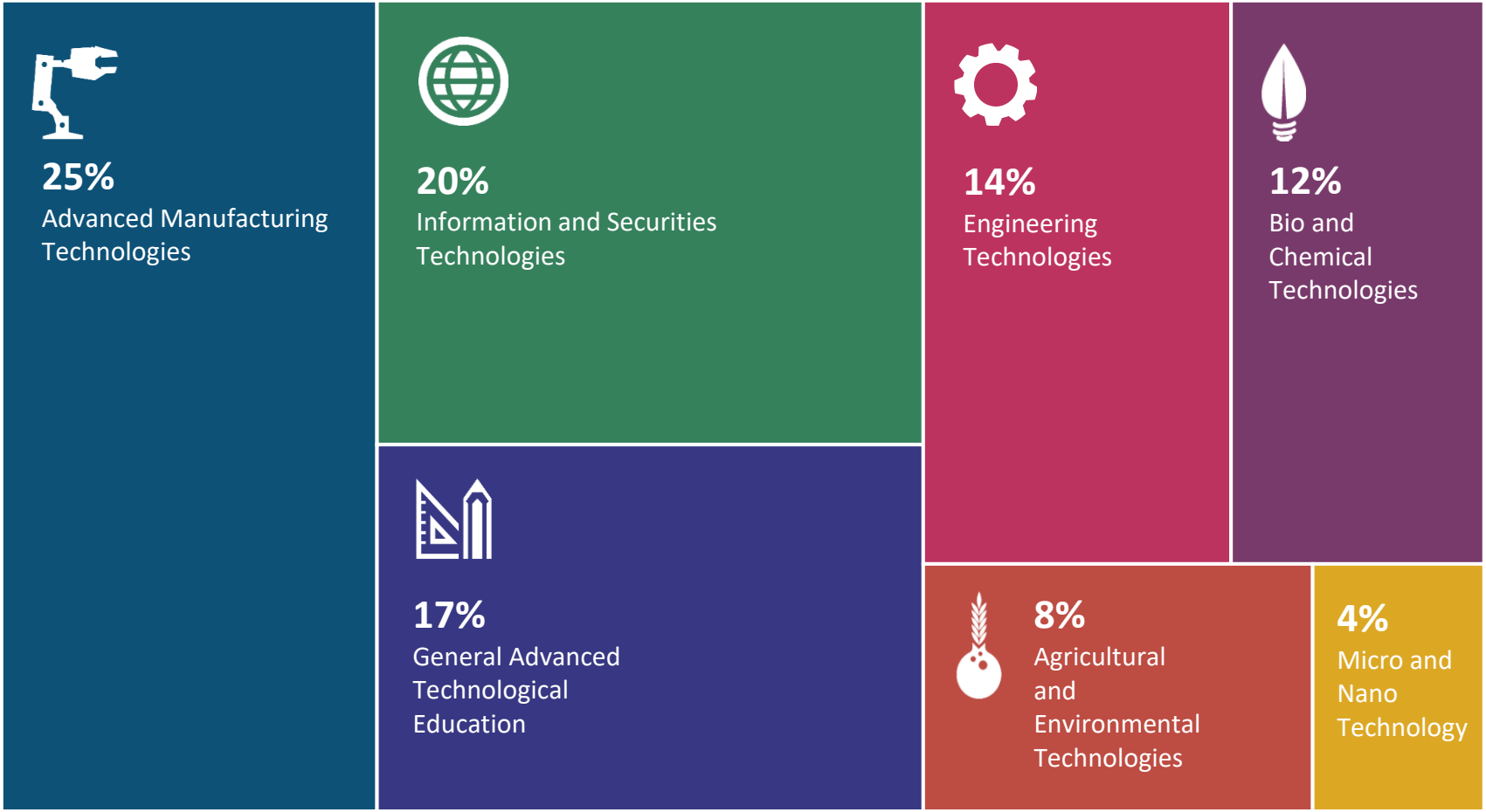



Figure 3: Disciplinary areas of ATE projects (*n*=312)

# ATE PROJECT ACTIVITIES

ATE projects engaged in a variety of activities in 2023 to improve the education of science and engineering technicians.

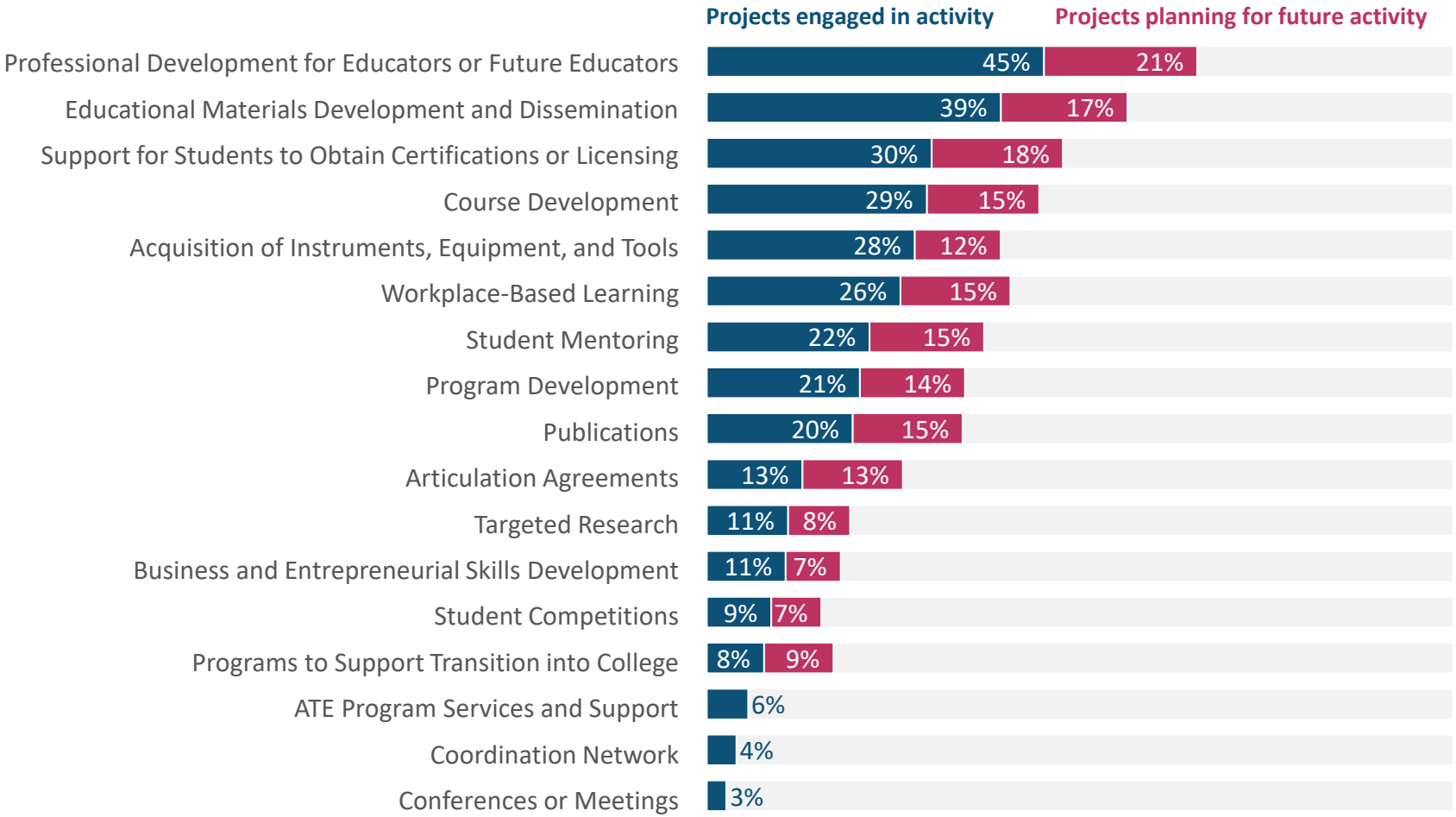


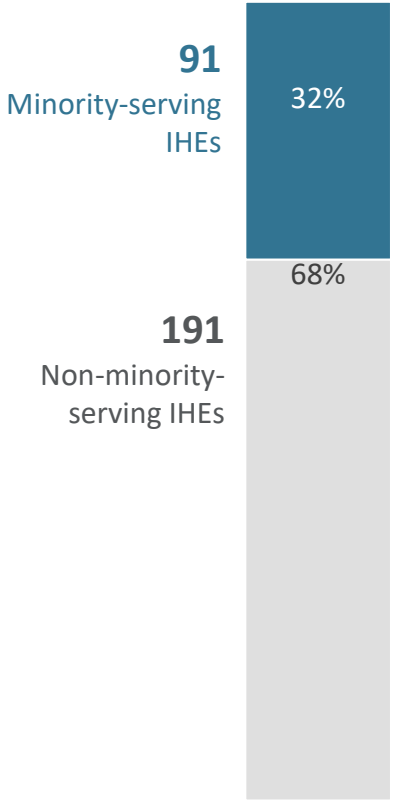

Figure 4. Percentage of projects that reported engaging in activities in 2020 and planning activities for the future (*n*=312)

# ATE PROJECTS AT MINORITY-SERVING INSTITUTIONS

Thirty-two percent of ATE projects are located at minority-serving institutions.

Ninety-one ATE projects are located at **minority-serving** institutions of higher education (IHEs).

Minority-serving institutions are defined in U.S. law under Title III of the Higher Education Act of 1965. The designation is based on the percentage of minority students enrolled in the school. **Of the 284 projects at IHEs, 32% are at minority-serving institutions.** The majority of these IHEs are Hispanic-serving (73%). Asian American and Native American Pacific Islander–serving made up 19% of IHEs, followed by 9% predominantly Black or historically Black colleges and universities, and 5% at Alaska Native or Native Hawaiian-serving institutions. Two percent (2%) of projects were reported to be located at Native American-Serving Nontribal Institutions and no projects were at Tribal colleges or universities.




Sixty-six ATE projects (73%) are located at **Hispanic-serving** institutions of higher education.

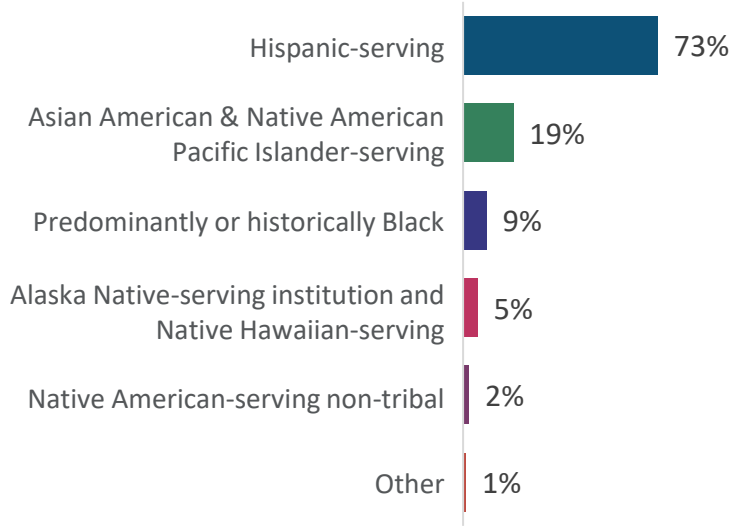



Figure 5. ATE projects at minority-serving institutions (*n*=284)

# ATE PRINCIPAL INVESTIGATORS

## Nineteen percent of ATE projects have PIs from racial and ethnic groups historically underrepresented in STEM.

The ATE community is still working toward increasing diversity among PIs. Females make up 51% of the U.S. population (United States Census Bureau, 2023). Comparatively, females are underrepresented as ATE PIs, since only 37% of ATE PIs in 2024 identified as female. Fourteen percent of ATE projects have PIs who are over the age of 65, while 33% of ATE projects have PIs who are between the ages of 55 and 64, 32% are 45–54, 17% are 35–44, and 3% are 25–34.

Only 37% of ATE projects have a PI who identifies as **female**.

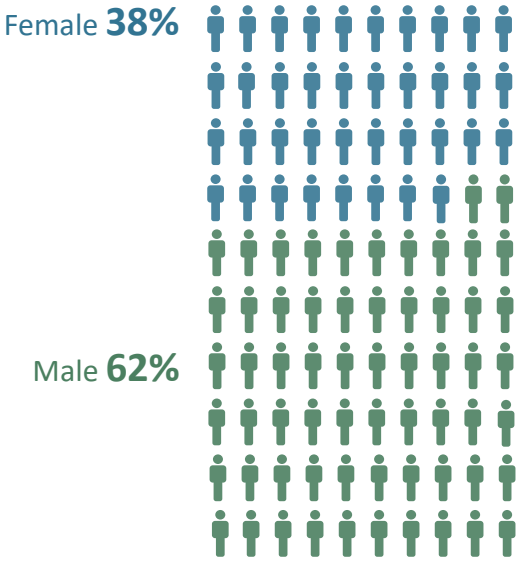



Figure 6. Gender identities of ATE PIs (*n*=310). Each icon represents 1%.

**Fourteen percent of ATE projects have PIs from historically underrepresented racial and ethnic groups**, which includes Black, Hispanic, American Indian or Alaska Native, and multiracial.

Only 21% of ATE projects have a PI who identifies as a race or ethnicity other than **white**.

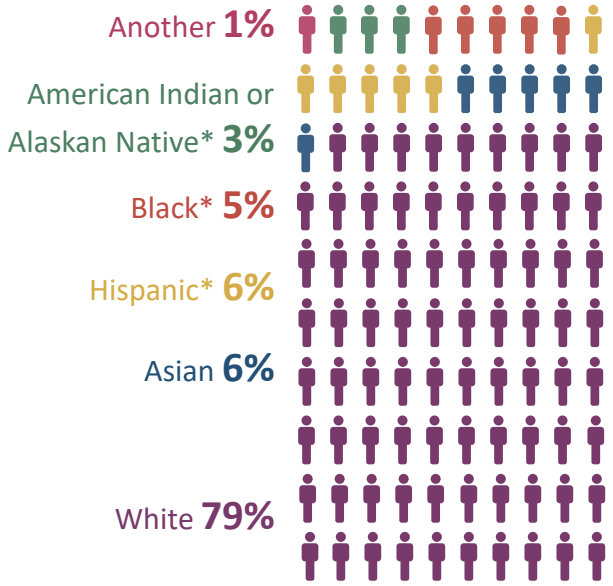



Figure 7. Racial and ethnic identities of ATE PIs (*n*=308). Each icon represents 1%. *Historically underrepresented racial and ethnic groups.

# ACADEMIC PROGRAMS, COURSES, AND PATHWAYS

The ATE program supports the creation and improvement of academic programs that lead to "an appropriate associate degree or specific occupational competency or certification" (NSF, 2018, p. 5). Examples of funded activities include creating new degree or certificate programs or courses; modifying the content, instructional strategies, or delivery modes of existing programs and courses; enhancing programs through the acquisition of instruments or equipment for use in instruction; and developing educational pathways (including articulation agreements) that facilitate students' movement across education levels.

# ACADEMIC PROGRAM DEVELOPMENT

## Twenty-one percent of ATE projects created or substantially modified an academic program.

The Committee on Science, Technology, Engineering, and Math Education's 2018 strategic plan emphasizes expanding the number of students pursuing STEM degrees and improving access to effective STEM programs across educational levels. One of the ways that ATE responds to this call is through the development of new STEM academic programs. ATE PIs were asked to identify the degree or certificate programs that their projects created or improved with ATE funding, and characteristics of students served by those programs.

A total of 110 academic degree programs were developed or substantially modified by 64 ATE projects in 2023. **Most of these programs awarded certificates (60%) or associate degrees (33%).** Three percent (3%) of programs awarded bachelor's degrees, and five percent (4%) of programs provided other types of credentials (e.g., minors or micro-credentials). **Over 9,580 students attended at least one course in these academic programs**, with a total of 2,240 completing a program in 2023; 330 students completed an associate degree program, while 900 students completed a certificate program. Programs with students completing certifications or degrees in 2023 graduated an average of 20 students.

**60** certificate programs served
**6,520** students

**30** associate degree programs served
**1,510** students

The Committee on STEM Education's 2023 progress report noted the persistence of labor shortages in STEM fields and underscored the importance of increasing diversity, equity, and inclusion in STEM. NSF (2024) has determined that women, persons with disabilities, and three racial and ethnic groups—Blacks, Hispanics, and American Indians or Alaskan Natives—are underrepresented in science and engineering.

Forty-six ATE projects out of the 64 that have developed academic degree programs emphasized recruitment of at least one of the following types of students.

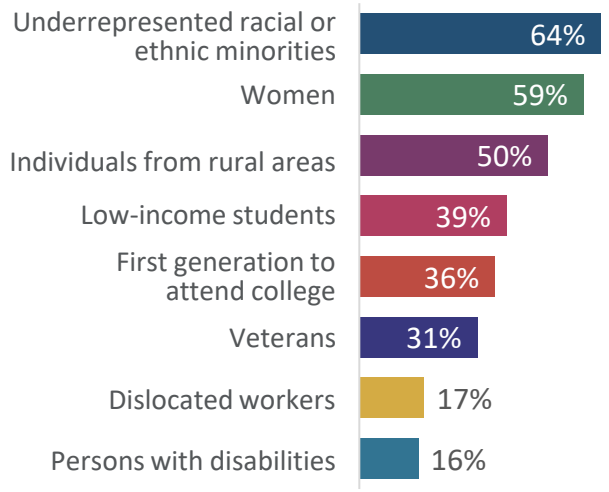



Figure 8. Percentage of projects that emphasized recruitment of students from specific demographic groups (*n*=64). Note that projects could choose more than one option.

# STUDENTS SERVED BY ATE ACADEMIC PROGRAMS

## Students from groups that have been historically underrepresented in STEM have rates of participation in the ATE program similar to national averages.

Of the 110 academic programs that were developed or modified by ATE projects in 2023, 53 programs (50%) reported data on student gender, and 53 programs (50%) reported data on student race. Due to this low response rate, the numbers reported here do not represent the entire ATE program nor all 64 ATE projects that created or substantially modified academic programs in 2023.[i]

The gender breakdown in ATE-supported programs is similar to what is observed in STEM programs nationally. **Overall, 17% of ATE students are women, although the proportion of women varies by STEM discipline.** According to the U.S. Department of Education, 26% of students in technical programs at two-year colleges and 14% of students who received certificates below the associate level in the U.S. are women.[ii]

Like other STEM programs, ATE projects still face a challenge in attracting **women** to the field.

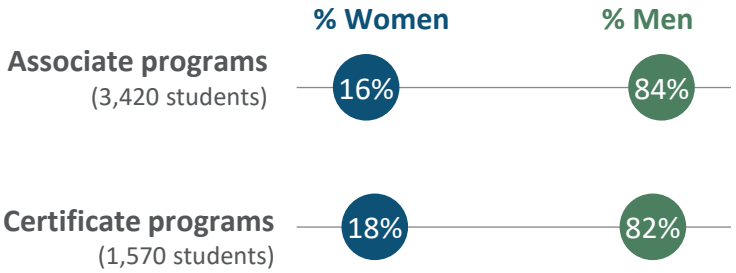



Figure 9. Percentage of women and men in ATE-supported academic programs by degree level (*n*=53). One percent of students in certificate programs identified as another gender.

Students who identify as Black/African American have slightly higher representation in ATE-supported programs than they do in the general population of students across educational degrees. (See the technical notes for a full explanation of comparison sources for national data.[iii])

The percentage of students who identify as **Black/African American** and **Hispanic or Latino/Latina** in the ATE program mimics national trends.

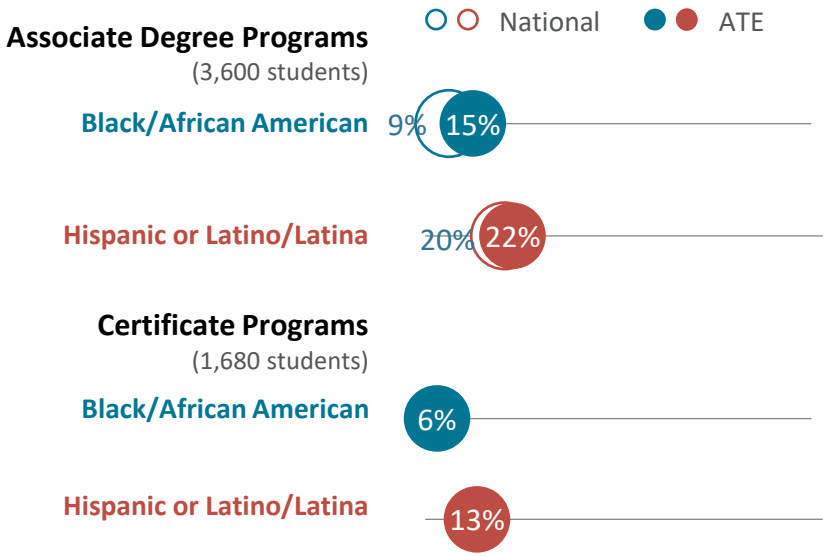



Figure 10. Percentage of students from underrepresented racial and ethnic minority groups in ATE-supported academic programs, compared with national rates (*n*=53).

# COURSE DEVELOPMENT

## Twenty-nine percent of ATE projects created or modified at least one academic course.

ATE PIs whose projects engaged in creating or substantially modifying academic courses were asked to identify the number and types of courses they created or modified, the academic levels of these courses, their primary delivery modes, and how many students enrolled in the courses. Some ATE projects engaged in course development as part of a larger initiative to develop or modify an entire degree or certificate program; others did so as a stand-alone effort.

A total of 330 courses were developed by 92 projects in 2023. The majority of these courses (89%) were for **two-year college students**.

**10**
high school courses were developed by
**6**
ATE projects

**300**
two-year college courses were developed by
**79**
ATE projects

**5**
four-year college courses were developed by
**2**
ATE projects

Fifty-five percent of these 332 courses were offered in 2023.

**4,020 students**
completed an ATE-developed or -modified course in 2023

ATE PIs were asked about the primary delivery modes for each of the courses they developed or modified.

Most ATE courses, regardless of education level, were designed for a **face-to-face** delivery (52%), as compared with **hybrid** (35%) or fully **online** (13%). (*n*=286).

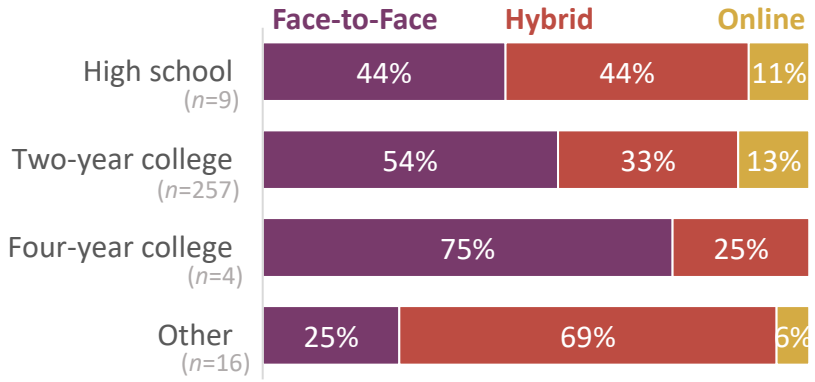



Figure 11. Percentage of courses designed, by differing delivery mode, by education level. High school adds to 99% due to rounding.

# INSTRUMENT ACQUISITION

## Twenty-eight percent of ATE projects acquired instruments or equipment to prepare students for work in business and industry.

Using state-of-the-art equipment contributes to the development of technical skills students will need for employment. Hands-on experience with such equipment has also been shown to contribute to students' self-efficacy and positively impact their longer-term career and educational goals (Amelink et al., 2015). The ATE program includes a funding stream to help grantees obtain instruments or equipment that can be used in instruction to prepare students for employment in business and industry.

Eighty-seven ATE projects acquired instrumentation or equipment in 2023. Examples of instruments purchased and utilized by projects might include 3D scanners, computers for adversarial programming, assessment devices, mini drones, virtual reality viewers, and laboratory equipment. Eighty-six projects reported the amounts they spent on instrumentation or equipment. **Projects spent between $211 and $380,000 on instrument acquisition in 2023.**

A majority of projects spent **25% or less** of their grant funds on instrumentation in 2023.

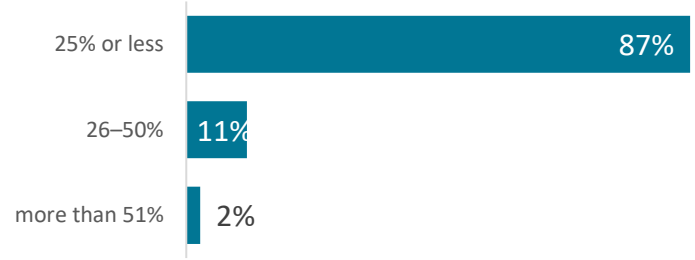



Figure 12. Percentage of total grant amount spent on instrumentation or equipment in 2023 (*n*=85)

Projects that use ATE funding to purchase instruments or equipment are expected to revise their academic programming to maximize the value of the items for student learning. In 2023, 5,270 students used instruments and equipment.

A median of 20 students used the equipment or instrumentation acquired by each ATE project.

**5,270 students**
benefited from purchased equipment

**540 educators**
used the purchased equipment

**260 courses**
used the purchased equipment

**Sixty-eight projects reported acquiring instrumentation, equipment, or tools to give students hands-on experience with instruments used in the field.** Nine projects reported acquiring instruments to allow students to perform technical tasks in a simulated environment, and 10 projects noted other reasons, such as fostering collaborative work, students' applied research experiments, hands-on experience with industry-standard equipment, enabling students with disabilities to perform certain technical tasks, and enhancing virtual instruction.

# ARTICULATION AGREEMENTS

## Thirteen percent of ATE projects created or maintained articulation agreements.

Articulation agreements are formal agreements between educational institutions that provide students from secondary schools with pathways and education access to two-year colleges and four-year colleges. These agreements contribute to increasing the number and diversity of scientists, engineers, and technicians (National Academy of Engineering & National Research Council, 2012).

In 1992, Congress saw the importance of these agreements and required their use in NSF's ATE program. The 2021 ATE solicitation calls for "developing life-long career and educational pathways for technicians to support the changing workplace" (NSF, 2021).

**Forty projects developed or maintained articulation agreements in 2023.** Note that one project was responsible for 75% of the 1,490 students who matriculated from high school to a two-year college.

Most articulation agreements created in 2023 were between high schools and two-year colleges**.** In 2023, more students also matriculated between high schools and two-year colleges than between two-year and four-year colleges.

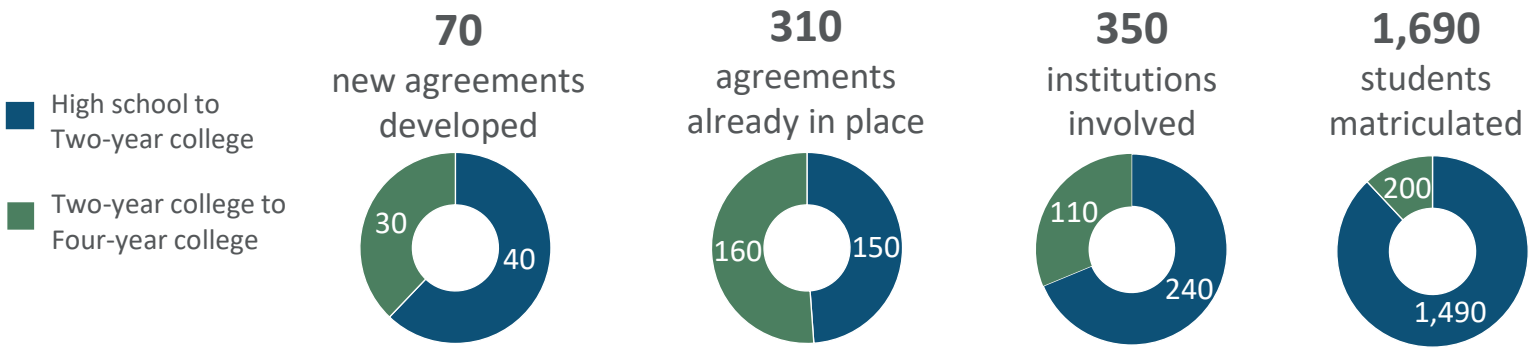
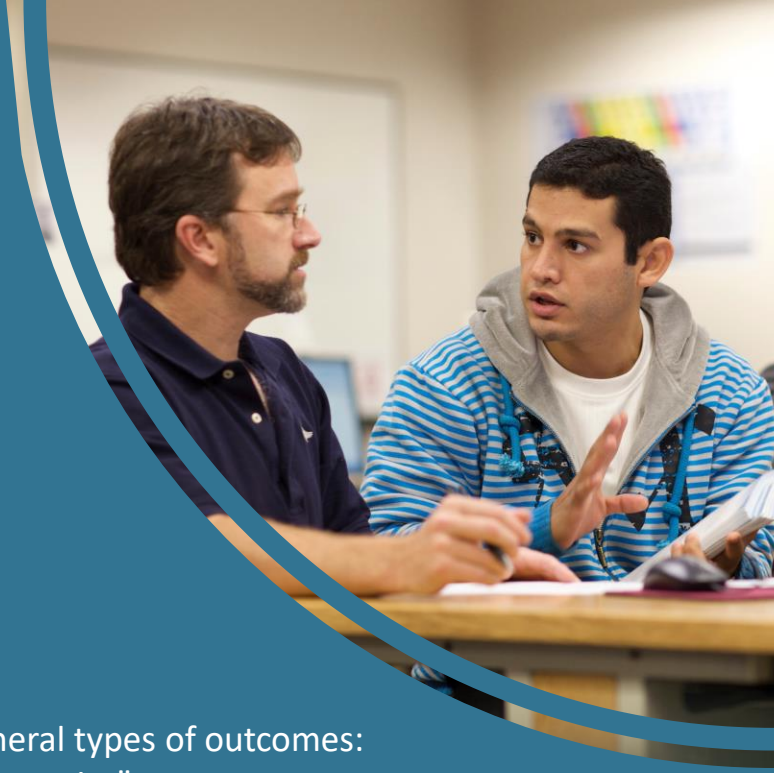



Figure 13. Number of articulation agreements, institutions, and students (*n*=40)



# EDUCATIONAL MATERIAL DEVELOPMENT

Instructors' use of curriculum materials is believed to have three general types of outcomes: (1) improvement of educators' pedagogical knowledge and "design capacity"; (2) increased opportunities for students to engage in "ambitious science" aimed at developing their skills in both generation and use of scientific knowledge; and (3) improved student learning outcomes (Davis et al., 2016). The ATE program supports the creation, validation, and dissemination of educational materials in print and digital formats to be used for instructional or assessment purposes. Such materials include—but are not limited to—tests, lab experiments, instructional modules, and textbooks.

The PIs whose projects developed educational materials were asked to report the type and number of materials they developed or adapted and how those materials were disseminated beyond their institutions.

# EDUCATIONAL MATERIAL DEVELOPMENT

Thirty-nine percent of ATE projects created or substantially modified educational materials.

123 ATE projects developed or modified over 5,270 educational materials in 2023.

**1,110**
Modules or instructional units

**1,310**
Assessment activities or tests

**570**
Lab experiments

**550**
Lessons or lesson plans

**510**
Course curricula

**450**
Mini-lecture videos

Additional materials developed include 230 instructor guides, 220 case studies or problem sets, 160 program curricula, 140 interactive simulations, and 15 textbooks. ATE projects also developed 290 other types of materials.

**Educational materials created in 2023 by ATE projects were primarily disseminated through conference presentations or booths (76%) and the projects' websites (67%).** This was followed by workshops (63%), ATE Central (the ATE program's archiving platform; 55%), other clearinghouses (23%), other methods (15%), and commercial publications (11%).

**One hundred five ATE projects disseminated educational materials that were created prior to 2023.** These materials were primarily course curricula (61%), modules or instructional units (52%), lab experiments (48%), and program curricula (47%). ATE projects also reported continued dissemination of instructor guides (41%), assessment activities or tests (40%), lesson plans (37%), videos (35%), case studies (29%), interactive simulations (20%), and textbooks (10%) created in previous years.

Conference presentations or booths (76%) were the most prominent avenue for disseminating materials created in previous years. Sixty-two percent distributed materials at workshops and 61% on a project webpage or website.

Twenty of the 123 projects that developed and/or disseminated educational materials kept track of which other institutions are using their program and/or course curricula.

**880 institutions**
Used program and/or course curricula created by 20 ATE projects

# STUDENT SERVICE AND SUPPORT

The ATE program supports an array of activities designed to enhance student learning and success in STEM programs outside of typical classroom environments. Studies have shown that students who experience these types of enrichment and support programs are more likely to have positive attitudes toward science and sustain interest in STEM (Merolla & Serpe, 2014).

ATE PIs were asked if their projects provided any of the following student-focused services: support for students transitioning into college, opportunities to participate in STEM competitions, mentoring, entrepreneurial skills development, or support for obtaining industry-recognized certifications or licenses. Respondents who answered affirmatively were asked additional questions about the nature of these activities and the number of students served.

# STUDENT SERVICE AND SUPPORT

Forty-eight percent of projects provided at least one type of student service or support.

151 ATE projects provided at least one type of student service or support.

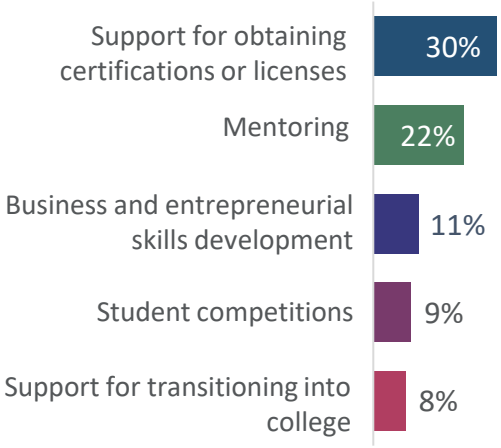



Figure 14. Percentage of projects that provided student services and support (*n*=364)

## BUSINESS AND ENTREPRENEURIAL SKILLS

Business and entrepreneurial skills development involves working with students to develop their skills in areas such as business development, marketing, networking, and understanding the global marketplace. **Eleven percent of ATE projects engaged 1,250 students in building their business and entrepreneurial skills.**

The 33 ATE projects that supported students' business and entrepreneurial skills development used a variety of strategies, predominately **in-course units or activities** and **mentoring and coaching**.


Figure 15. Percentage of skills development opportunities offered to students by ATE projects (*n*=33). Projects can select more than one mode.

# STUDENT SERVICE AND SUPPORT (continued)

Twenty-two percent of ATE projects provided students with mentoring or coaching, and 9% hosted or organized a student competition.

## MENTORING

Student mentoring involves an experienced industry professional, educator, or advanced student providing guidance and advice to help less-experienced students develop the skills and knowledge they need to enhance their academic and professional growth. Mentoring is a source of both psychosocial support and career advancement (Anderson et al., 2015). This type of support is especially important for students at two-year colleges, who typically face more barriers to degree completion than those at four-year institutions (Crisp, 2010).

Approximately **2,210** students received mentoring through ATE projects, including

**590**
High school students

**1,460**
Two-year college students

**140**
Four-year college students

**Mentoring was most often provided by educational faculty or staff (90%), followed by business and industry professionals (63%) and students or peers (53%).** Twenty-four percent of projects that offered mentoring or coaching provided training to the mentors. (*n*=68).

## COMPETITIONS

In student competitions, students compete as individuals or teams using skills related to a STEM discipline or industry, such as robotics, information technology, or engineering. Research shows that participation in STEM competitions has a positive impact on students' interest in pursuing STEM careers, even when controlling for prior interest and ability (Miller et al., 2018).

**4,460** students participated in one of the 65 ATE-hosted student competitions. .

**9**
agricultural and environmental technologies competitions engaged
**2,200**
students

**20**
information security competitions engaged
**952**
students

**10**
engineering competitions engaged
**790**
students

In addition, 23 other competitions engaged 419 students in advanced manufacturing, and 2 competitions in information and securities technology engaged 60 students, one other competition engaged 37 students.

# STUDENT SERVICE AND SUPPORT (continued)

Eight percent of ATE projects provided extra support for students transitioning into college, and 30% helped students prepare for certification or licensure.

## TRANSITION PROGRAMS

Community colleges enroll disproportionate numbers of students who are economically disadvantaged and from underrepresented minority groups (Edgecombe, 2019). Programs that support students as they transition into college are an important means for enhancing academic persistence and completion among these and other students (Baber, 2018). **The ATE program supports efforts to facilitate students' transition into college and equip them with the skills they need to successfully navigate college.** Such programs include—but are not limited to—summer bridge programs, college readiness workshops or classes, first-year programs, and support for nontraditional students.

The majority of transition programs are for **high school students**.

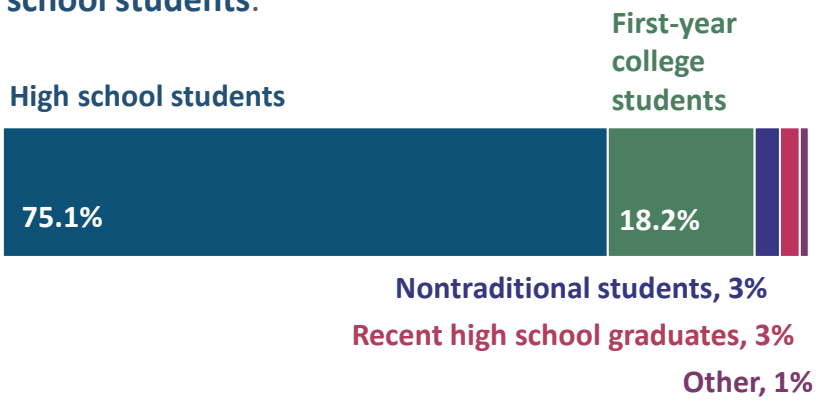
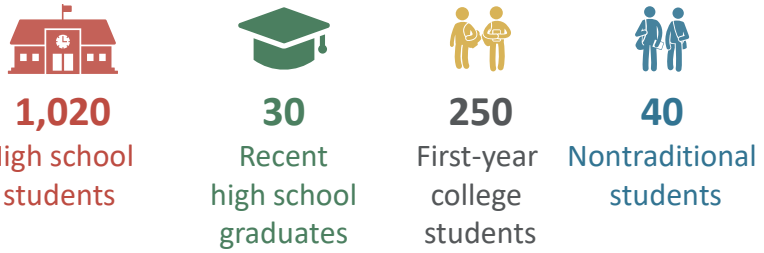



Figure 16. Percentage of programs offering transition programs (*n*=40).

Over **1,340** students transitioning into college received support from ATE projects.




## SUPPORT FOR CERTIFICATION OR LICENSURE

Professional certifications, typically awarded by industry groups or professional organizations, serve as verification that an individual has the knowledge and skills required for certain jobs. Many community colleges assist students in obtaining these credentials.

**Ninety-four ATE projects provided students with support for obtaining certifications or licenses in 2023.** Eighty-seven percent of those ATE projects reported supporting students through aligning existing courses with licensing or certification requirements. ATE projects also provided test preparation workshops or learning modules (66%) and served as testing centers (45%). ATE projects involved in this activity were asked to identify the type of entity that awards the licenses or certifications they help students obtain. The most common response was non-governmental organizations (64%), followed by for-profit companies (32%) and government agencies (21%).

# WORKPLACE-BASED LEARNING

Workplace-based learning includes any situation in which a student gains experience at a work site, such as through internships, apprenticeships, co-op learning, and job shadowing. Research indicates that such experiences contribute to students' confidence in their abilities and enhance employability skills, such as problem-solving, communication, and professionalism (Jackson, 2014).

ATE PIs whose projects offered workplace-based learning were asked about key characteristics of the workplace-based learning opportunities they offered and about the number of students who participated in these activities in 2024.

# WORKPLACE-BASED LEARNING

## Twenty-two percent of ATE projects provided workplace-based learning opportunities for students.

**In 2023, 1,030 students participated in workplace-based learning opportunities offered by 70 ATE projects.** An additional 11 ATE projects reported offering field trips to business and industry sites. The 22% of projects that provided workplace-based learning in 2023 excludes the 11 projects that only reported offering field trips.

### Most ATE projects offered workplace-based learning through **internships**.

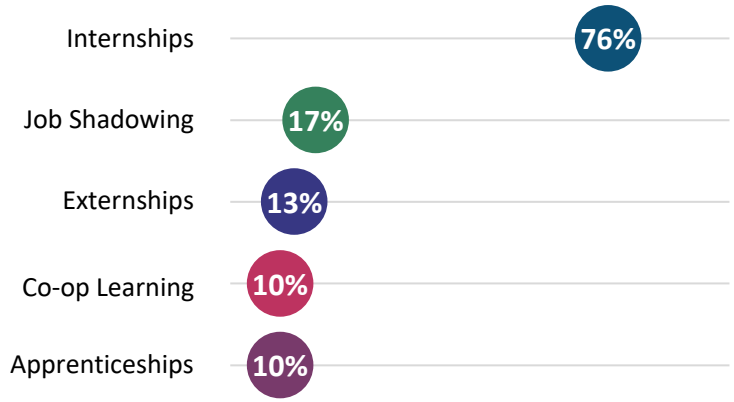



Figure 17. Percentage of ATE projects that offered each type of workplace-based learning (*n*=770)

The median number of weekly hours that students spent in a workplace-based learning activity ranged from 4 to 40, and the median number of weeks spent in an activity ranged from 4 (externships) to 52 (apprenticeships).

Respondents discussed a variety of benefits to both students and employers. As one respondent noted:

> **"The students improve their scientific communication skills and gain confidence in communicating the work that they are doing… In addition, the students learn what it takes to be successful in an industry… Finally, networking with other people in the industry is very important as many times this leads to employment in the field."**

Survey respondents reported on the characteristics of the workplace-based learning their projects offered.

| | Internships (*n*=53) | Job Shadowing (*n*=11) | Externships (*n*=9) |
|---|---|---|---|
| Required by program | 53% | 36% | 33% |
| Academic credit | 62% | 18% | 56% |
| Coupled with a course | 43% | 36% | 56% |
| Received payment | 89% | 27% | 67% |

Table 1. Characteristics of the three most frequently reported workplace-based learning activities

# PROFESSIONAL DEVELOPMENT FOR EDUCATORS

Community college faculty have diverse responsibilities. They design and deliver courses and are often charged with responsibilities related to student retention or institutional administration. Incoming faculty are typically subject matter experts with minimal training in pedagogy (Strickland-Davis et al., 2019). Furthermore, instructors in advanced technological fields must keep pace with rapidly changing technology and workforce needs. Increasingly, secondary school teachers are being called up to play a part in building students' STEM knowledge and skills and instilling interest in STEM careers.

The ATE program provides support for projects to develop and deliver professional development for educators, with a focus on enhancing their "disciplinary capabilities, teaching skills, understanding of current technologies and practices, and employability skills" (NSF, 2018, p. 5). ATE PIs were asked to report on the focus, number, and length of professional development activities provided by their projects, as well as the number and type of participants and number of students subsequently impacted by those participants.

# PROFESSIONAL DEVELOPMENT FOR EDUCATORS

## Forty-five percent of ATE projects provided training or professional development to current or future educators.

**One-hundred forty-one ATE projects provided 650 training or professional development activities for educators in 2023.** A plurality of these activities were a day or less in length (40%), including webinars and one-day workshops. Twenty-two percent lasted from one to several weeks, including courses and summer institutes. Twenty-nine percent lasted more than one day but less than one week, including workshops and online modules. The remaining 9% were long-term and periodic and included internships and peer coaching.

ATE projects offered 650 professional development activities for educators in 2023.

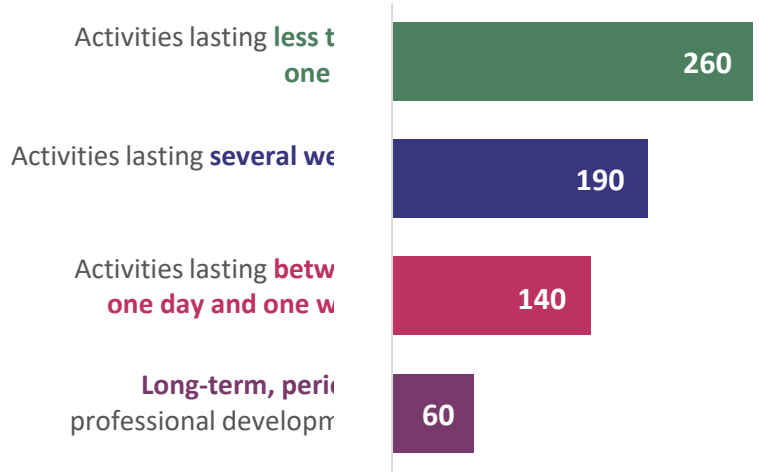



Figure 18. Number of professional development activities for educators, by length of time (*n*=141)

Professional development activities focused on a range of skills and topic areas. Eighty-six percent focused on discipline- or industry-specific knowledge or skills, 66% on training on specific equipment, and 50% on employability skills. Additional professional development topics reported by ATE projects included pedagogy (49%); addressing issues of equity, diversity, or inclusion (42%); recruitment or retention of students (39%); and other professional skills (11%) (*n*=140).

The most common professional development audience was in the "Other or Unknown" category (50%) followed by 2-year faculty (33%). At least 16,420 students were taught by educators who participated in ATE-sponsored professional development (most likely many more, due to underreporting and projects' inability to collect this data).

**4,460 educators**
participated in ATE-sponsored professional development in 2023 (*n*=135)

**4,390 people of other or unknown roles**
participated in ATE-sponsored professional development in 2023 (*n*=42)

**16,430 students**
were taught by educators who participated in ATE-sponsored professional development (*n*=31)

# PROFESSIONAL EXCHANGE

Bringing together professionals from different organizations and geographical locations facilitates knowledge diffusion, collaboration, and professional interaction (Chai & Freeman, 2019). Research has shown that “diverse collaborative networks” enhance innovation and complex problem-solving (Biancani et al., 2014).

The ATE program has two funding tracks that support activities to catalyze professional exchange. One such track supports **coordination networks**, which facilitate collaboration and communication about research, training, and education across disciplines, organizations, and geographical boundaries. The other track provides funding for **conferences, meetings, and events** to improve understanding of advanced technological education issues (NSF, 2018, p. 9).

ATE PIs whose projects hosted conferences or similar events were asked to identify the names and purposes of the events and the number of attendees. Those engaged in network coordination were asked to identify the purpose of their networks.

# COORDINATION NETWORKS

## Three percent of ATE projects indicated coordination networks as a primary purpose of their grant.

Ten ATE projects indicated that developing and facilitating coordination networks was the primary purpose of their grant.

- **National Center for Autonomous Technologies** has partnered with the Federal Aviation Administration to help lead the Uncrewed Aircraft Systems Collegiate Training Initiative. UAS-CIT is a consortium of higher-education institutions that shared educational philosophy and content resources to create a uniform standard of education for uncrewed aircraft systems.
- **Advanced Technological Education Coordination Network for Knowledge Sharing in Robotics/Automation and Cybersecurity** intends to facilitate the sharing of best practices about how to develop community college students' knowledge and skills in robotics/automation and cybersecurity.
- **Advanced Technological Education Network for Utilities and Energy Technical Education** facilitated relationships and resource sharing between educators, industry leaders, and workforce developers focused on closing the workforce gap in the energy industry.
- **The IT Innovation Network (ITIN)** is comprised of community colleges who will participate in a community of practice (CoP) to benchmark best practices and emerging ideas to advance IT education nationally.
- **National Cybersecurity Training & Education (NCyTE)**'s academic and industry partner membership is a large consortium network (ecosystem) contributing to advancing the quality and quantity of the cybersecurity workforce.
- **Collaborative Research: Revolutionizing Electric Vehicle Education** is designing, developing, implementing, and evaluating battery electric vehicle (BEV) curricula. They will build networks and provide professional development addressing the new BEV sector and future PI development.
- **Mount San Antonio College** is coordinating a network of four-year colleges to enhance access to research facilities and mentorship for their students.
- **NEVTEX NEXT** is a network of 15 community colleges developing electric vehicle programs.
- **The Necessary Skills Now Network** facilitates collaboration between educators and employers to improve the employability skills of entry-level technicians in STEM fields.
- **National Electric Vehicle Consortium (NEVC)** promotes the interaction of a critical mass of academic, agency, and industry experts across all EV disciplines to help secure the nation's EV workforce pipeline.

# CONFERENCES AND MEETINGS

## Three percent of ATE projects engaged in organizing a conference or meeting for the purpose of professional exchange in 2023.

One ATE project was explicitly funded to coordinate conferences or meetings in 2023. Five additional projects hosted conferences in 2023. These six projects hosted a total of ten conferences or meetings, with attendance that ranged from 30 to 810 people. ATE PIs identified the purposes of these events as networking and professional development, disseminating best practices, and bringing together stakeholders from industry and education.

**10 conferences and meetings**
were organized by five ATE projects

**1,290 people**
attended conferences and meetings organized by four ATE projects

Projects that organized conference or meeting events in 2023 included:

- **Preparing Cybersecurity Technicians with the Technical and Entrepreneurial Skills Required to Work as Independent Contractors** hosted an event called "Sheros: Protecting Business Systems."
- **Manufacturing Talent Development Innovation Laboratory** hosted a Manufacturing Momentum Summit.
- **Enhancing Preparation of Students for Technical Careers in Cloud Computing Technologies** organized an event called "IT READY!"
- **Map Your Success** hosted a GIS Day.
- **Advancing STEM Technician Education & Innovation: The Community College Leadership Role** hosted the 2023 ATE PI Conference.
- **NEVTEX Next** hosted five events that facilitated professional exchange among 15 colleges.

# RESEARCH AND PUBLICATIONS

All NSF-funded projects are expected to advance the frontiers of knowledge (NSF, 2024). The ATE program's **targeted research track** funds studies to generate knowledge and build an evidence base for technician education and the development of a skilled technical workforce. ATE PIs whose projects engaged in research were asked about the purpose and status of their research, their methods and findings, and their dissemination strategies.

**Publications** are a vehicle not only for disseminating research findings, but also for sharing promising practices, lessons learned, and information about project developments and materials. Survey respondents were asked about the number and types of publications produced by their projects, such as articles, reports, white papers, and other documents of publishable quality (not including projects' annual reports to NSF, evaluation reports, or conference materials).

# ATE TARGETED RESEARCH AND PUBLICATIONS

Eleven percent of ATE projects conducted some type of research, and 20% developed materials intended for publication.

## TARGETED RESEARCH

Nine ATE projects were specifically funded to conduct targeted research in 2023. Between them, they reported 14 active studies. At the time of the survey, 7% of these studies were in a planning phase, 7% were collecting data, 43% were analyzing data, 14% were writing up results, and 29% had findings published or submitted for publication.

In addition to these 9 targeted research projects, 25 other ATE projects indicated they conducted some sort of research in 2023. Together, these projects reported 50 research studies. Most of this research was descriptive (68%), followed by correlational studies (28%), experimental or quasi-experimental (28%), and document review (28%). Only a few studies used meta-analysis methods (2%) or other methods (4%).

Research findings are frequently disseminated through **conference presentations** or **articles in peer-reviewed journals**.


Figure 19. Percentage of research activities shared via various dissemination channels (*n*=50)

## PUBLICATIONS

While publication is an expectation for all projects engaged in targeted research, many other ATE projects also prepare publications of various types. Therefore, all ATE PIs were asked if their projects developed publications (excluding annual reports prepared for NSF, evaluation reports, and conference proceedings).

Sixty-one ATE projects prepared a total of **204 publications**.

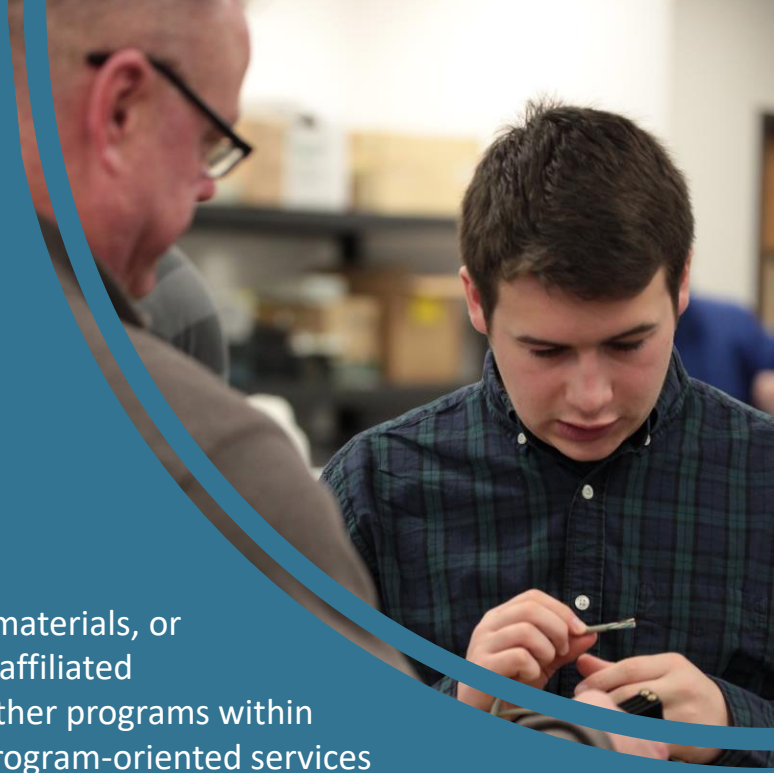
**66** Manuscripts for academic journals

**4** Manuscripts for practitioner journals

**23** Reports

**28** Magazine articles

PIs reported 83 other publication types, such as journal special issues, news posts, blogs, and newsletter articles.



# ATE PROGRAM SERVICES

For a few ATE projects, the primary purpose is to provide activities, materials, or services to enhance the capacity of ATE grantseekers, grantees, and affiliated stakeholders to plan and conduct successful ATE projects. In some other programs within NSF's Education and Human Resources directorate, these types of program-oriented services are consolidated and provided by a single organization. The ATE program is configured differently; ATE program–specific support, technical assistance, and other services are delivered by multiple grant-funded entities that focus on narrower areas of expertise, with an array of other projects contributing to program capacity in various ways. The ATE program also has a culture of sharing and support to advance the shared interests of program stakeholders.

ATE PIs were asked to identify the ways in which their projects supported the ATE community and the number of people served through their service activities.

# ATE PROGRAM SERVICES

## Four percent of projects were funded specifically to serve the ATE program.

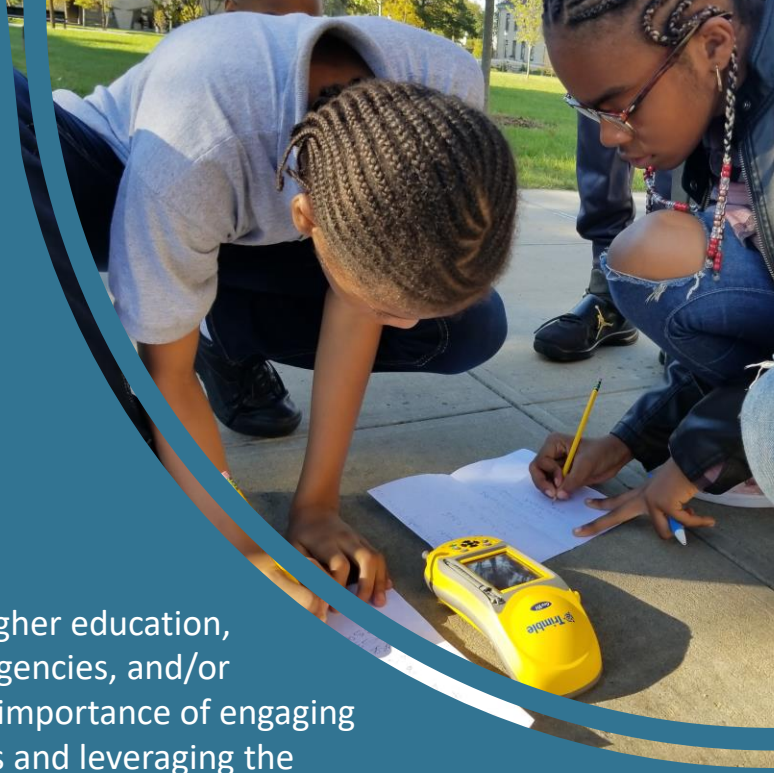
Twelve ATE projects are funded to provide services and support specifically for ATE grantseekers and grantees and their affiliates. These projects include the following:

- **AccessATE** supported ATE projects in making their materials and activities more accessible to all students and faculty, including those with disabilities.
- **ATE Central** served as the ATE program's information hub, dedicated to highlighting ATE projects' work and supporting them in various aspects of their work, such as archiving, outreach, and connecting with others in the ATE community.
- **ATE Collaborative Outreach and Engagement** raised awareness of the ATE program, primarily through the publication of the *ATE Impacts* book.
- **Community College Presidents Initiative – STEM (CCPI STEM)** strengthened leadership skills and grant awareness in community college faculty and administrators.
- **EvaluATE** strengthened the evaluation capacity of those involved with ATE projects through training, networking opportunities, and research, including administration of the ATE Survey.
- **Journal of Advanced Technological Education (JATE)** supported scholarship and published peer-reviewed publications relevant to the ATE community.
- **Mentor-Connect** served as a mentoring and leadership development program for two-year institutions of higher education new to the ATE program.
- **Mentor Links** served as a mentoring initiative to support community colleges in developing new or strengthening existing STEM technician education programs.
- **Mentor Up** served as a mentoring initiative to support teams in developing and submitting successful ATE proposals.
- **Project Vision** encouraged presidents of colleges new to NSF funding to apply for grant programs in the NSF Division of Undergraduate Education.
- **Pathways to Innovation** supported ATE projects in integrating the Business Industry Leadership Team model for productive partnerships with industry.
- **Working Partner Workshops** provided training to ATE project teams on how to effectively and sustainably collaborate with industry partners.

**Delivered 53 workshops**
that engaged an average of
**50 people per webinar**

**Delivered 65 webinars**
that engaged an average of
**53 people per webinar**

**Provided over 450 people**
with one-on-one technical assistance



# COLLABORATION

NSF encourages ATE projects to partner with other institutions of higher education, secondary schools, businesses, industries, economic development agencies, and/or government agencies. The ATE program solicitation emphasizes the importance of engaging with industry to ensure programs are responsive to workforce needs and leveraging the assets of industry in preparing students for employment (NSF, 2018). According to the Brookings Institution, hallmarks of successful community college–based workforce training programs include employer involvement in curriculum development and workplace experiences for students (Soliz, 2016).

ATE PIs were asked about the types of entities with which they collaborated and the benefits of those collaborations, including monetary and in-kind support. Projects that collaborated with business and industry were asked to identify the specific ways in which they worked with these groups.

# COLLABORATION

## ATE projects collaborated with over 5,760 other organizations and institutions.

**In 2023, ATE projects collaborated with 2,380 business and industry partners, 1,210 colleges, 900 K–12 schools, 390 entities within their host institutions, 530 other ATE projects, 270 public agencies, and 90 other types of partners**. ATE projects collaborated with a median of three business and industry groups, one K–12 school, one college, and one other ATE project.

ATE projects most frequently collaborated with **business and industry** groups, followed by other **two- or four-year colleges**.

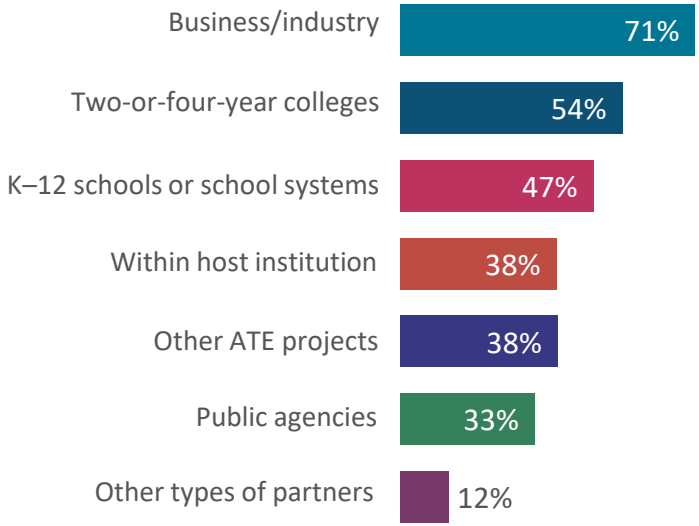



Figure 20. Percentage of ATE projects that collaborated with other groups, by type (*n*=312)

Most projects that indicated they worked with other types of partners identified these collaborators as professional associations and networks.

Collaborators provided over $11 million in monetary and in-kind support to 96 ATE projects.

$7,844,200 monetary support

$3,159,960 in-kind support

**Thirteen percent of projects reported receiving monetary support from collaborators, while 23% reported receiving in-kind support (*n*=312).** The median contributions for monetary support and in-kind support across projects were $48,750 and $10,000, respectively. Of the 73 projects that reported in-kind support, this primarily consisted of staff time (68%) and equipment (36%). Other types of in-kind support included access to facilities, materials, and supplies.

Participating with business and industry is important to the ATE community. The next page presents more information on how projects collaborated with these groups.

# COLLABORATION WITH BUSINESS AND INDUSTRY

Seventy-one percent of ATE projects collaborated with business and industry partners.

A total of 223 projects reported collaborating with business and industry groups. Most used these partners to **identify workforce needs**, **serve on an advisory board**, or **review and advise on curriculum**.

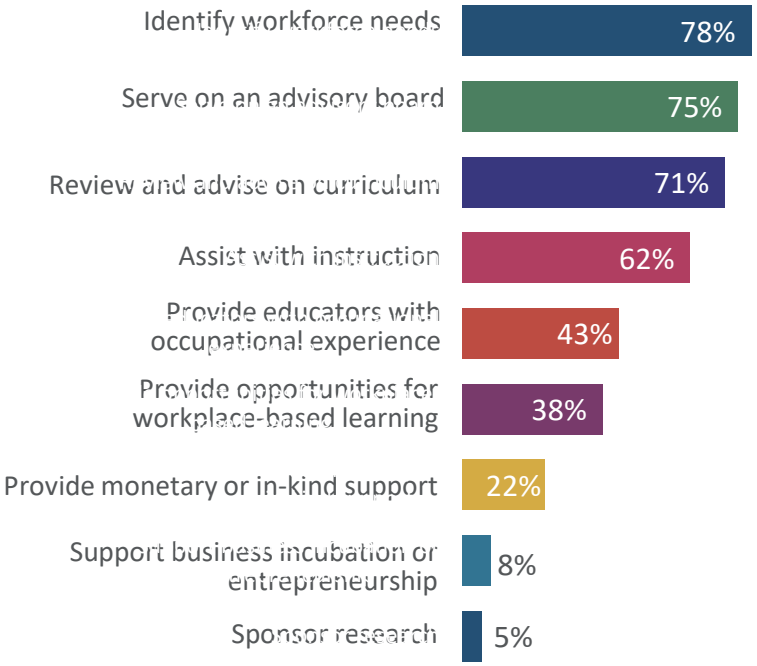



Figure 21. Percentage of projects reporting contributions from business and industry partners (*n*=223)

Business and industry representatives serve on advisory boards for 167 projects. Most of these projects (54%) reported that their advisors from business and industry committed two to five hours per year to their ATE projects.

When asked to identify the benefits of collaborating with different organizations and groups, PIs frequently pointed to the utility of the information that they received from them. For example, one PI noted:

> **"By collaborating with multiple internal and external partners, … [the] team was able to create a community for support for the… project that increased awareness of the career path and helped increase enrollment."**

Collaborations with industry groups were also noted by PIs as important to project innovation and growth:

> **"Collaborating with industry allowed us to bridge the gap of what students learn in the classroom compared to applying it in industry… to learn what is new in the industry, what academic and career pathways students should track to get into the career of interest [and] learn how other females navigated traditional male-dominated careers."**


# EVALUATION

Each ATE project is required to have an evaluation component to assess its quality and effectiveness. Evaluation of ATE and other NSF-funded projects is intended to serve two distinct purposes: (1) Produce information that can be used to improve a project as it is being implemented and (2) Determine and document a project's achievements (Frechtling, 2010).

ATE PIs were asked about their evaluators and interactions with them, as well as their projects' use and dissemination of evaluation results.

# EVALUATION

## Ninety-three percent of ATE projects engaged an evaluator.

Two hundred and ninety ATE projects had evaluators in 2023. Of the 22 PIs who said they did not have evaluators, 8 reported that evaluators would start work in 2024 either by design or due to delays, 2 projects did not require an evaluator, 1 reported terminating their original evaluator, and 1 reported a lack of internal support for the project. The remaining 9 did not provide a rationale.

**Of the 290 projects with evaluators, 90% reported having an external evaluator only, with 7% having both an internal and external evaluator and 3% having only an internal evaluator.**

Forty-four percent of PIs reported that they interacted with their evaluators occasionally (more often than quarterly), while 24% interacted with their evaluators often (two or three times a month) and 16% interacted infrequently (once a quarter or less). Eight percent interacted continuously (at least once a week) with their evaluator, and 7% interacted with their evaluator rarely (annually or semiannually).

More than half of ATE projects received **both oral and written** evaluation reports.

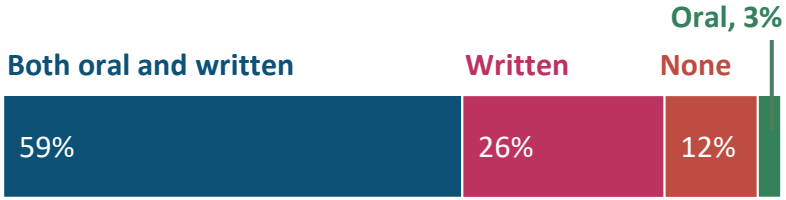



Figure 22. Types of evaluation reports received by ATE projects (*n*=290)

**Of the 256 PIs who received evaluation reports, 53% indicated their project's evaluation caused them to make a change in implementing their project**, and 46% indicated that the evaluation caused them to make a change in their project's timing.

Most projects shared their evaluation results with **NSF program officers**, **faculty or staff at their host institution**, and **executive administrators** in their organization.

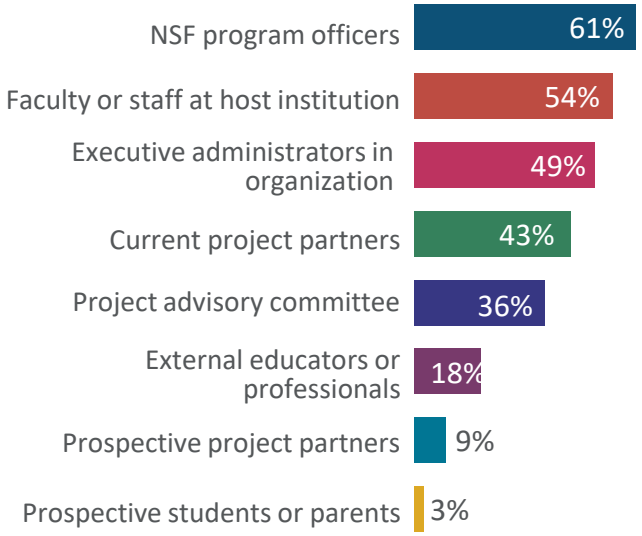



Figure 23. Percentage of projects that shared their evaluation results with various audiences (*n*=312)

# ATE SURVEY
## 2024 HIGHLIGHTS

This summary of activities and achievements of the Advanced Technology Education (ATE) program is based on the 2024 ATE Survey. Principal investigators for 97% of ATE grants (*n*=312, out of a total of 322 active ATE grants) completed the survey. Respondents represented grants supporting 281 projects, 21 centers, 1 conference, and 9 targeted research projects.

## 110 DEGREE PROGRAMS AND 330 COURSES

were developed by 64 ATE projects.

Most (60%) of all academic degree programs developed were certificate programs, and a majority (89%) of courses developed were at the associate degree level.

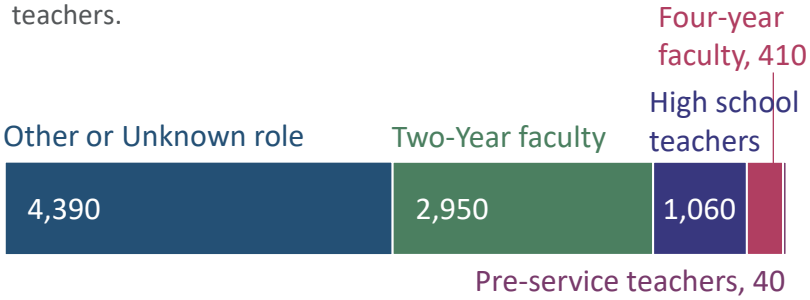
**30** associate degree programs served 1,510 students

**60** certificate programs served 6,520 students

## 4,460 EDUCATORS

Participated in 650 professional development activities.

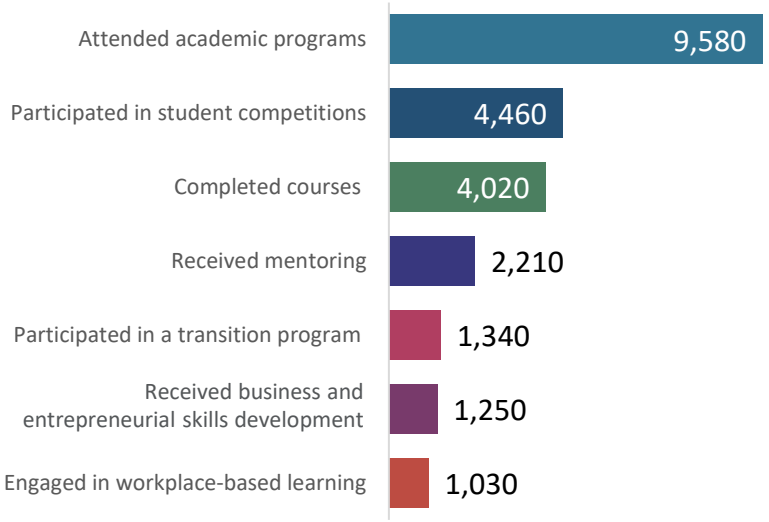
Over 2,950 educators who received professional development were located at two-year colleges followed by 1,060 high school teachers.




## 23,890+ STUDENTS

were served by ATE projects.

ATE projects served over 23,890 students through a variety of activities in 2023.* ATE projects served the most students through developing or modifying academic programs, followed by developing business and entrepreneurial skills.




* Due to the structure of the survey questions, the total number of students served may not represent a count of unique students.

McClure, L., Sturgis, E., & Becho, L. W. (2024). ATE annual survey: 2024 highlights.

# ATE SURVEY
## 2024 HIGHLIGHTS (continued)

### 5,270 EDUCATIONAL MATERIALS
were developed by 123 ATE projects.

Educational materials developed included assessment activities, modules or instructional units, lessons, lab experiments, curricula, case studies, instructor guides, and textbooks.

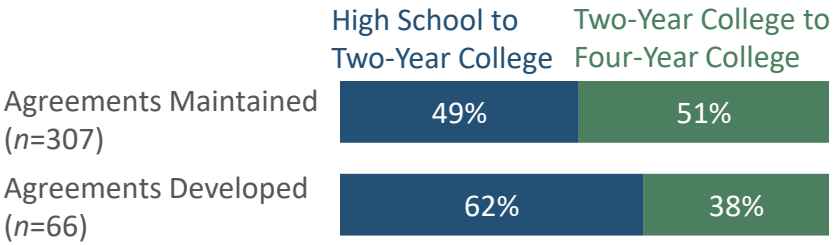
**1,110**
Modules or instructional units

**1,310**
Assessment activities or tests

**570**
Lab experiments

### 380 ARTICULATION AGREEMENTS
were developed or maintained by 40 ATE projects.

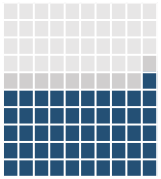
1,690 students matriculated to a higher-level education institution with the aid of an ATE-supported articulation agreement.




### 5,760 COLLABORATORS
were engaged by ATE projects.

ATE projects most frequently collaborated with business and industry groups and other colleges and universities.

**71%** collaborated with **business and industry groups**



**54%** collaborated with **other two- and four-year colleges**

### OTHER ACTIVITIES were conducted by ATE projects in 2023 in support of advanced technological education.

ATE projects engaged in a wide range of activities. More information about those listed below and others can be found in the full report.

operated **10 coordination networks**

conducted **50 research studies**

hosted **10 conferences**

developed **200 publications**

This material is based upon work supported by the National Science Foundation under grant number 1841783. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

McClure, L., Sturgis, E., & Becho, L. W. (2024). ATE annual survey: 2024 highlights.

# TECHNICAL NOTES

[i] The 2021 ATE Survey asked about the racial, ethnic, and gender identities of students in alignment with how the National Center for Education Statistics requests student demographic data from colleges. This involves asking students' race, ethnicity, and gender in a single question. This approach differs from years prior to 2019, when PIs were asked to report on the race, ethnicity, and gender identities of their students in separate questions. Additionally, ATE PIs were asked to report demographics for only students who had attended at least one course in an academic program that was developed or substantially modified in 2019. Prior to 2019, projects reported demographic information on students who attended at least one course in an ATE-supported academic program. This, in addition to a lower than previous response rates, resulted in a decrease in student demographic data for the 2020–22 reports.

[ii] National data for two-year STEM programs and certificates are from the 2011-2012 National Center for Education Statistics Digest of Education Statistics *Table 320.10* and *Table 321.10.* (Retrieved from https://nces.ed.gov/programs/digest/current_tables.asp.) Selected fields of study include agriculture and natural resources, biological and biomedical sciences, communications technologies, computer and information sciences, construction, engineering and engineering technologies, mechanic and repair technologies/technicians, physical sciences and science technologies, precision production, and transportation and materials moving. While these are not exact comparison groups, they are as close as available data allow.

[iii] Comparison data for student demographics are from the National Center for Education Statistics. The referenced NCES tables were retrieved from https://nces.ed.gov/programs/digest/current_tables.asp. The national percentage of underrepresented minority students at the two-year level reflects STEM degrees conferred in the 2019–20 school year, derived from *Table 321.30*. Selected fields of study are the same as those listed in note ii. National rates for certificate programs are not presented because they are not reported by race and STEM field.

# REFERENCES


Amelink, C. T., Artise, S., & Lue, T. K. (2015). Examining the self-efficacy of community college STEM majors: Factors related to four-year degree attainment. *Community College Journal of Research and Practice, 39*(12), 1111–1124.

Anderson, M. K., Tenenbaum, L. S., Ramadorai, S. B., & Yourick, D. L. (2015). Near-peer mentor model: Synergy within mentoring. *Mentoring & Tutoring: Partnership in Learning, 23*(2), 116–132.

Baber, L. D. (2018). "Living in the along": Validating experiences among urban community college students in a college transition program. *Community College Review, 46*(3), 316–340.

Biancani, S., McFarland, D. A., & Dahlander, L. (2014). The semiformal organization. *Organization Science, 25*(5), 1306–1324.

Chai, S., & Freeman, R. B. (2019). Temporary colocation and collaborative discovery: Who confers at conferences. *Strategic Management Journal,* 1–27.

Committee on STEM Education, National Science and Technology Council. (2018). *Charting a Course for Success: America's Strategy for STEM Education.* Washington, DC: Executive Office of the President. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf

Committee on STEM Education, White House Office of Science and Technology. (2024). *2023 Progress Report on the Implementation of the Federal Science, Technology, Engineering, and Mathematics (STEM) Education Strategic Plan.* Washington, DC: Executive Office of the President. https://www.whitehouse.gov/wp-content/uploads/2024/04/2023-CoSTEM-Progress-Report.pdf

Crisp, G. (2010). The impact of mentoring on the success of community college students. *The Review of Higher Education, 34*(1), 39–60.

Davis, E. A., Janssen, F. J. J. M., & Van Driel, J. H. (2016). Teachers and science curriculum materials: Where we are and where we need to go. *Studies in Science Education, 52*(2), 127–160.

Edgecombe, N. (2019). Demography as opportunity. *Community College Research Center Working Paper, 16.* https://ccrc.tc.columbia.edu/publications/demography-opportunity.html

Frechtling, J. (2010). *The 2010 user-friendly handbook for project evaluation*. Washington, DC: National Science Foundation.

Jackson, D. (2014). Employability skill development in work-integrated learning: Barriers and best practice. *Studies in Higher Education, 40*(2), 350–367.

# REFERENCES

(continued)


Merolla, D. M., & Serpe, R. T. (2014). STEM enrichment programs and graduate school matriculation: The role of science identity salience. *Social Psychology of Education, 16*(4), 575–597.

Miller, K., Sonnert, G., & Sadler, F. (2018). The influence of students' participation in STEM competitions on their interest in STEM careers. *International Journal of Science Education, 8*(2), 95–114.

National Academies of Sciences, Engineering, and Medicine (NAS). (2017). *Building America's skilled technical workforce*. Washington, DC: The National Academies Press.

National Academy of Engineering and National Research Council. (2012). *Community colleges in the evolving STEM education landscape: summary of a summit.* Washington, DC: National Academies Press. http://www.nap.edu/catalog.php?record_id=13399

National Science Foundation (NSF). (2018). *Advanced technological education program solicitation* (NSF18-571). Washington, DC: Author. https://www.nsf.gov/publications/pub_summ.jsp?WT.z_pims_id=5464&ods_key=nsf18571

National Science Foundation (NSF). (2024). *Advanced technological education program solicitation* (NSF24-584). Washington, DC: Author. https://new.nsf.gov/funding/opportunities/ate-advanced-technological-education/nsf24-584/solicitation

National Science Foundation (NSF). (2023). *Diversity and STEM: Women, minorities, and persons with disabilities in science and engineering.* Washington, DC: Author. https://ncses.nsf.gov/pubs/nsf23315/

Scientific and Advanced-Technology Act of 1992, Pub. L. No. 102–476, 106 Stat. 2297 (1992). https://www.govinfo.gov/content/pkg/STATUTE-106/pdf/STATUTE-106-Pg2297.pdf#page=4

Soliz, A., (2016). *Preparing America's labor force: Workforce development programs in public community colleges.* Washington, DC: Brookings Institution. https://www.brookings.edu/research/preparing-americas-labor-force-workforce-development-programs-in-public-community-colleges/

Strickland-Davis, S., Kosloski, M., & Reed, P. A. (2019). The impact of professional development grounded in social learning on community college faculty efficacy. *Community College Journal of Research and Practice.*

United States Census Bureau. (2023). 2023: ACS 1-year estimates subject tables – Age and sex. *American Community Survey*. [data set]. Accessed October 31, 2024. https://data.census.gov/table/ACSST1Y2023.S0101?moe=false.

# ATE Survey

## 2024 Report

November 2024

Lee McClure
Erika Sturgis
Lyssa Wilson Becho
Lori A. Wingate
Arlen Gullickson

Suggested citation:

McClure, L., Sturgis, E., Marshall, V. A., Becho, L. W., Wingate, L. A., & Gullickson, A. *ATE Survey: 2024 report*. Kalamazoo, MI: The Evaluation Center, Western Michigan University. Retrieved from https://atesurvey.evalu-ate.org/

This material is based upon work supported by the National Science Foundation under grant number 1841783. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.