

**Reforming Engineering Technology Education:
Fifth Year Evaluation of the South Carolina Center for
Advanced Technological Education**

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Introduction

This report presents a preliminary evaluation of the South Carolina Advanced Technological Education (SC ATE) program, a combination of curriculum reform, faculty development, and student services designed to increase the quantity, quality, and diversity of engineering technology graduates. The following three sections of this report analyze the need for the ATE program, document the implementation of the program, and estimate the program's initial impact on students. Since the ATE curriculum has only been offered for two full academic years, not enough data are available to evaluate the program thoroughly and definitively. At this time, however, preliminary evidence suggests that the program is succeeding in reaching its goals. In the coming year, Academy for Educational Development (AED) evaluators, in partnership with SC ATE Center for Excellence staff, will continue to gather both quantitative and qualitative data in order to verify the conclusions made in this report.

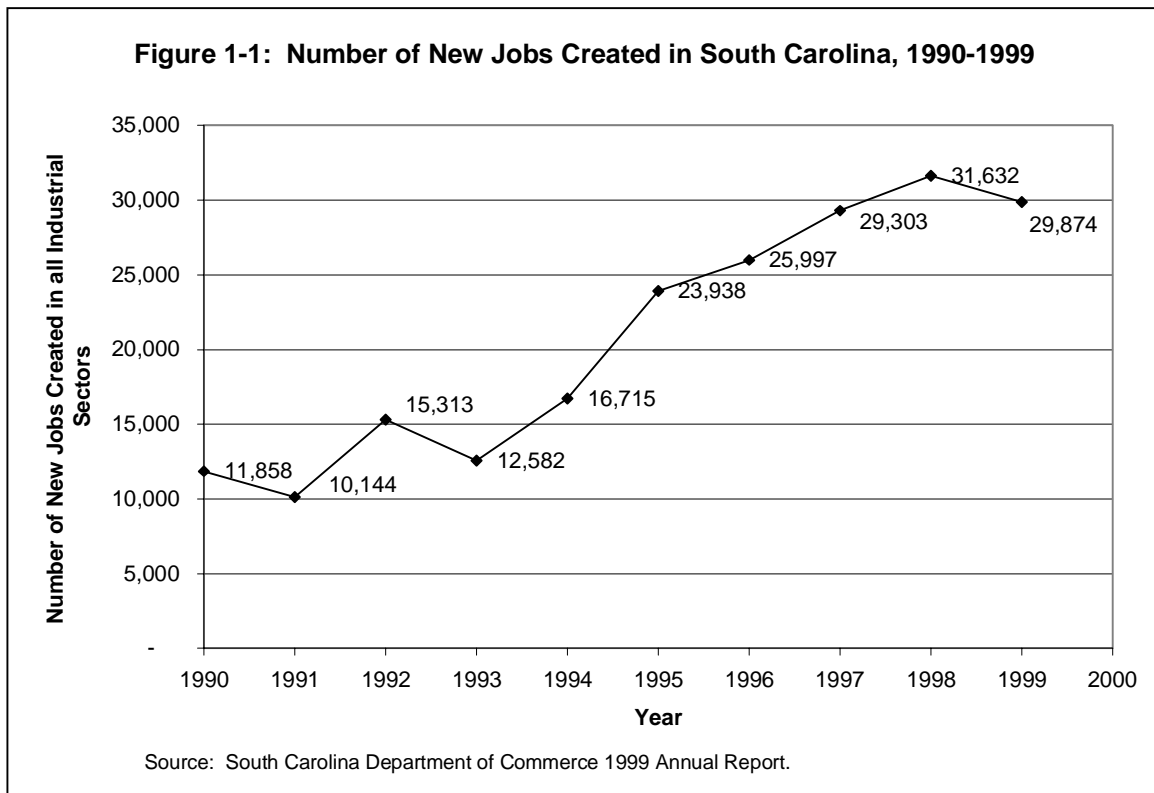
1. Background: There is a shortage of qualified engineering technicians in South Carolina.

South Carolina faces a shortage of engineering technicians, especially those who are “workplace ready.” A recent South Carolina Chamber of Commerce survey found that machine operators were the most difficult positions for employers to fill in 2000, a year in which historically low unemployment made it difficult to fill almost any position.¹ One year earlier, more than 15,000 technology-intensive jobs were unfilled in South Carolina, according to the South Carolina Technology Alliance.² The combination of tremendous growth in manufacturing jobs and low output of engineering technology graduates have contributed to a worker shortage. Employers are not only calling for more workers, they are also calling for more well-rounded workers, workers who have communication, cooperation, and problem-solving skills in addition to technical skills.

1.1. Demand for manufacturing technicians in South Carolina is booming.

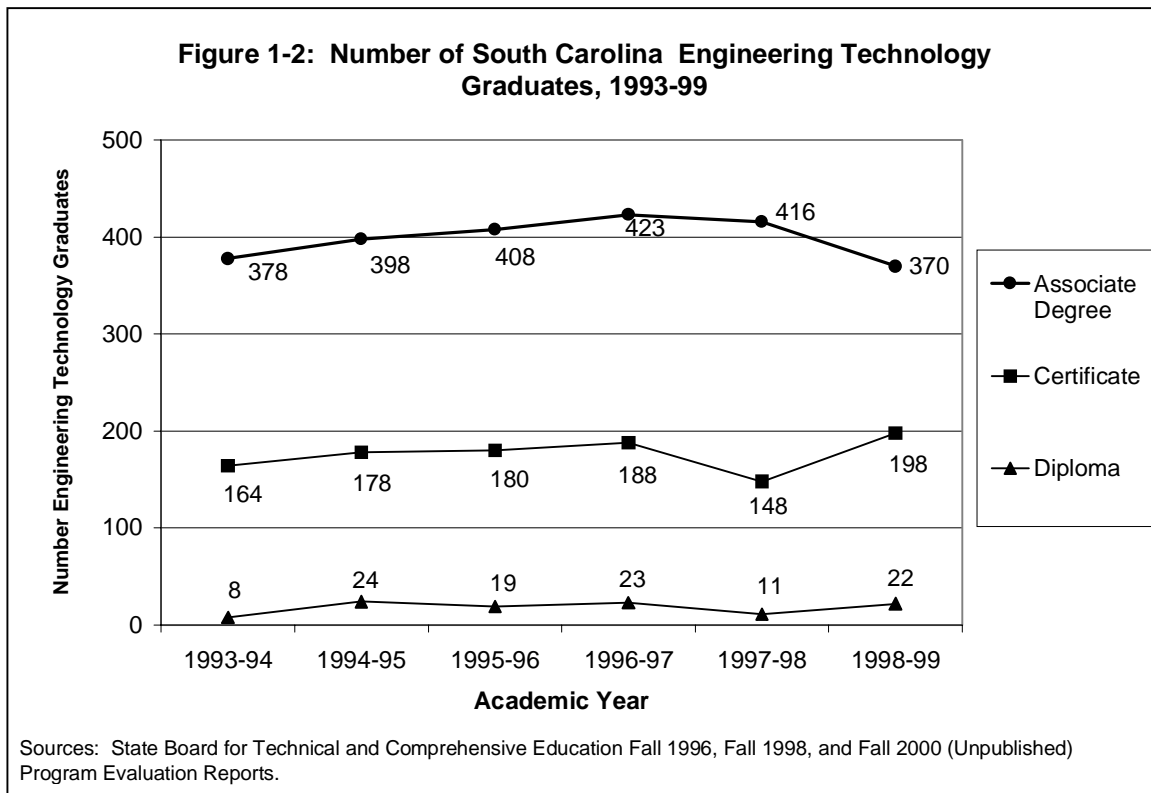
The increasing use of technology among South Carolina manufacturers and influx of new technology-intensive companies to the state are boosting demand for engineering technicians. Throughout the 1990s, South Carolina industry created jobs at a breakneck pace. (See figure 1-1 below). Manufacturing, the largest and fastest growing sector of the South Carolina economy,³ created 153,000 manufacturing jobs between 1990 and 1999, accounting for 74% of the

total new jobs in the state.⁴ In 1999 alone, 1,296 South Carolina manufacturing companies announced capital investments totaling \$6 billion and creating 23,039 jobs.⁵ Many of these were major international corporations, including Michelin (1,400 jobs), Siemens Diesel Systems Technology (500), Robert Bosch Corporation Automotive Group, (400), BMW Manufacturing Corporation (400), and Mack Truck, Inc. (350). These expansions also generate jobs for small firms that supply parts and services for the larger operations. The U.S. Bureau of Labor Statistics and the South Carolina Employment Security Commission predict that jobs for engineering technicians and related support workers in South Carolina will increase by 20% (3,460) from 1996 to 2006.⁶ With such rapid growth, South Carolina manufacturers have a strong demand for engineering technicians.



1.2. Engineering technology graduates are in short supply.

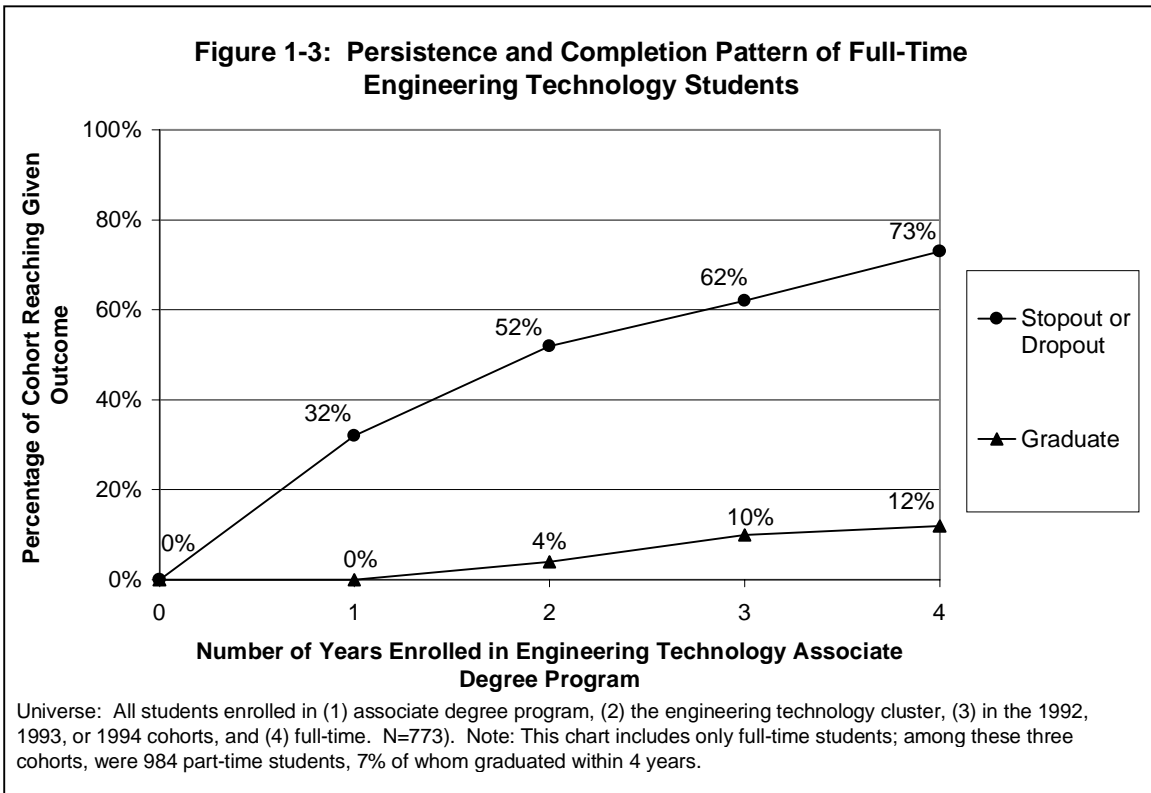
In spite of the strong demand for engineering technicians, and although the vast majority of entering engineering technology students cite “completing an ET degree” as their main objective,⁷ few South Carolina students graduate with engineering technology degrees. In any given year between 1994 and 1999, roughly 400 students graduated with associate degrees in engineering technology from the state’s technical colleges; less than half of that number graduated with certificates, and even fewer completed diplomas. (See figure 1-2, below). In comparison to the thousands of new manufacturing jobs opening up each year, this output is low. Any of several major manufacturers produced enough jobs in 1999 alone to employ an entire graduating class of ET students. Output is so low because few students, particularly African Americans, complete



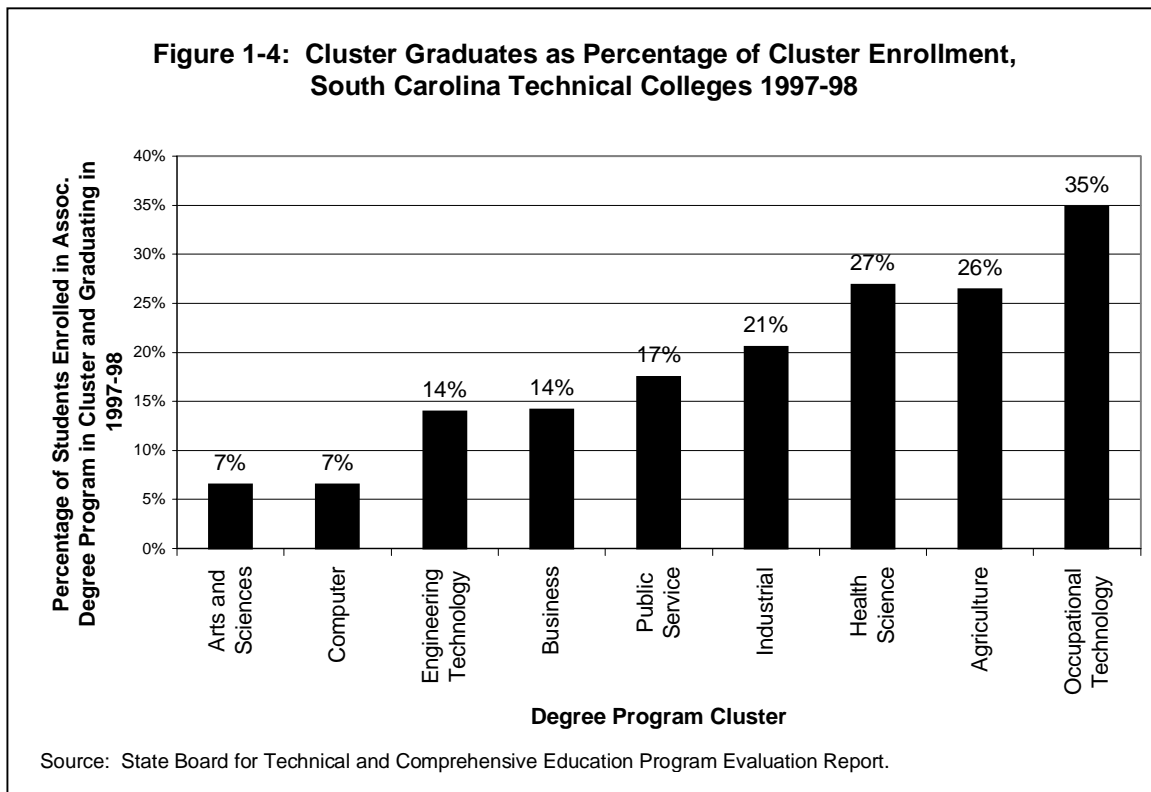
ET degree requirements and because few women and minorities enroll in engineering technology programs.

1.2.1. Few students persist through engineering technology programs to graduation.

Only a handful of students who enter engineering technology programs ever graduate. After being enrolled in technical college for four years, only 12% of full-time students in the 1992, 1993, and 1994 cohorts graduated with an associate degree in engineering technology.⁸ Nearly three-quarters (73%) had either stopped out or dropped out after four years.⁹ The remainder either were still enrolled but had not completed a degree (18%) or had switched from engineering technology and graduated with an associate degree in a different



program (5%). (See figure 1-3, previous page). Of the nine degree program clusters at South Carolina state technical colleges, students in the engineering cluster are among the least likely to graduate. In the 1997-98 academic year, graduates accounted for only 14% of students enrolled in associate degree programs in the engineering technology cluster.¹⁰ Graduation rates in other clusters, by contrast, were as high as 35%.¹¹ (See figure 1-4, below). At such low degree completion rates, the State of South Carolina loses most of its investment in engineering technology students. If just one-fourth of all full-time engineering technology associate degree students were to earn a degree, instead of the current rate of one-eighth, the state technical college system would double its output of engineering technicians and supply hundreds of badly needed workers to South Carolina industries each year.

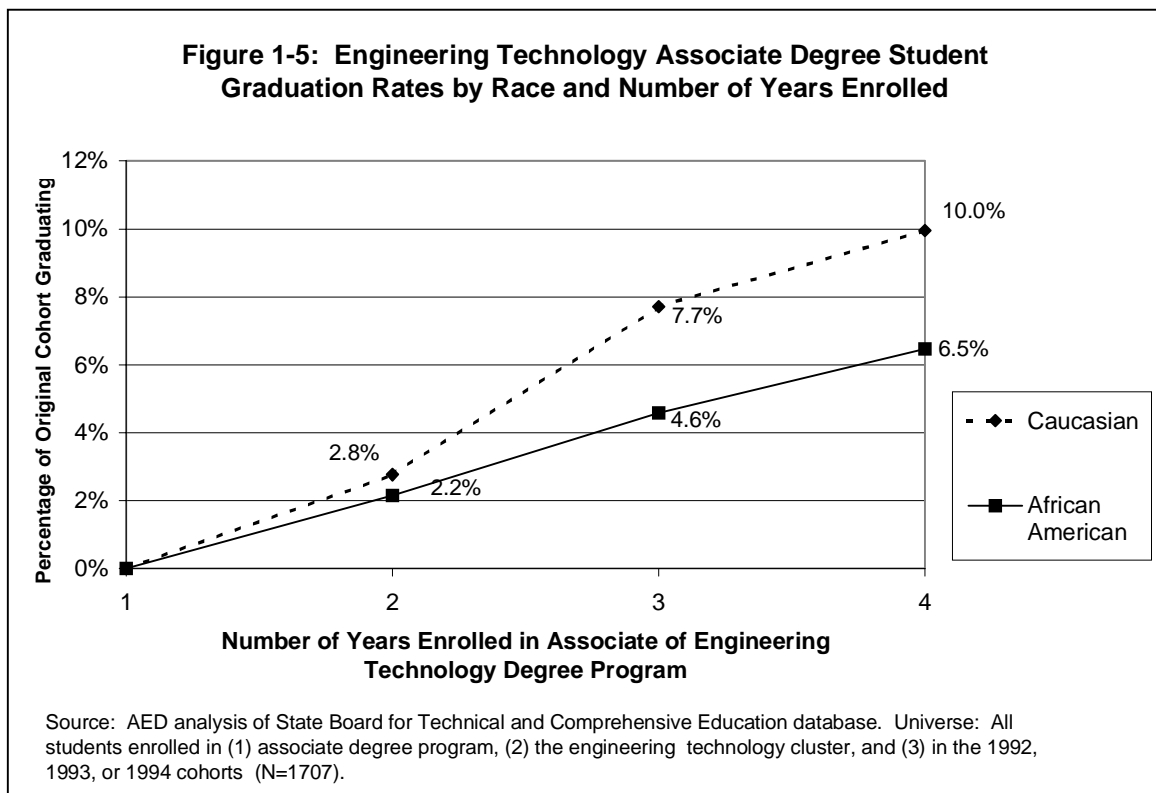


The key to such an increase in graduation rates likely lies in getting more students through critical 100-level general education courses. Of the students who stop out or drop out of engineering technology, nearly half (44%) do so within the first year when students typically take 100-level courses. Even fewer engineering technology students advance from 100-level to 200-level ET courses. AED reviewed student records from two South Carolina technical colleges and discovered that only 35% of engineering technology students in the 1995 and 1996 cohorts had advanced to 200-level ET courses by Fall 2000.¹² Interviews and focus groups with South Carolina technical college students, faculty, and administrators indicate that general education courses, which include English, math, and science, pose the biggest stumbling block to student persistence and graduation.¹³ Many engineering technology students do not see the relevance of these theoretical courses or find the abstract subject matter too difficult and subsequently abandon their pursuit of an ET degree. Boosting the number of students who pass these courses would likely have a big impact on the number of ET graduates.

1.2.2. African Americans students are particularly likely to drop out of engineering technology programs.

African American engineering technology students are 50% less likely to graduate than Caucasian engineering technology students. Just 6.5% of blacks beginning ET studies in the 1992, 93, and 94 cohorts graduated with an Associate in ET after four years compared to 10% of whites. (See figure 1-5,

below). This disparity is consistent with national trends. A recent U.S. Department of education study found that rates of Asians and whites graduating from undergraduate science and engineering programs were 71% higher than rates for underrepresented minorities.¹⁴ If the graduation rate for black students were to rise to parity with the graduation rate for white students, roughly 20 additional students from each annual cohort would graduate.¹⁵ Program improvements that increase graduation rates for all students, in combination with increased recruitment of minority students, would increase this output even more.



The ethnic achievement gap begins even before students enroll in college. African American students in South Carolina are less academically prepared for college, on average, than their Caucasian peers. They score significantly lower in all subject areas of the Scholastic Aptitude Test (SAT), the American College

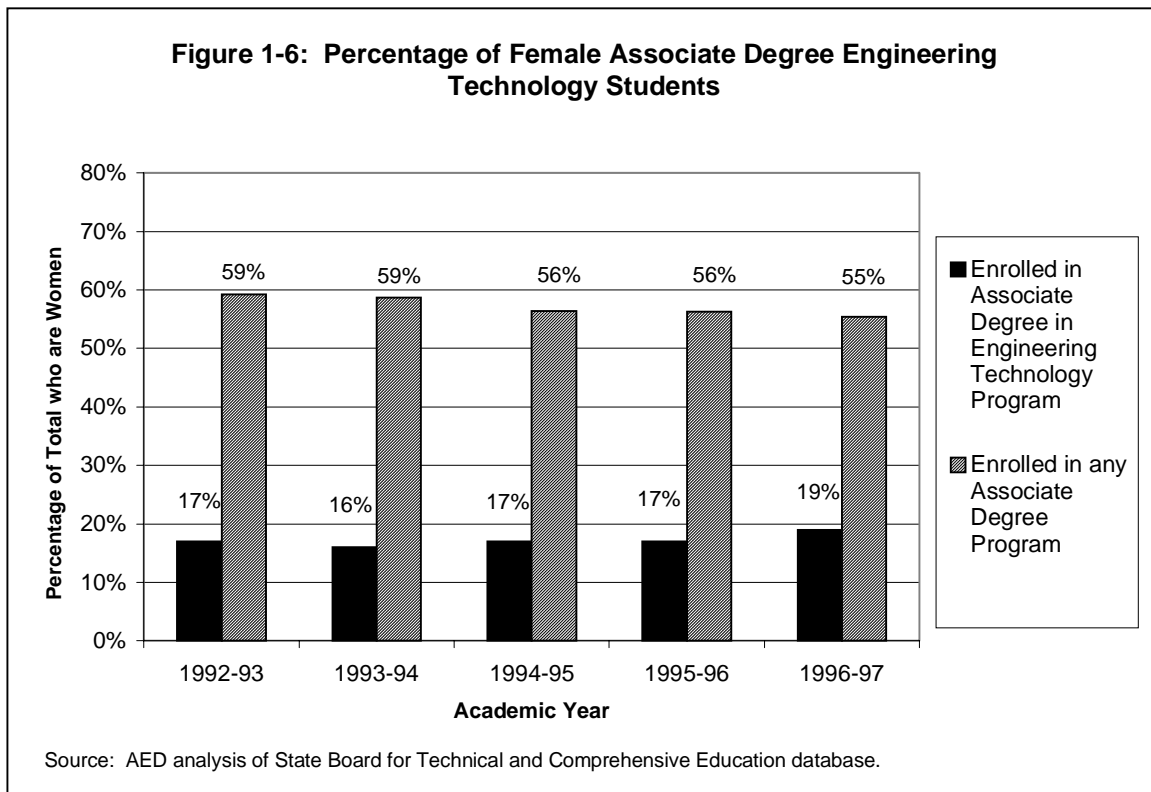
Test (ACT), and the state High School Exit Examination and they are far less likely to complete 20 or more high school academic courses, the minimum number recommended by the College Board.¹⁶ In spite of this gap, the State Tech system historically has not had a special program to prepare under-achieving students for engineering technology.

A second cause of the ethnic graduation disparity may be a disproportionate level of financial need. National research indicates that a lack of financial support is a major reason that so many underrepresented minorities drop out of post-secondary science and engineering programs.¹⁷ South Carolina research corroborates this, indicating that minority engineering technology students are more likely than their Caucasian peers to require financial aid to finish their degrees.¹⁸ On average, African Americans in South Carolina have much less ability to pay for college. The per capita income for black South Carolinians (\$6,800) was less than half that for white South Carolinians (\$14,115) in 1989, according to the 1990 US Census.¹⁹ In spite of this financial need and graduation disparity, no scholarships specifically directed at engineering technology students have been historically available in the South Carolina technical college system.

1.2.3. Few women and minorities study engineering technology.

Few women enroll in engineering technology programs in South Carolina. From fall semester 1992 to spring semester 1998, less than one in five engineering technology students in the South Carolina technical college system

was female even though women comprised over half of total college enrollments. Although there was a small spike in female enrollment in the 1996-97 school year, female enrollment remained roughly constant during the mid-1990s, ranging between 16% and 19%. Meanwhile, the proportion of women enrolled in all associate degree programs was roughly three times higher, ranging between 55% and 59% during the same years. (See figure 1-6, below). This gender gap mirrors national trends. In the late 1990s, women made up only 13% of all engineering students in associate degree programs²⁰ and 19% of those in bachelor degree programs.²¹ If the number of female engineering technology students were to rise by half, so that the proportion of women in ET programs increased from 18% to 27%, and if historical persistence and graduation rates were to remain constant, roughly 30 additional students would graduate from



each annual cohort.²² With additional efforts to boost overall graduation rates, this number would be even higher.

Low female enrollment in engineering technology programs may be caused, in part, by a lack of women who are adequately prepared in science and math. National studies indicate that although girls take a similar number of most high school math and science courses as boys, they achieve a lower level of proficiency in advanced courses.²³ Although South Carolina women score higher than men on the verbal sections of the American College Test (ACT) and the South Carolina High School Exit Examination, they score lower on the math and science sections. They also score lower than men on both the verbal and math sections of the Scholastic Aptitude Test (SAT). Once enrolled in engineering technology programs, however, women are more likely than men to graduate. Ten percent of women beginning ET studies in the 1992, 93, and 94 cohorts graduated with an Associate in ET after four years compared to just eight percent of men. This is consistent with national trends.²⁴ A National Science Foundation study, for example, shows that more women (5.4%) than men (4.8%) completed an associate degree program within five years.²⁵

Minorities, particularly African Americans, are also underrepresented in engineering technology programs. Roughly the same percentage of minority students (19%) enroll in associate degree programs in engineering technology as enroll in associate degree programs overall. Relative to students enrolled in all South Carolina technical colleges for any purpose, including those pursuing diplomas, certificates, and or simply further education in addition to those

pursuing degrees, however, enrollments of minority students in engineering technology programs are low. Of the 54,100 students enrolled in credit programs in the South Carolina technical college system in Fall 1996, 28% (15,000) were black.²⁶ By comparison, in that same year, only 20% of engineering technology degree students were black. The disparity in academic preparation and financial resources mentioned in section 1.2.2. likely explain this disparity.

1.3. South Carolina businesses demand employees with “workplace readiness skills,” although traditional engineering technology programs do not emphasize these skills.

Surveys of South Carolina employers indicates that “workplace-readiness skills,” in addition to technical skills, are critical for engineering technicians, yet

| Table 1-1: Top 15 Worker Skills in Demand by South Carolina Employers | |
|--|---------------------------------------|
| Rank | Skill |
| 1 | Integrity and Honesty |
| 2 | Team Player |
| 3 | Listening Skills |
| 4 | Responsibility |
| 5 | Knowing How to Learn |
| 6 | Self Esteem |
| 7 | Reading Skills |
| 8 | Social Skills |
| 9 | Reasoning Skills |
| 10 | Ability to Allocate Time |
| 11 | Interpret and Communicate Information |
| 12 | Self-Management Skills |
| 13 | Problem-Solving |
| 14 | Working with Diversity |
| 15 | Arithmetic Skills |

Source: South Carolina Chamber of Commerce “Skills that Work 2000: A Comprehensive Analysis of South Carolina’s Workforce, Critical Jobs, and Necessary Skills.”

these skills are rarely taught in the traditional program of stand-alone, lecture-based courses. A 2000 survey by the South Carolina Chamber of Commerce of over 400 businesses found that employers are most interested in workers who can cooperate, communicate, solve problems, and act responsibly. (See table 1-1, left). Even for machine operators, the top five skills –

integrity/honesty, knowing how to learn, responsibility, team player, listening, and self esteem – were non-technical. State technical college faculty members visited 18 South Carolina manufacturers and discovered that employers seek similar skills in engineering technicians as they seek in workers generally. In addition to performing technical operations, they found, engineering technicians need to effectively communicate and cooperate with co-workers and supervisors. (See table 1-2, below). Not only must a worker be able to analyze graphs, he must be able to produce these graphs on a computer and explain their significance to others. Instead of just taking measurements, an engineering technician must be able to direct a coworker to do the same. In order to be fully prepared for the workplace, engineering technicians need interpersonal and communication skills, in addition to technical skills.

| Table 1-2: Major Workplace Skills Required of South Carolina Manufacturing Workers | |
|---|--|
| Communication/Interpersonal | Technical Operations |
| Read critically | Perform measurements |
| Give oral directions | Keep records of procedural steps |
| Use electronic communication technology | Conduct fundamental math operations, including unit conversion |
| Plan and prepare short reports | Solve problems and make decisions |
| Work in teams and small groups | Analyze data graphically |
| | Express quantities with precision and identify experimental errors |
| Source: Lynn G. Mack, Thomas V. Mecca, and Sara Cushing Smith. "Shaping a Curriculum for Workplace Research." Presentation to the ASEE Annual Conference. 1998. | |

The traditional engineering technology curriculum, however, is not structured to prepare students to apply these crucial communication and

interpersonal skills in a high-tech manufacturing workplace. Giving oral directions or preparing report about technical topics, for example, require a worker to integrate communication skills and technical skills. Communications skills, however, are typically taught in English, speech, or communications classes devoid of engineering content. Students may learn to write term papers in these courses, but the content of these papers is rarely technical. Likewise, in engineering courses, students acquire technical knowledge but rarely practice communicating this knowledge to others on paper, in speeches, or through group activities. Instead, students are left to their own devices to integrate communications and technical knowledge into workplace skills. Teamwork and problem-solving are skills rarely taught in textbook and lecture-based courses. In these classes, students have few opportunities to work in a team. Instead of solving the complex, open-ended problems they are likely to encounter in the workplace, students apply their skills to textbook exercises. Employers, administrators, and faculty indicated the importance of teaching workplace readiness skills in engineering technology programs during site visits by AED evaluators:

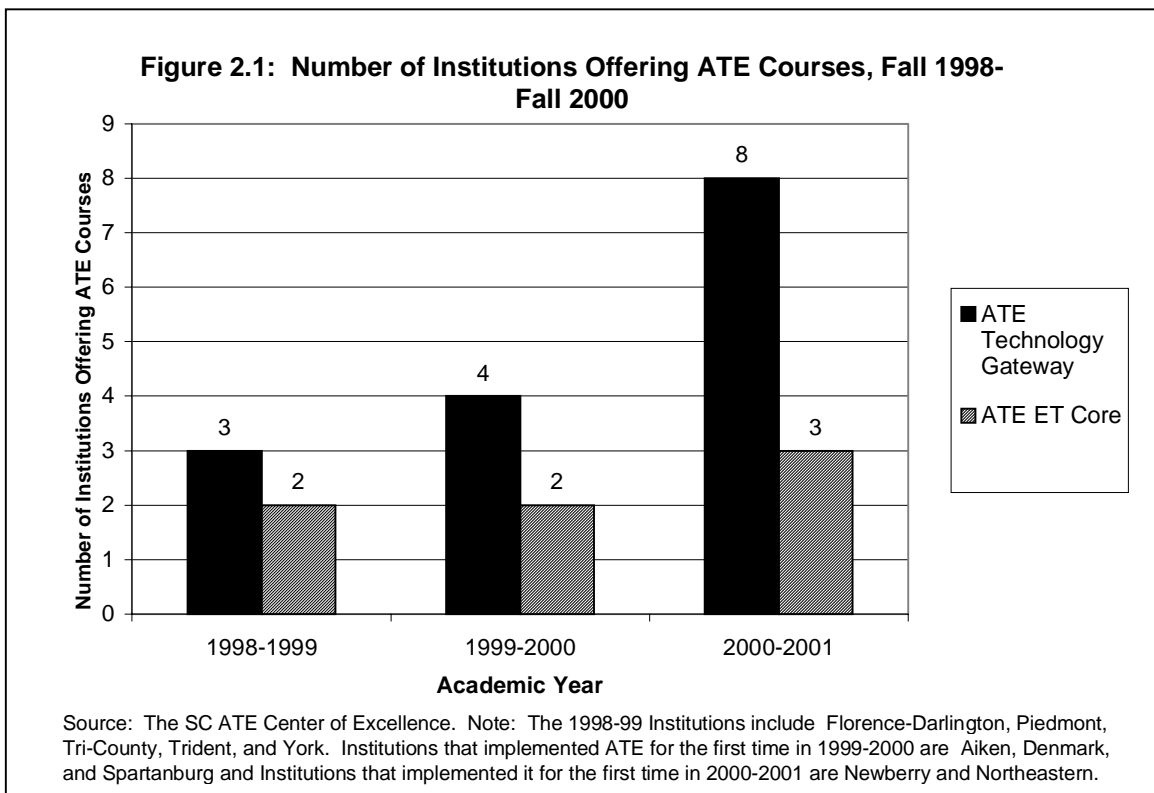
- “That’s all we do here – problem-solving and teamwork. . . the whole experience of learning how to deal with other people’s opinions – all of those skills are extremely valuable,” said one employer.
- “Students need to learn to solve problems. We don’t live in an a, b, c, or d world. People learn when they can make connections . . . not when you’re pounding them with information. In the traditional approach, what’s important

is that I cover the information, not that you learn it,” said a college administrator.

- “It’s very easy to cover a lot of material. That doesn’t mean the students will learn a lot of material. Are you assessing content or problem-solving ability?” said one faculty member.
- “I was in the real world for 20 years and I realize that much of the traditional content is unnecessary on the job. The process maybe is more important than the content. [Students] need to know how to solve problems. The answer is not always on page 49. The traditional model does not prepare you for how to solve a problem,” said another faculty member.
- “You can give me a book full of formulas or you can . . . not just define a stress-strain curve but actually do it. . . . You can do all the problems you want . . . I would rather cover less and know more than cover more and have less understanding,” said a third faculty member.

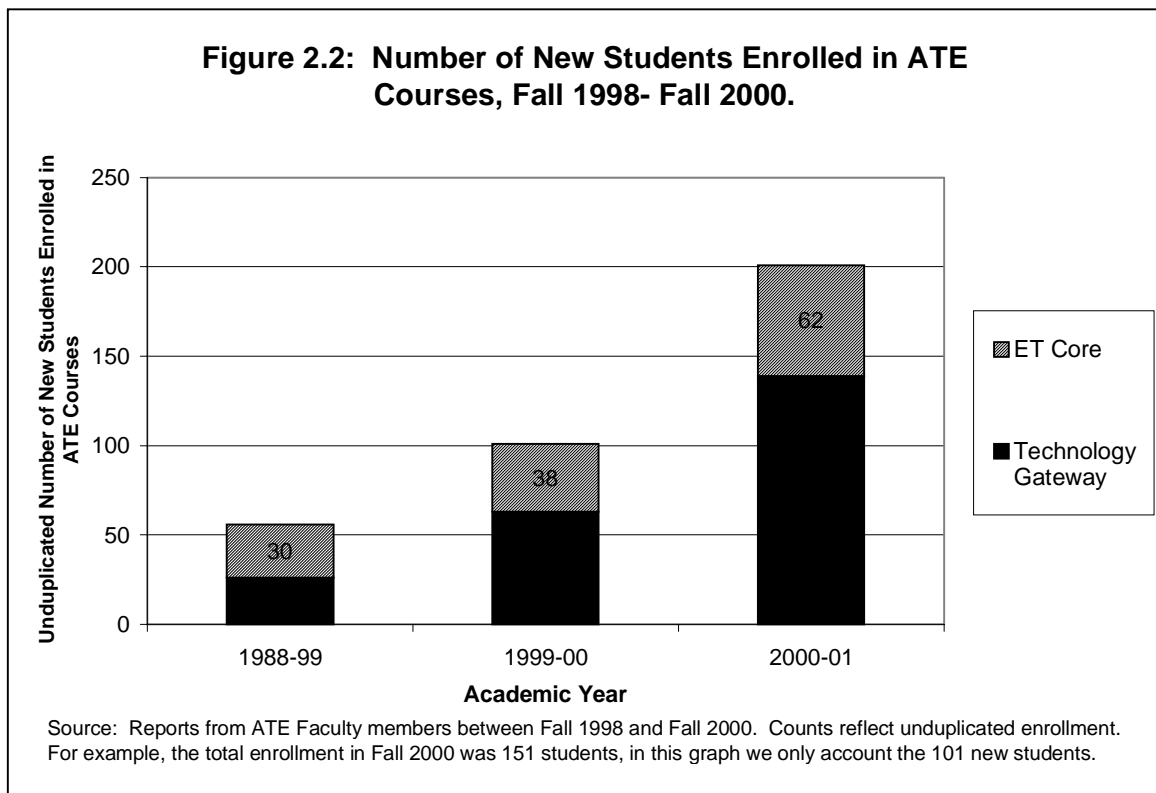
2. The Intervention: ATE classrooms model the workplace.

The ATE approach to engineering technology education, developed by the South Carolina Advanced Technological Education (SC ATE) Center of Excellence, is designed to increase the quantity, quality and diversity of engineering technology graduates by tailoring classroom teaching to workplace reality. Funded by two three-year grants from the National Science Foundation's Advanced Technological Education program, the Center has involved faculty members from across the state in curriculum development, faculty training, and ancillary program improvement activities.



Since 1998, the number of colleges, faculty, and students participating in the ATE program has grown steadily. In Fall 2000, three colleges offered the three-semester ET Core curriculum while seven colleges and one high school offered the one-semester preparatory Technology Gateway. (See figure 2-1, above). At

each college, three or four faculty members implement the ATE curriculum as a team. In Fall semester 2000, there were 34 such ATE teaching faculty. Other faculty members are prepared to deliver the ATE curriculum but have not yet had an opportunity to do so.²⁷ As more and more colleges have adopted the ATE curriculum, more and more students have participated in the ATE program. In the 2000-01 academic year, over 200 students enrolled for the first time in the ATE program, 82 in the ET Core and 151 in the Technology Gateway – over three times the number of students enrolled just two years earlier. (See figure 2-2, below).



In order to evaluate Center activities and ATE implementation, AED researchers administered a faculty survey, developed beginning and end of semester student surveys, interviewed faculty members, visited ATE classrooms,

and reviewed ATE training and curriculum materials. AED posed the following formative evaluation questions:

- What is the theory behind the ATE approach?
- What are the quality and extent of Center curriculum development, faculty training, and program improvement activities?
- Have faculty and administrators adopted and implemented the ATE approach as planned? If not, why?

This section presents preliminary answers to each of these questions.

2.1. The ATE approach incorporates integrated courses, problem-based learning, just-in-time teaching, student teaming, and industry scholarships and internships.

The ATE approach differs significantly from the stand-alone, lecture-based courses in the traditional engineering technology program. It is designed to model the workplace, thereby motivating students, enhancing their academic success, and developing their workplace skills. The five major elements of ATE approach – integrated courses, problem-based learning, just-in-time teaching, student teaming, and industry scholarships and internships – are explained below. (See table 2-1, on page 22, for a summary).

In the traditional engineering technology program, students are required to take a series of stand-alone general education courses, including English, mathematics, and science. The ATE approach, by contrast, integrates these subjects with each other and with engineering into a block of three or four

courses taught by a team of instructors. As mentioned in Section 1, many engineering technology students traditionally fail to complete their degrees because they find general education courses to be either too difficult or irrelevant. Course integration, according to education research, makes abstract concepts more comprehensible and more relevant to ET students. As one ATE faculty member put it, “The integration is the innovation.”

In the traditional method of instruction, faculty lecture students about academic concepts while students take notes, read textbooks, and take exams. This method may help students build a body of knowledge – as long as it engages them – but it will not teach them to apply academic concepts on the job. Through problem-based learning (PBL), the ATE curriculum is structured around a series of workplace problems – based on extensive faculty research in South Carolina industry – that students solve. Faculty act as coaches or facilitators, monitoring the progress of student solutions, answering questions, and teaching concepts as necessary. In addition to traditional testing methods, faculty collaborate in developing scoring rubrics for use with alternative student assessment methods. Being able to apply certain concepts to solve real-life problems, according to ATE workplace research and the tenets of PBL, is more important than being able to recall every concept in a disciplinary canon.

In order to teach disciplinary concepts within a problem-based curriculum, the ATE approach incorporates “just-in-time” instruction. Traditionally, instructors introduce concepts so that each one builds upon the previous one according to the logical sequence within an academic discipline. With the ATE approach,

faculty introduce academic concepts exactly when students need the concepts to solve a workplace scenario. An English instructor, for example, might teach students to draft official memos so students can better present their problem scenario solutions to a hypothetical supervisor. Likewise, a math instructor might explain geometric concepts as students determine the appropriate length of a conveyor belt for an workshop of given dimensions.

In the traditional curriculum, instructors tend to emphasize individual student effort and often discourage students from working together. In the ATE approach, students work in teams to complete all major classroom projects. According to education research, by working together, students engage in their coursework, assist each other with difficult concepts, and develop the critical workplace skills of cooperation, communication, and responsibility. In order to facilitate student teaming, faculty employ techniques from multiple intelligences, learning styles, and cooperative learning.

Traditionally, no scholarships have been available exclusively for engineering technology students in the South Carolina technical colleges. As mentioned in Section 1, many students, particularly minorities, drop out of engineering programs in technical college because they do not have enough money to stay in school. Scholarships and internships allow students to continue to work towards their degree while earning income and gaining relevant work experience. The ATE Center encourages colleges to solicit scholarships and internships for ATE students through local business consortia. Selected by business leaders, ATE scholars work as technicians in local industry and receive

a full-tuition scholarship and book stipend, equivalent to \$2,800 to \$3,000 per year. Business also donate \$500 to college trust funds on behalf of each ATE Scholar. Because of the strong connection between the ATE approach and industry needs, businesses may be more likely to provide students with scholarships and work experience, thereby enabling many students to attend college who might otherwise drop out.

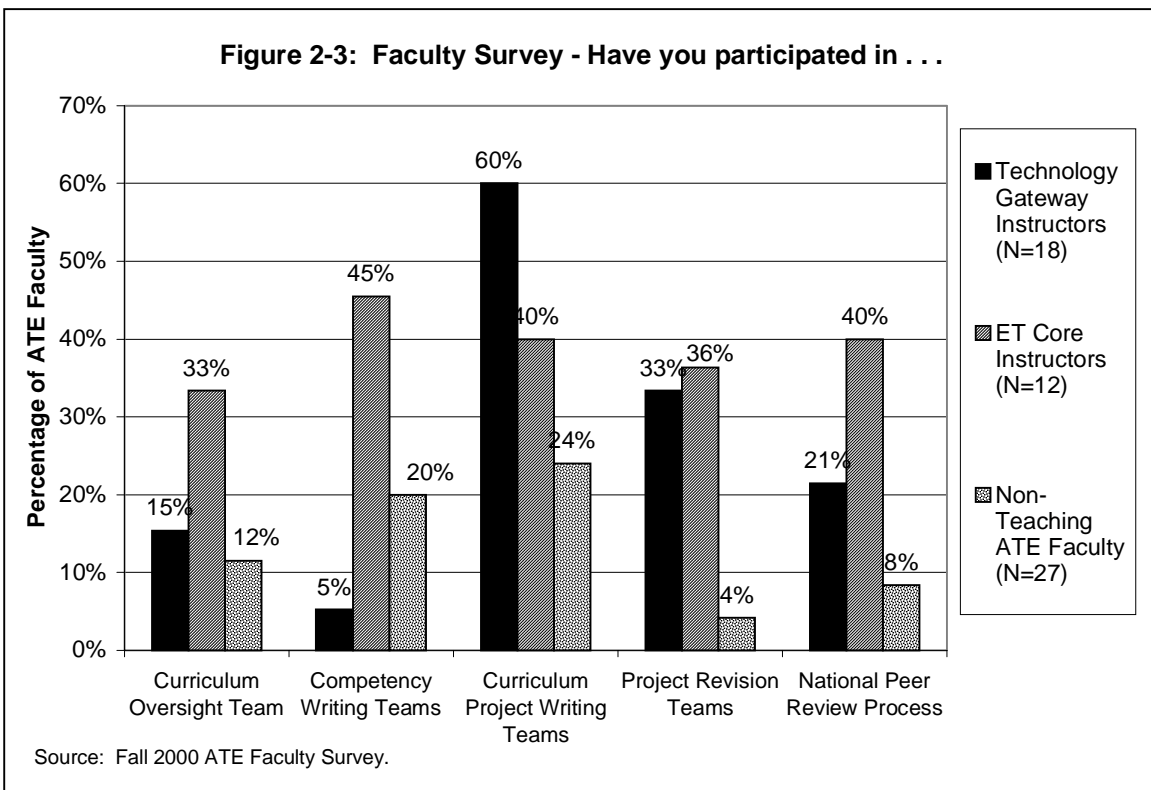
| Table 2-1: Comparison between Traditional and ATE Approaches to Engineering Technology Education | | |
|---|---|---|
| | Traditional Approach | ATE Approach |
| Relationship among General Education Courses | Separate | Integrated |
| Focus of Curriculum | Learning Academic Concepts | Solving Workplace Problems |
| Sequence of Academic Concepts | Logic of Academic Discipline | Just-in-Time |
| Students Interaction and Assessment | Individual Work | Individual Work and Teamwork |
| Financial or Employment Support | No scholarships or internships specifically for ET students | Full scholarships plus part-time internships specifically for ET students |

2.2. The SC ATE Center has sponsored quality curriculum writing, faculty training, and ancillary program improvement activities.

In order to make the idealized version of the ATE approach described above into a reality in South Carolina technical college classrooms, the SC ATE Center has sponsored quality curriculum writing, faculty training, and ancillary program improvement activities.

2.2.1. South Carolina faculty have written ATE curricula.

The Center has trained faculty to write curricula and provided them with release time from their teaching duties to do so. Since 1998, ATE faculty, under the leadership of Center staff, have developed three semesters of an integrated ET Core curriculum plus the curriculum for a one-semester preparatory block of courses, the Technology Gateway. The curriculum-writing process began with Curriculum Oversight Teams that identified the major components of the curricula such as ATE course descriptions. Then, Competency Writing Teams drafted lists of the learning outcomes students should achieve in ATE courses. The



Curriculum Project Writing Teams, which included 30 faculty members, visited over 60 manufacturing sites to develop real-life problem scenarios. Project Revision Teams, which included one representative from each discipline, made

subsequent revisions to the curriculum and Campus Teaching Teams pilot-tested the curriculum. (See figure 2-3, previous page, for rates of ATE faculty participation in these curriculum-writing activities).²⁸

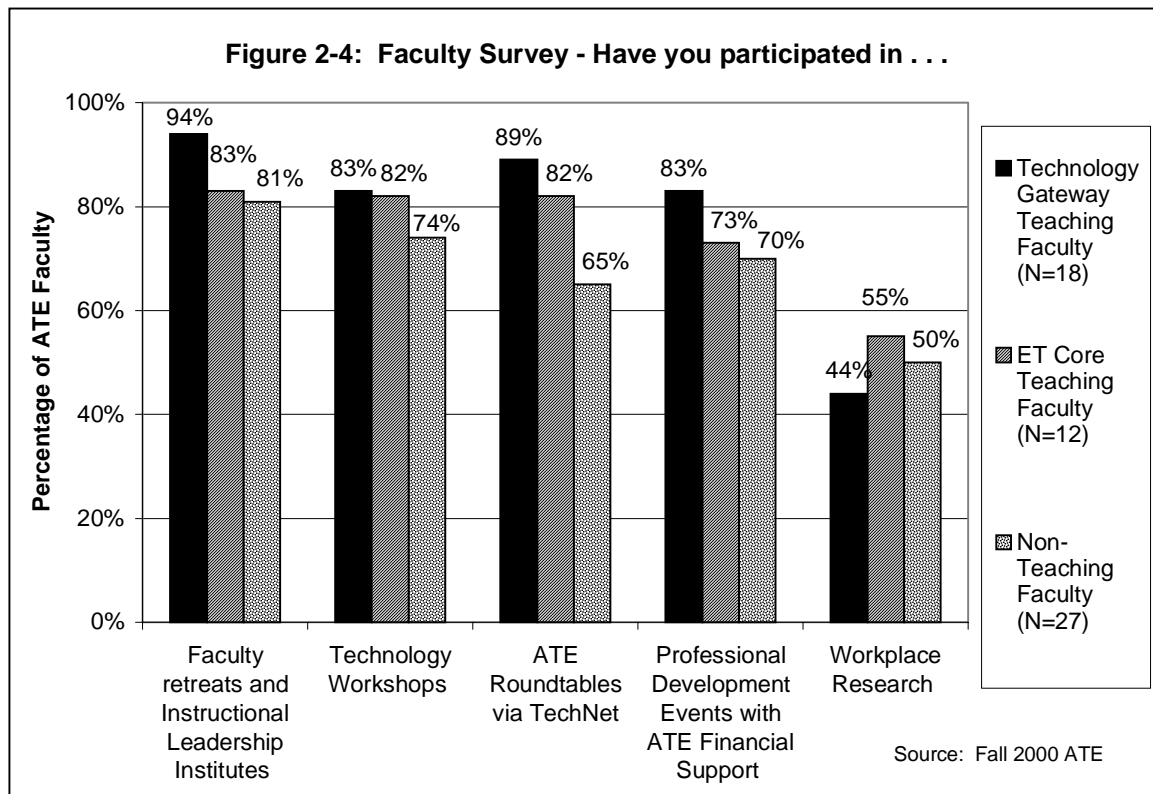
The curriculum was reviewed in industry focus groups and by national peer reviewers. The 11 experts who conducted the peer review, which took place at Clemson University in September 1999, agreed that the Technology Gateway curriculum provided an excellent immersion in computers and communications, was based on accurate workplace scenarios, and prepared students well for study in the ET Core. They also indicated that the first semester of the ET Core curriculum was likely to facilitate student learning, promote faculty teaming, and meet the needs of industry. One member, Arnold Packer of Johns Hopkins University, said, “The SC ATE approach will, I hope, be the future of ET education.”²⁹

2.2.2. The SC ATE Center has trained faculty to implement the ATE curriculum.

The SC ATE Center recommends that all faculty who will teach the ATE curriculum take the teaching-team training. These training sessions last one to three days, depending upon how much training a faculty member needs, and cover problem-based learning, team teaching, learning styles, instructional technology, student assessment, and other pedagogical concepts. Thirty-two faculty members participated in the training sessions in 2000. Supplementing these sessions are the annual Instructional Leadership Institutes (ILI) where

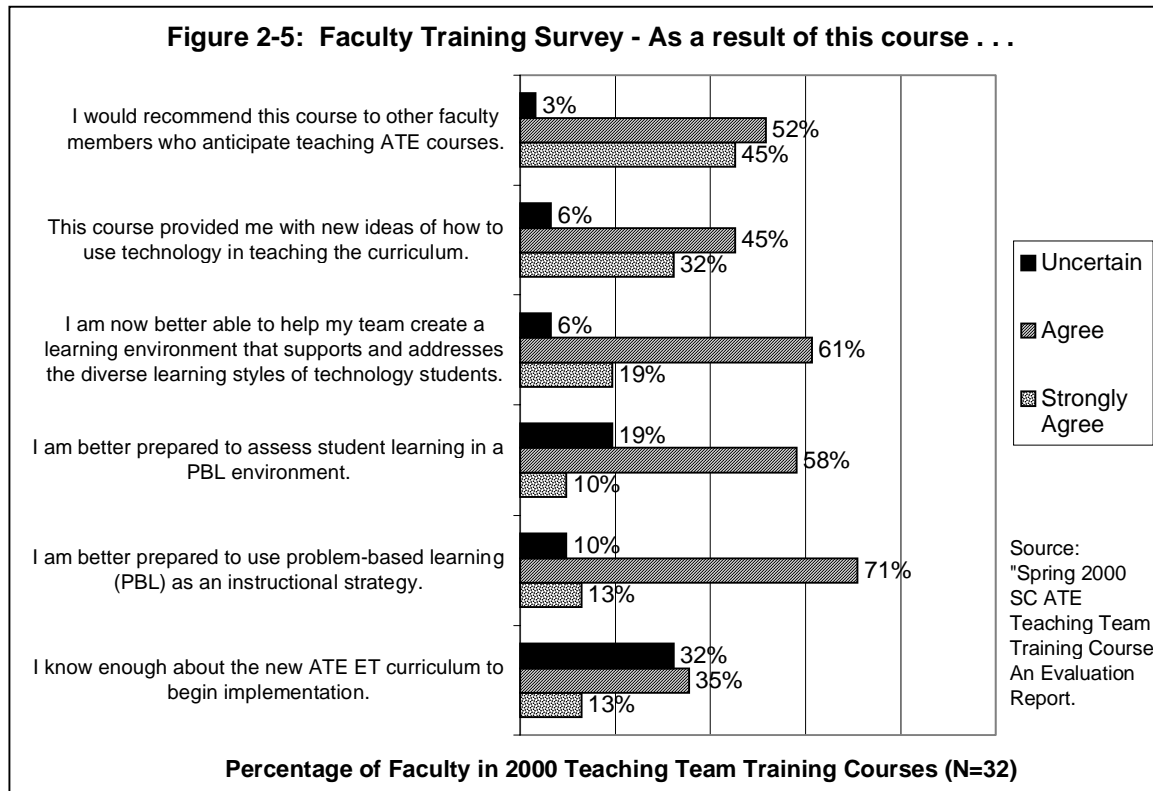
faculty discuss implementation of the ATE curriculum and build upon concepts introduced in the training sessions. Nearly 70 faculty members attended the ILI in 2000 and over 100 attended in 2001. ATE faculty training events also include technology workshops and ATE Roundtables via the state teleconference system. Four-fifths of ATE faculty members attended these activities. Finally, ATE funded several faculty members to attend national conferences on technical education. (See figure 2-4, below, for details on the percentage of ATE teaching faculty participating in these events).

Faculty overwhelmingly indicated in multiple surveys and interviews that ATE training programs were helpful. Eighty-five percent of ATE faculty members surveyed indicated they were “generally satisfied with ATE professional



development activities.” A full 94% of teaching faculty were satisfied while three-fourths of non-teaching faculty were.³⁰ A vast majority of the 32 participants in

the 2000 faculty training workshops indicated that they were prepared with new ideas and that they would recommend the workshop to other instructors. Faculty were less confident, however, about whether they knew enough to implement the ATE curriculum in the classroom, although a full two-thirds felt they did. (See figure 2-5, below).



Each teaching faculty member interviewed indicated that the ATE faculty development opportunities improved his or her teaching ability. In particular, they indicated that ATE training allowed them to observe different colleges across the state, develop a supportive network of peers, learn new pedagogical theories, visit workplaces to learn what industry expects of workers, and use technology in the classroom. Overall, teaching faculty members were effusive in their praise

for ATE professional development opportunities, as evidenced by the following representative comments:

- “As good of a professional development program as there has ever been. I will always be a better teacher.”
- “I have thoroughly enjoyed the experience and have learned a tremendous amount.”
- ATE provided a “superb” faculty development opportunity.
- ATE professional development activities makes ATE faculty “head and shoulders above the rest.”
- “I don’t know of any other technique that could rival ATE.”

2.2.3. Center staff and faculty have developed the ATE Scholars program.

ATE partnerships with local industry and banks raise significant funds for ATE scholarships each year. In Fall semester 2000, 36 students at four colleges – or one-third of all students in the Fall 1999 and Fall 2000 ET Core cohorts – participated in the ATE Scholars program. In total, the ATE Scholars program raised over \$100,000 of new scholarship money for engineering technology students during the 2000-01 academic year.³¹ The South Carolina Technology Alliance and the South Carolina Department of Commerce have endorsed the Scholars Initiative and business leaders have praised it:

- “The [ATE Scholar] apprentices who have been through ATE, there is no hesitation to take on a problem at a plant. They just dive right in and get it done.”

- “The ATE program . . . is right in line with what industry needs today.”³²
- ATE program “is our answer [to employee training].”³³
- “The SC ATE Scholars initiative is very timely. It’s really a leading-edge program.”³⁴
- “We need more of these programs throughout the state. This is the best technical training that our state could offer.”

In addition to the Scholars Initiative, the SC ATE Center has arranged for low-income high school students enrolled in the Technology Gateway through a partnership between Piedmont Technical College and the Newberry Career Center to receive scholarships. A local bank has supported this partnership by providing scholarships to cover the college tuition for students eligible for free or reduced-price lunches. All other ATE students in the class will be reimbursed by the bank for their college tuition expenses if they earn grades of B or better in ATE classes.

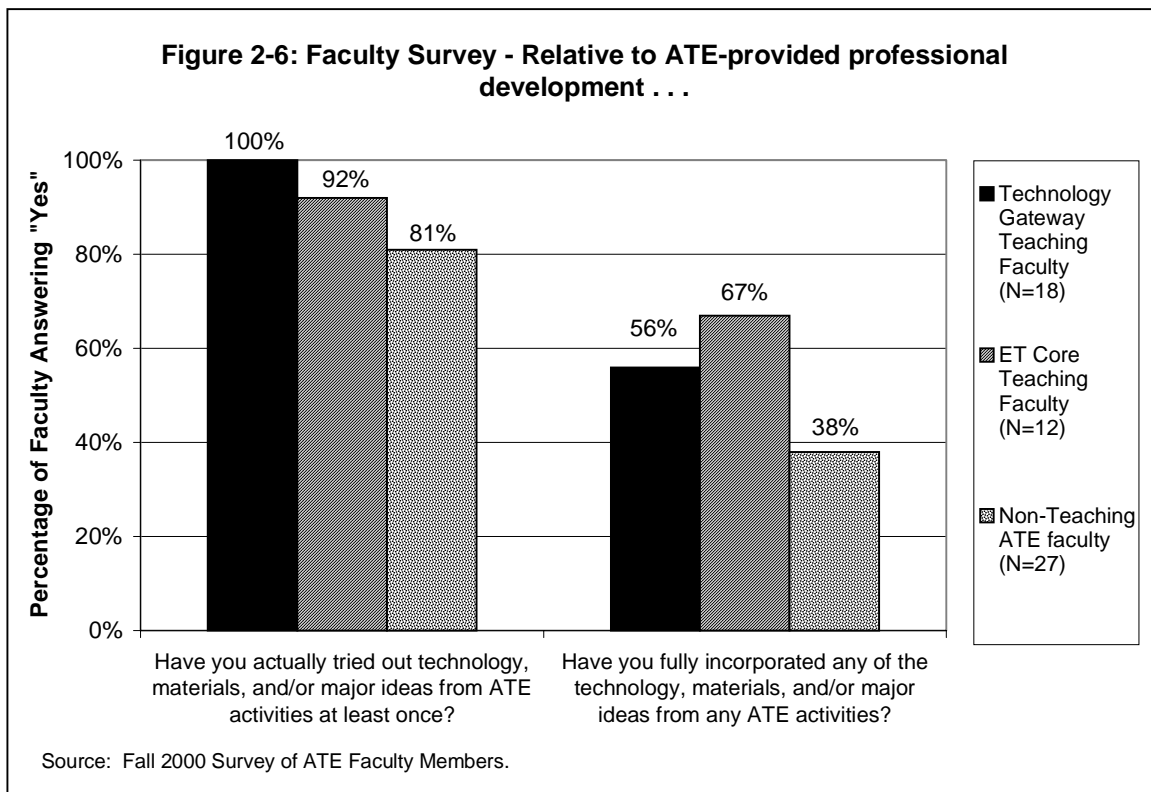
2.3. Faculty are implementing the ATE approach in their classrooms.

Walking into an ATE classroom, an observer immediately notices something different: instead of listening to a lecture and taking notes, students work on solving industry-based problems.³⁵ During the second unit of the Technology Gateway, which AED evaluators observed at several colleges, student teams figure out a way to move heavy aluminum coils to a warehouse loading dock using only simple tools and muscle power. At the beginning of the unit, students experiment with the properties of simple machines. Four students attach metal washers to the end of a lever to test the amount of force required to raise a small weight. They repeat this test several times, each time varying the number of washers, and record the outcomes into a spreadsheet. Other groups of students conduct similar tests with inclined planes and pulleys. The physics instructor visits each group to answer questions and to lead discussions. When the bell rings, it is the faculty – not the students – who switch classrooms. The mathematics instructor shows students how to enter data from their experiments into spreadsheets, how to graph scatter plots, and how to estimate the relationship between weight and force. After several days, students apply these concepts to design scale models of simple machines, their solutions to the problem scenario. One team builds a pulley powered by a hand crank; another presents a working conveyor belt. Now, the communications instructor helps students communicate their solutions by showing them how to summarize information, explaining principles for designing PowerPoint slides, and

demonstrating public speaking techniques. To complete the unit, each team describes its model in a formal presentation to the rest of the class.

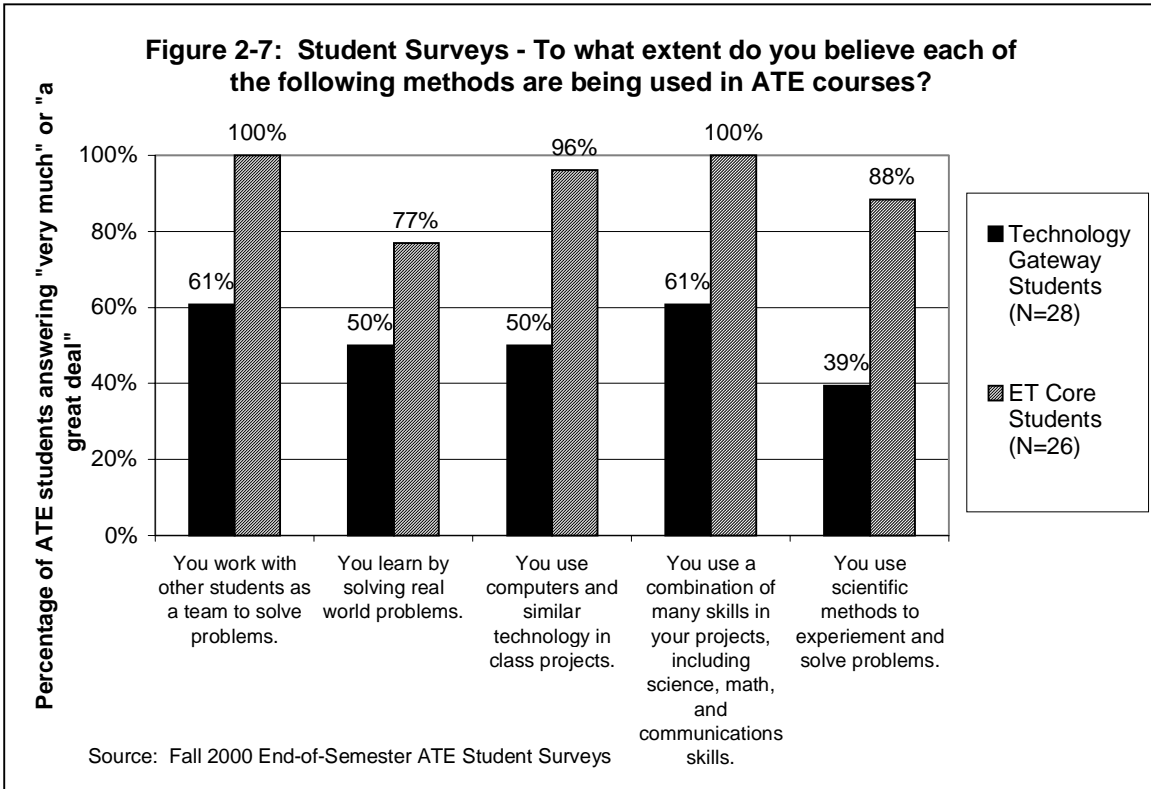
2.3.1. Faculty apply the ATE approach to their ET Core classes, and to a lesser extent, to their Technology Gateway classes.

ET Core faculty implement the ATE approach more fully than do Technology Gateway faculty. Two-thirds of ET Core faculty members indicate that they have “fully incorporated any of the technology, materials, and/or major ideas from any ATE activities” compared to 56% of Technology Gateway faculty. (See figure 2-6, below). From the students’ perspective, however, this difference is more



dramatic. ET Core students were far more likely than Technology Gateway students to say they use scientific methods to experiment and solve problems, use a combination of skills in class projects, use computers to solve problems,

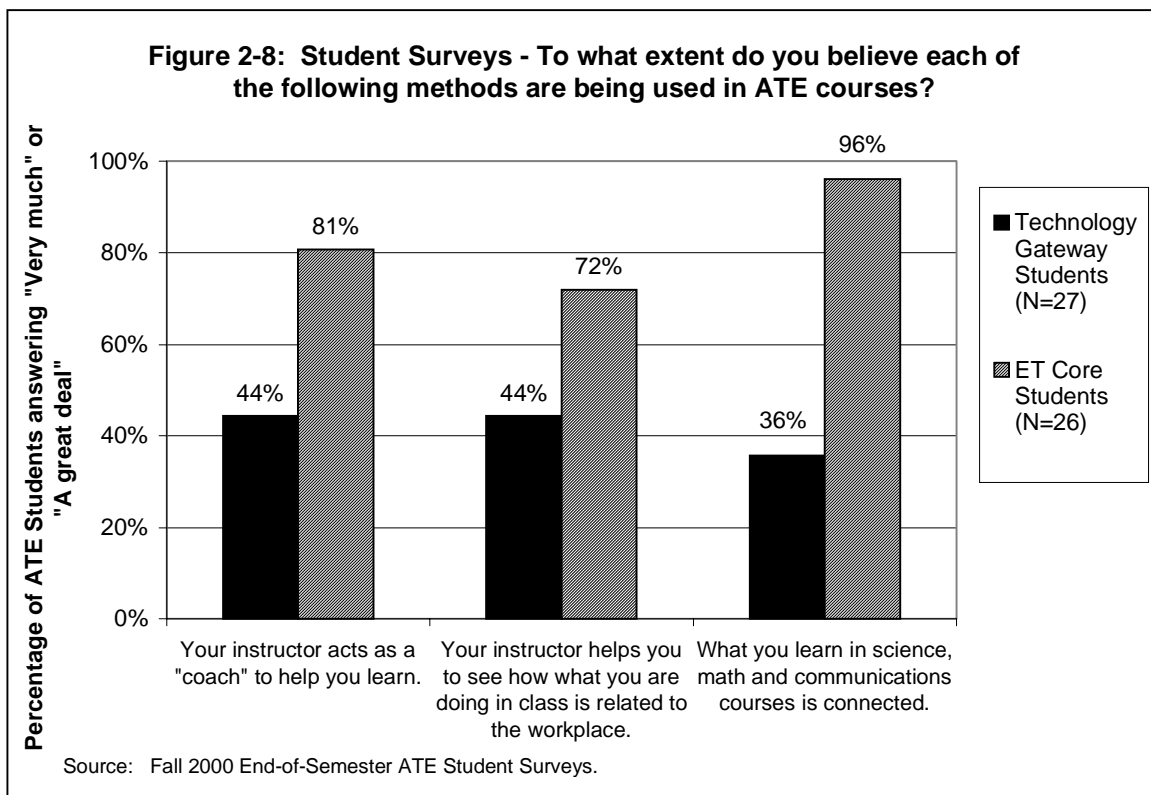
learn by solving real world problems, and work with other students as a team. (See figure 2-7, below). ET Core students were also more likely to indicate that their instructors act as a coach, that their instructors help them to see the



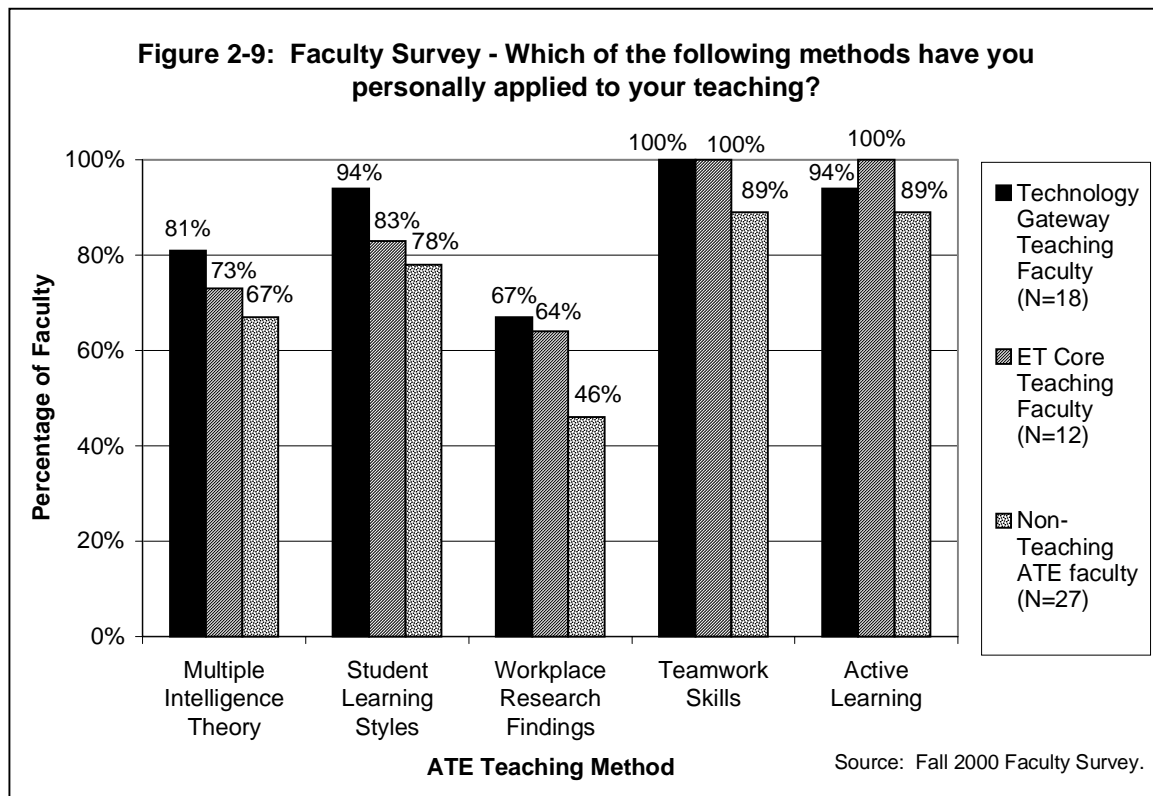
relationship between class work and the “real world,” and that general education concepts are connected. The largest disparity in the responses of these two groups was that nearly all ET Core students indicated that what they learn in science, math and communications “is connected” while just over one-third of Technology Gateway students indicated the same. (See figure 2-8, next page).

There are several plausible explanations for the disparity in ATE implementation between ET Core and Technology Gateway classrooms. First, the two groups of students are at different educational levels and may have different perceptions of course activities. Since ET Core students are more advanced academically, they may be more likely to see the connections between

the general education subjects. Second, the content of the ET Core is more sophisticated and may better lend itself to applying academic concepts to workplace situations. For example, since students in the Technology Gateway are just beginning to use college-level skills, it might be more difficult to engage them in using the scientific method. Third, as mentioned in Section 3, many faculty members believe Technology Gateway students are less mature than other students. It could be that this level of maturity makes it more difficult to implement active learning concepts. At the same time, many concepts – such as faculty “coaching students” and students working together in a team – are effective regardless of the level of students and yet are being used less in Technology Gateway classrooms.³⁶ Fourth, there are no discernable differences in the level of participation in ATE faculty development or curriculum writing



events that could explain the difference in implementation. Based on faculty interviews and site visits, it is possible that faculty have more difficulty implementing the ATE approach in the Technology Gateway as opposed to the ET Core. AED evaluators suggest that ATE faculty and SC ATE Center staff consider these and other reasons for the disparity in implementation and take action to enhance implementation of ATE in Technology Gateway classrooms.



2.3.1. ATE faculty apply some ATE methods to their non-ATE courses.

ATE faculty members apply ATE teaching methods to their non-ATE courses. One hundred percent of ATE teaching faculty members and 91% of ATE non-teaching faculty members surveyed indicated that they apply at least one of the following methods – multiple intelligence theory, student learning styles, workplace research findings, teamwork skills, and active learning – to their non-

ATE courses. During site visits and telephone interviews, faculty indicated that ATE teaching methods have affected their teaching of non-ATE courses to varying degrees. Some mentioned that they only apply one or two ATE methods to non-ATE courses while others indicate that they do so to the fullest extent possible. Faculty said they now lecture less and lead more student-centered activities – such as computer-based projects, weekly journal entries, and exercises based on customized hand-outs rather than textbooks. Other faculty said they incorporate the concepts of multiple intelligence and learning styles into non-ATE courses.

Some instructors mentioned that the lack of problem-based, integrated curricula in non-ATE courses prevented them from fully implementing ATE methods in those courses. Using the just-in-time instructional method, for example, is difficult to apply to a curriculum that is structured around academic concepts rather than workplace problems. Others, however, mentioned that they overcome this obstacle by using textbooks less and creating their own problem-based classroom activities based on real-world scenarios. Some instructors mentioned that they were already using ATE methods such as cooperative learning and active learning before their involvement with ATE.

Below are representative comments by ATE faculty members about their use of ATE methods in non-ATE courses:

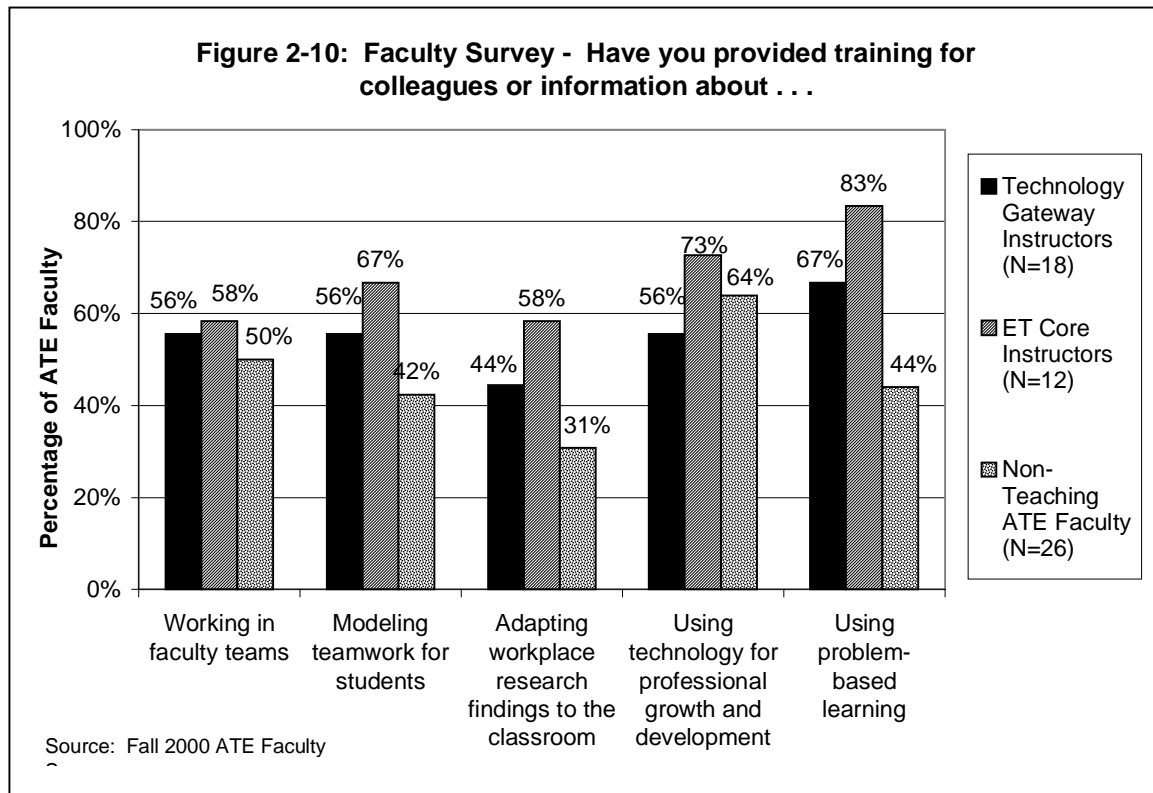
- “I teach my regular classes differently now . . . I never lecture for 55 minutes now.”

- “Some of these teamwork ideas have gotten in up here [points to head] and I realize I might be able to use them [in other classes].”
- “There are no ‘non-ATE’ classes,” an instructor said while explaining that she uses ATE methods in all of her courses.
- One instructor mentioned that before the ATE program, he “had no option” but to constantly lecture in all of his courses even though he knew it was not effective because most of the students are “hands-on learners.” ATE has given him alternatives.
- Another instructor mentioned he uses teaming in non-ATE courses because he has realized that sometimes students can teach a concept to each other better than he can.
- “In my other classes, [I am] getting them [the students] to look at the outside world, use the Internet, interview industry and write up a report.”

2.3.2. ATE faculty disseminate the ATE approach to other faculty, although some non-ATE faculty members remain skeptical.

Over half of ATE teaching faculty members and nearly half of ATE non-teaching faculty members have “provided training for colleagues or information about” the ATE program to other faculty members, according to faculty surveys. ATE faculty were most likely to provide information about problem-based learning with four out of five ET Core faculty members doing so. They were slightly less likely to provide information on using technology for professional growth and modeling teamwork for students while roughly half of teaching faculty provided

information on working in faculty teams and adapting workplace research findings in the classroom. (See figure 2-10, below).



In telephone interviews, all faculty members mentioned that they disseminate ATE ideas to their peers. At one college, ATE instructors meet with other faculty members twice each semester to explain the benefits of the ATE program. At other colleges, ATE faculty disseminate ideas through faculty retreats, industrial advisory committees, campus panel discussions, and informal conversations with colleagues. One instructor taught a graduate-level course on ATE concepts to other faculty members at her college.

In spite of this communication, a significant portion of non-ATE faculty members are “set in their ways” and are not interested in learning or adopting ATE teaching methods, according to faculty interviews and site visits. There

seem to be two main reasons for this dissent. First, some non-ATE faculty members, particularly those in the hard sciences, worry that the ATE program will “soften” the intellectual integrity of their academic discipline. They are concerned, for example, that student teamwork may not be the best way for students to learn or for teachers to teach. Second, other non-ATE faculty members are deterred from adopting the ATE approach by the amount of time ATE faculty spend in preparation and instruction, several ATE faculty members posited: “They were scared initially because of the level of commitment to ATE.” Some mentioned that it might be easier for non-ATE faculty members to adopt small, discrete concepts such as learning styles because “change is hard to accept and to implement.”

2.3.3. Block scheduling prevents wider adoption and implementation of the ATE approach.

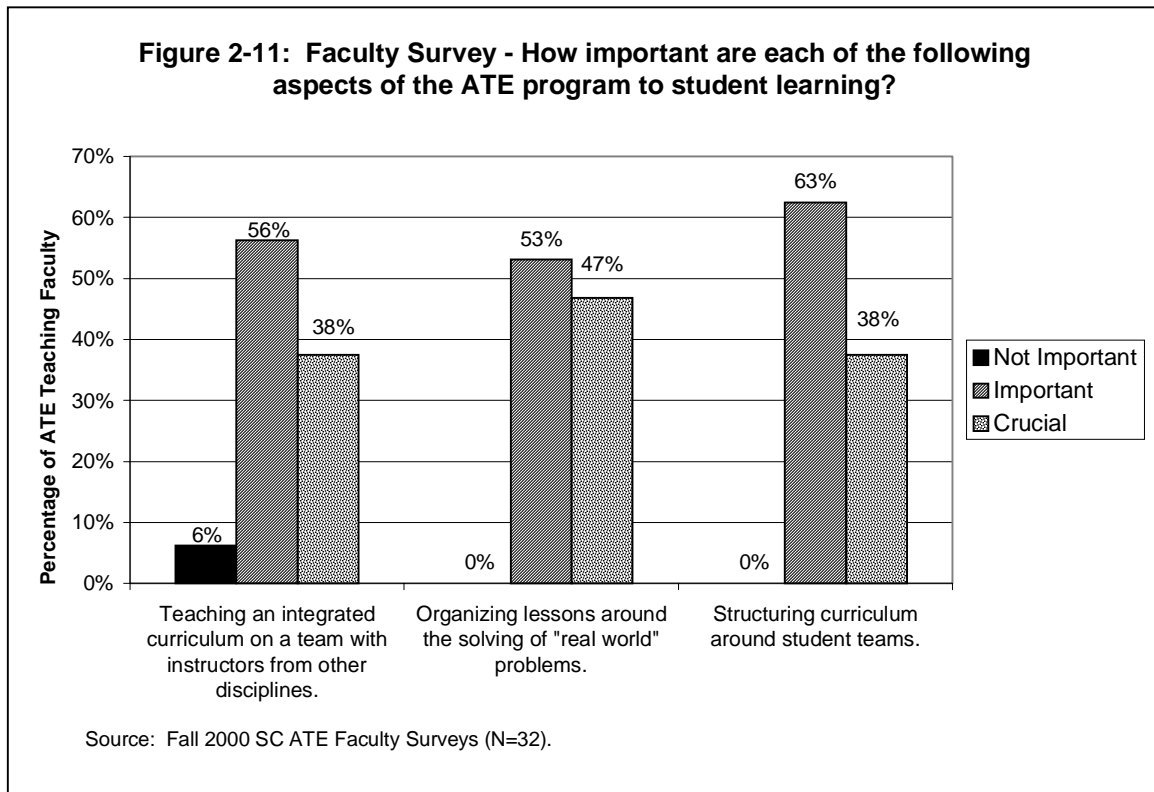
The strength of the ATE approach – the integration of multiple subjects into a block of courses taught by several instructors – may also be its weakness. Course integration helps students to apply multiple skills to solve complex workplace problems and is a critical means of motivating students and enhancing their learning. College course schedules, however, traditionally have not been designed to accommodate three and four hours class periods. In addition, the boundaries of traditional academic departments impede cross-disciplinary collaboration. Furthermore, part-time students – who made up over half (54%) of all ET students in the 1999-2000 academic year – may not be able to register for

10 credits in one semester.³⁷ One of the most common complaints about the implementation of the ATE program raised by faculty has been the difficulty of scheduling ATE courses. Following are representative comments taken from the faculty survey:

- “Make the courses more flexible. That is so that they do not need to be block scheduled. The students at our college do not like to enroll in block classes. We also have a large evening program which does not lend itself to ATE program . . . “
- “Make it less time intensive so that part-time students and evening students can use it. Many cannot come for several hours every day.”
- “Do not have the curriculum structured in blocks of four courses. At the most, two courses in a block.”
- “Do courses separately, not in a three course block.”

Evaluators recommend that the college administrators, ATE faculty, and SC ATE Center staff consider several ways to make the ATE program accessible to more students. First, expanding the ATE Scholars program would provide more ATE students with enough income to attend college and a job that relates to their studies. This may allow more students to earn income without sacrificing college enrollment. Second, college administrators and SC ATE Center staff should encourage non-ATE faculty to adopt as much of the ATE approach as possible. Faculty can use methods of student teaming and problem-based learning, for example, regardless of whether or not their courses are integrated with other courses or whether their curricula are based on ATE problem scenarios. In fact,

ATE faculty ranked problem-solving and student-teaming methods to be as important or more important to the success of students than course integration (See figure 2-11, below). All faculty should take advantage of SC Center training activities to enable them to apply ATE techniques to their classes,



regardless of whether or not they are teaching the ATE curriculum. Third, all parties should continue to develop part-time versions of the ATE program in which only two – instead of four – ET Core courses would be integrated in a particular semester. Finally, college administrators should consider adjusting administrative procedures – such as course schedules, faculty loading, and departmental organization – to accommodate integrated blocks of ATE courses. At one college, faculty mentioned that administrators were considering restructuring the traditional academic departments into interdisciplinary teams because of the success of ATE. The above recommendations do not mean that

ATE courses should not be integrated but rather that the integrated block of ATE courses should be supplemented by other approaches. These and other changes may encourage additional colleges to adopt the ET Core and may boost enrollment of ATE students.

3. Students Outcomes: ATE boosts student engagement, workplace readiness skills, retention and graduation dramatically.

AED evaluators and State Board for Technical and Comprehensive Education (SBTCE) administrators identified several hypotheses about the outcomes they expected to observe in ATE students:

- Students will be more engaged in ATE courses than in otherwise similar non-ATE courses.
- Students will develop greater communication and cooperation skills in ATE courses than in otherwise similar non-ATE courses.
- Students will develop greater problem-solving skills in ATE courses than in otherwise similar non-ATE courses.
- Students will be more likely to complete general education courses, and to subsequently graduate, in the ATE program than in the traditional ET program.
- Underrepresented minorities and women will be more likely to enroll in the ATE program than in the traditional ET program.
- Underrepresented minorities will be just as likely as Caucasians and women will be just as likely as men to complete ATE courses.

To answer these questions, AED evaluators conducted site visits, administered a faculty survey, administered beginning and end-of-semester student surveys, interviewed faculty, reviewed ATE materials and education research, analyzed historical student records, and analyzed ATE student records. The remainder of Section 3 explores the evidence in support of each of

these hypotheses. AED data collection and analysis give preliminary indication that many of these hypotheses may be correct, although further information is needed to answer them with a high level of certainty.

3.1. ATE students tend to be more engaged in their studies than students in comparable non-ATE courses.

Comments from ATE students indicate their enthusiasm for the ATE approach:

- “I’m thrilled about it [ATE]! I wish regular school was [sic] taught this way. All of the subjects tie in together.”
- “I would take ATE over the [traditional program] just for the simple fact of the physics and math.”
- “Learning seemed easier and more fun.”

Traditional disciplinary, lecture-based English, math and physics courses do not interest engineering technology students as much as ATE courses, according to interviews and site visits; students tend to perceive these courses as too theoretical, as too difficult, or as irrelevant to their careers. The applied nature of the coursework in the SC ATE curriculum helps students see the relevance of general education courses such as communications, math, and science to their careers, makes difficult concepts more comprehensible, and motivates students to succeed. Because of the emphasis on student teamwork and active learning, ATE students build relationships with their peers, giving them encouragement and support. The participation of multiple faculty members and the emphasis on

problem-based learning boosts student interaction with faculty members. Performance standards – such as minimum grade requirements for ATE Scholars and strict attendance policies – motivate students to take their coursework seriously. The high level of ATE student engagement is evident in increased student-student interaction, student-faculty interaction, and demonstrations of student maturity, all of which are described in the subsequent three sections.

3.1.1. Students interact with each other more in ATE courses.

Students engage with each other more during ATE than during traditional courses, primarily because of the ATE emphasis on student teaming. Student teaming, which is rare in traditional courses but standard in ATE courses, helps students understand difficult concepts and makes learning more enjoyable, according to both students and faculty. Students added that their relationships with fellow ATE students extend to other classes where they are more likely to work in teams, even though traditional instructors do not encourage doing so. Following are some representative comments from students about the effects of ATE on student interaction:

- “Probably more important are the friends you make. You’ll learn from them too. I’m in an economics class right now. I don’t know anyone’s name. I know one guy’s called Joshua but I don’t talk to anyone. I’m counting the minutes to get out. I have no doubt that it would definitely be better with the ATE approach.”

- “We wouldn’t be as self-motivated if we had to work alone.”
- “Teams make big assignments a lot easier.”
- “Three to four people do better than one. By yourself you have one brain instead of four. [A group of students] can put our own answers together and make better answers.”
- ATE is “easier. There are more ideas. You can be more creative. You can bring more ideas to the table. You can look at it [a problem] in different ways.”
- “Students may walk out of their first year with less stuff in their brains [but] I never saw study groups before ATE. [ATE Instructors] could leave the room and [students] will still be working.”

A few students and faculty mentioned that group work has the potential downside of encouraging “freeriders” or that it might allow students to rely on their strengths at the expense of learning new skills. “In our group, there were a lot of students that was [sic] looking for a free ride,” mentioned one student. This concern, however, was not mentioned frequently. It was evident during evaluator site visits that most students were actively and genuinely participating in group work. At nearly every college, evaluators discussed with students the extent to which they were allowed to rely on their strengths rather than develop new skills. In each case, students pointed out that a student with a unique strength helped other students in the group to learn, rather than carrying the weight of the group. At one college, for example, students explained that a student in their group was particularly good at using Microsoft PowerPoint. Although this student was

responsible for making the group's slide presentations, all of the other students in the group remarked that they learned from his expertise. One faculty member said, "Without student teams, slackers wouldn't get anything right, wouldn't learn anything. At least with the team, they learn something." This question needs to be studied further during year six of the evaluation.

3.1.2. Students and faculty interact more with each other in ATE courses.

Communication between ATE students and faculty is more like a two-way radio exchange than a one-way mass broadcast. As instructors transform from lecturer to "coach," as faculty members cooperate through integrated courses rather than teach in isolation, and as students change from passive observers of lectures to active participants in projects, students take on more responsibility for their learning and faculty take on more responsibility for their students.

In problem-based learning, the responsibility to gather and interpret information rests with students. As a result, ATE students tend to take control of their education and to feel more comfortable interacting with instructors. In interviews, nearly all instructors said that ATE students are more likely than non-ATE students to ask questions both during and after class. ATE students ask so many questions, one instructor commented, "They literally wear me out!" In the faculty survey, 48% of ATE teaching faculty indicated that ATE students are more likely than traditional students to use email to contact them or to conduct class work, while no faculty members indicated the reverse was true.³⁸

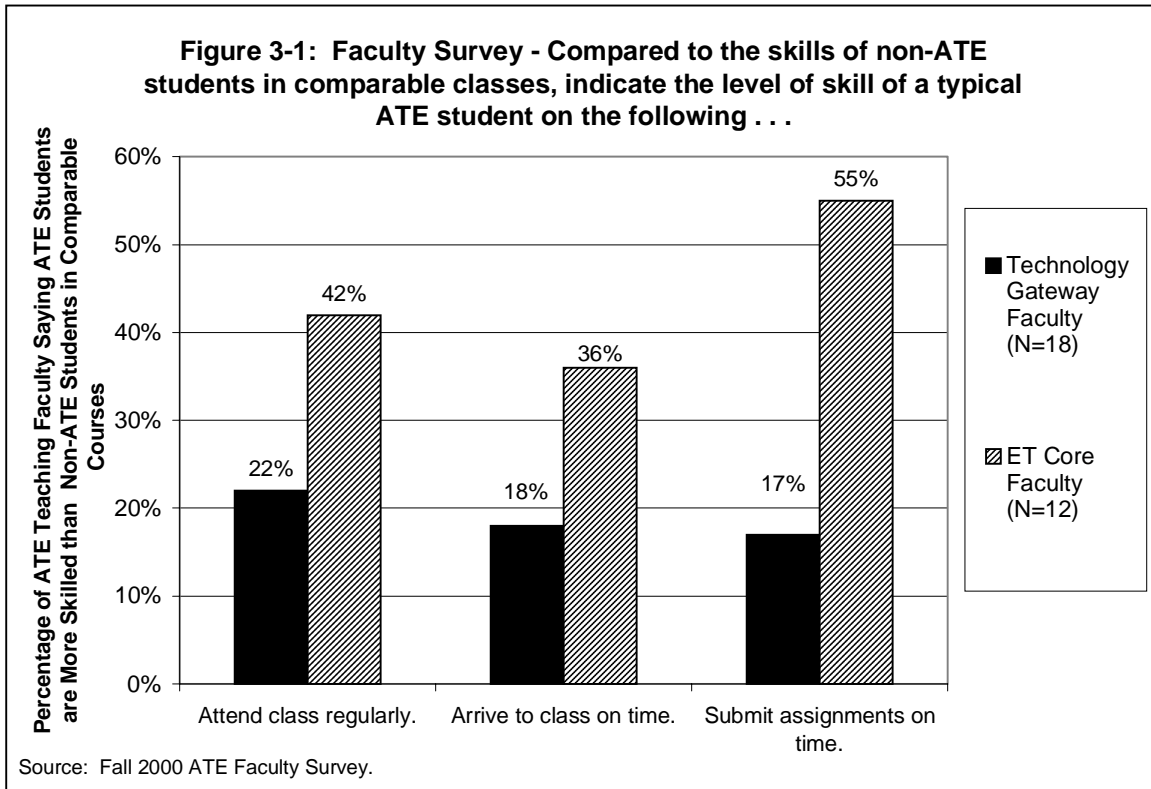
With an interdisciplinary curriculum, multiple faculty members share responsibility for a group of students; it is less likely that a particular student will “fall through the cracks.” One instructor pointed out that, with team teaching, students have more than one faculty member looking out for them, making them feel “special and privileged.” In problem-based learning, where the instructor acts as a “coach” rather than as a lecturer, and through group activities, where instructors can more easily manage one-on-one interaction with students, instructors tend to spend more time answering questions and giving students individual attention. During AED site visits, ATE students described the heightened level of faculty attention:

- “Teachers take more time with students. You can see they care that students learn.”
- “Professors make it fun. They will take time to show each individual person to make sure they get it rather than just writing on the board.”
- “It boils down to having four instructors for each course. The [curriculum] is so integrated, we can go to any of them [for help].”

3.1.3. ET Core students tend to behave more responsibly and maturely than students in non-ATE courses.

ET Core students behave more responsibly and maturely than students in comparable non-ATE courses, but instructors cite problems with the maturity level of Technology Gateway students. Roughly half of the ET Core instructors indicated that ATE students are more likely than students in comparable non-

ATE courses to attend class regularly and to submit assignments on time; only one in five Technology Gateway instructors indicated the same. Approximately one-third of ET Core faculty members believe that ET Core students are more likely to attend class on time than students in comparable non-ATE courses. (See figure 3-1, below).



In the ET Core, student teaming and high performance standards, particularly for ATE Scholars, seem to build student maturity. Group activities – in combination with enthusiasm for the applied nature of ATE coursework mentioned above – apparently motivate students to meet course requirements. During telephone interviews, one instructor told a story of an ATE student who came to class, dropped off a paper with classmates, and then walked out of the room. When the instructor confronted her, she said that although she could not

stay in class because her son was in the hospital, she needed to contribute her portion of the group project. Another faculty member told the story of a student who decided to drop out of the ATE block of courses during the middle of the semester when he realized he was failing. He continued to participate in class activities, however, until his team members completed their group project, saying he did not want them to score poorly simply because he was dropping out.

Performance standards – such as minimum grade requirements for ATE Scholars and strict attendance policies – also motivate students to take their coursework seriously. In interviews, many faculty mentioned that the presence of ATE Scholars in ET Core classrooms increased the overall maturity level of the class. They also mentioned that the block of interdependent courses along with the high cost of missing a class period motivate students to attend class. ATE seems to reinforce maturity in ET Core students.

By contrast, however, many faculty members complain that Technology Gateway students are immature. AED evaluators do not have enough data to explain this disparity but offer two possible explanations. First, the ATE program demands maturity from students. It requires them to take control of their learning, to act independently, and to be responsible to their peers. At the same time, Technology Gateway students may be less mature than other students *a priori*. They are at a lower academic level than ET Core students and they are younger, on average. The demands of the ATE program may simply expose their immaturity. Second, it is difficult to find students whose academic level matches the competencies of the Technology Gateway since the Technology Gateway fits

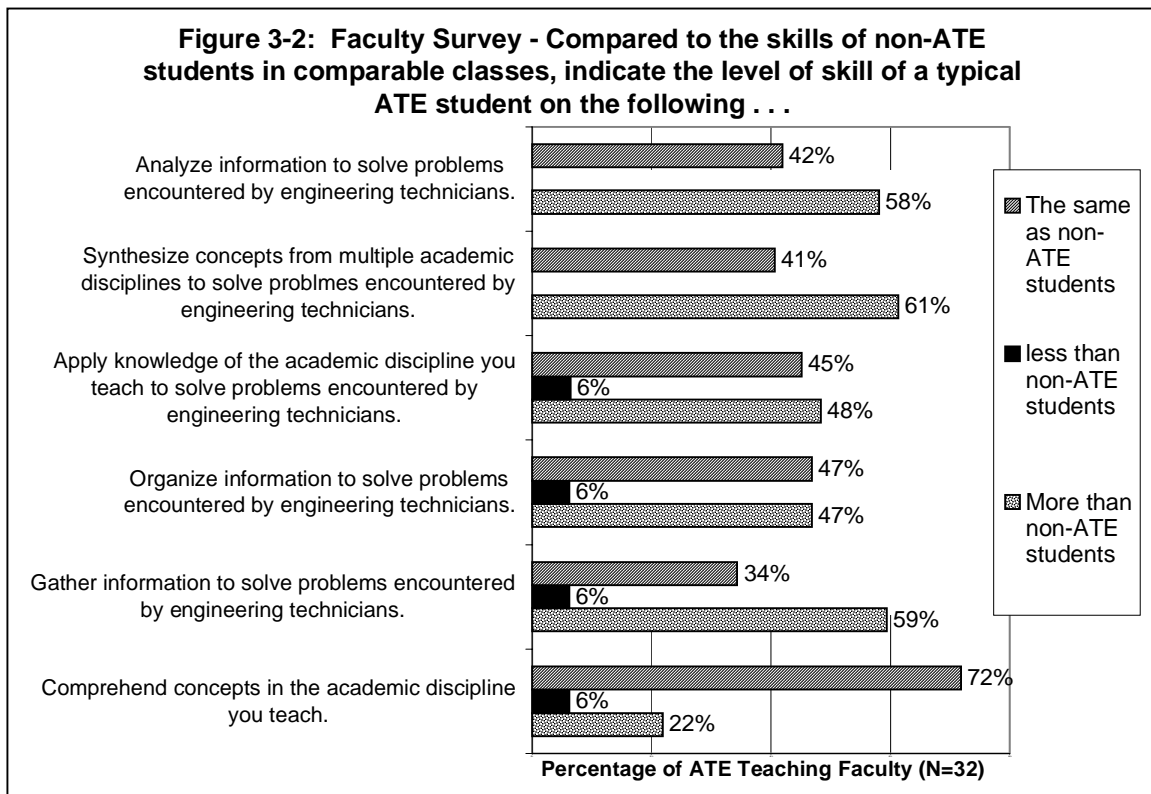
somewhere between developmental studies and college-level courses. A student may have enough ability in English, for example, to take college-level courses but only enough skill in math to take developmental courses. Such a student would be overly prepared in English, and thus under-stimulated by the English portion of the Gateway, but under-prepared in mathematics, and thus overly-challenged by the math portion of the Gateway. In several instances, AED evaluators spoke with students who stated that a particular portion of the Technology Gateway was too easy for them. At the same time, faculty mentioned that a major problem with implementing the Technology Gateway is that students have poor academic skills. This paradox – and the perceived low level of maturity among Technology Gateway students – could be explained by the difficulty of matching student academic levels to the expectations of the Gateway. The above comments are simply speculations, however, as these questions need to be investigated more thoroughly.

3.2. ATE students become better problem-solvers than students in comparable non-ATE courses.

Since the keystone of ATE courses is the application of knowledge to hypothetical workplace scenarios, students get plenty of practice – and develop proficiency – in solving real-world problems. Although AED has not conducted a formal assessment of employer opinions, one employer summed up the impact of ATE on student problem-solving ability during evaluator site visits: “That’s all we do here: problem-solving and teamwork . . . The whole experience of

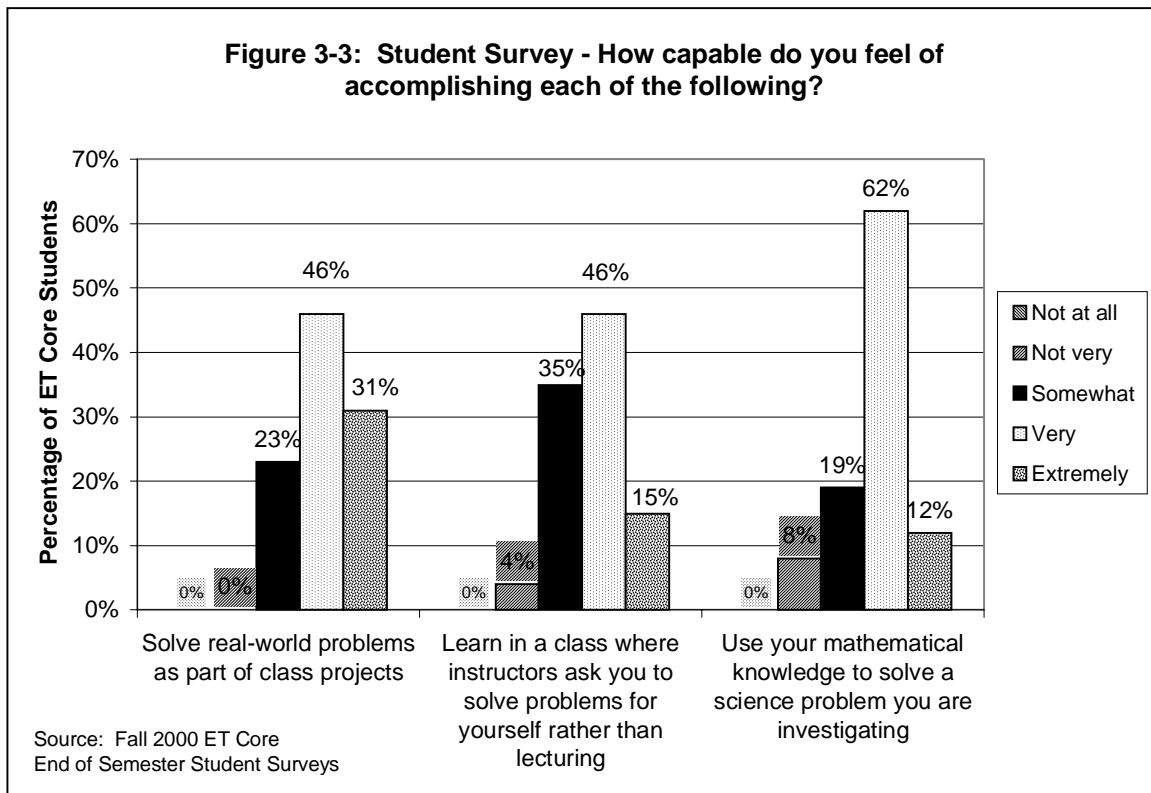
learning how to deal with other people’s opinions – all of those skills are extremely valuable . . . That’s what this program brings to the table.”

Faculty and students surveys, in addition to site visit observations, indicate that ATE students develop a strong problem-solving ability. Depending upon how the question is asked, approximately half of ATE faculty members indicate that ATE students are better problem-solvers than students in comparable non-ATE courses, whereas no more than 6% indicate the reverse. In particular, 58% of faculty members indicate that ATE students can better “analyze information to solve problems encountered by engineering technicians.” Sixty-one percent said ATE students can better “synthesize concepts from multiple academic disciplines to solve problems encountered by engineering technicians.” Finally, 59% said



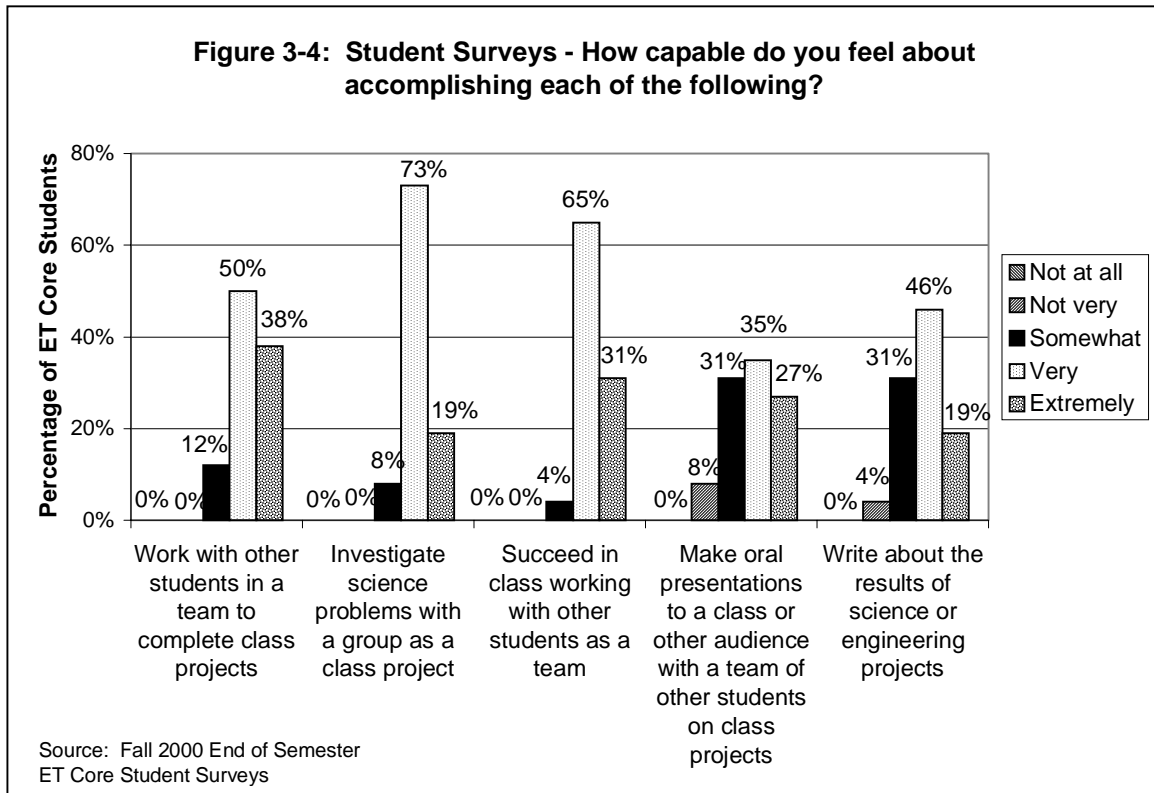
ATE students can better “gather information to solve problems encountered by engineering technicians.” (See figure 3-2, previous page).

ATE students, too, assess their own problem-solving ability as high. Seventy-seven percent of ET Core students indicated they felt “very” or “extremely” capable of “solv[ing] real-world problems as part of a class project.” Sixty-one percent said they felt “very” or “extremely” capable of “learn[ing] in a class where the instructors ask you to solve problems for yourself rather than lecturing.” A full eighty-eight percent said they feel “very” or “extremely” capable “us[ing] your mathematical knowledge to solve a science problem you are investigating.” (See figure 3-3, below). As one student pointed out, “What we do learn, we learn. We have good retention of it. [ATE is not] memorizing for a test – you actually learn it.”

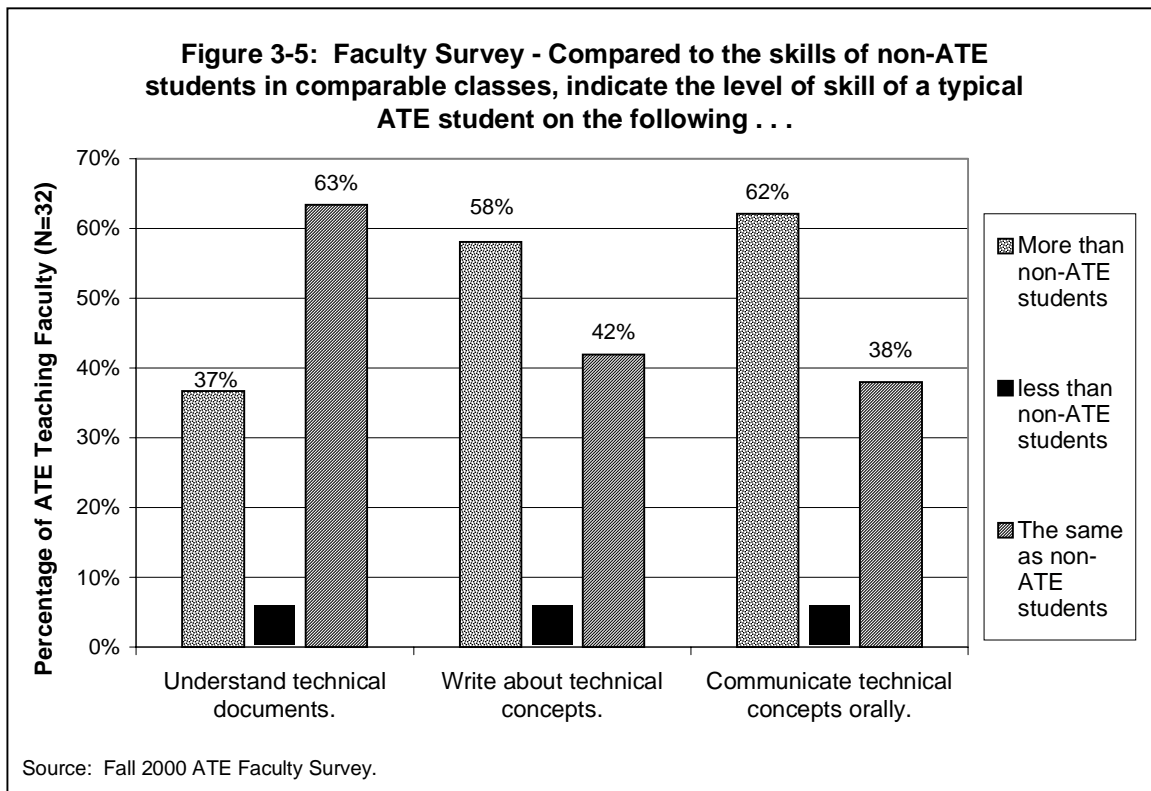


3.3. ATE students communicate and cooperate better than students in comparable non-ATE courses.

The ATE emphasis on teamwork, multiple intelligences and learning styles, and English and communication projects that are relevant to students' work aspirations seem to develop students' communication and cooperation skills. According to student surveys, faculty surveys, faculty interviews, and site visits, ATE students develop stronger communication skills than they would otherwise develop if they were in the traditional program. Nearly all ET Core students indicated they feel "very" or "extremely" capable of working in a team to complete class projects. Fewer – but still a clear majority – indicated they felt "very" or "extremely" capable of making oral presentations and writing about the results of projects. (See figure 3-4, below). In addition, an average of 60% of

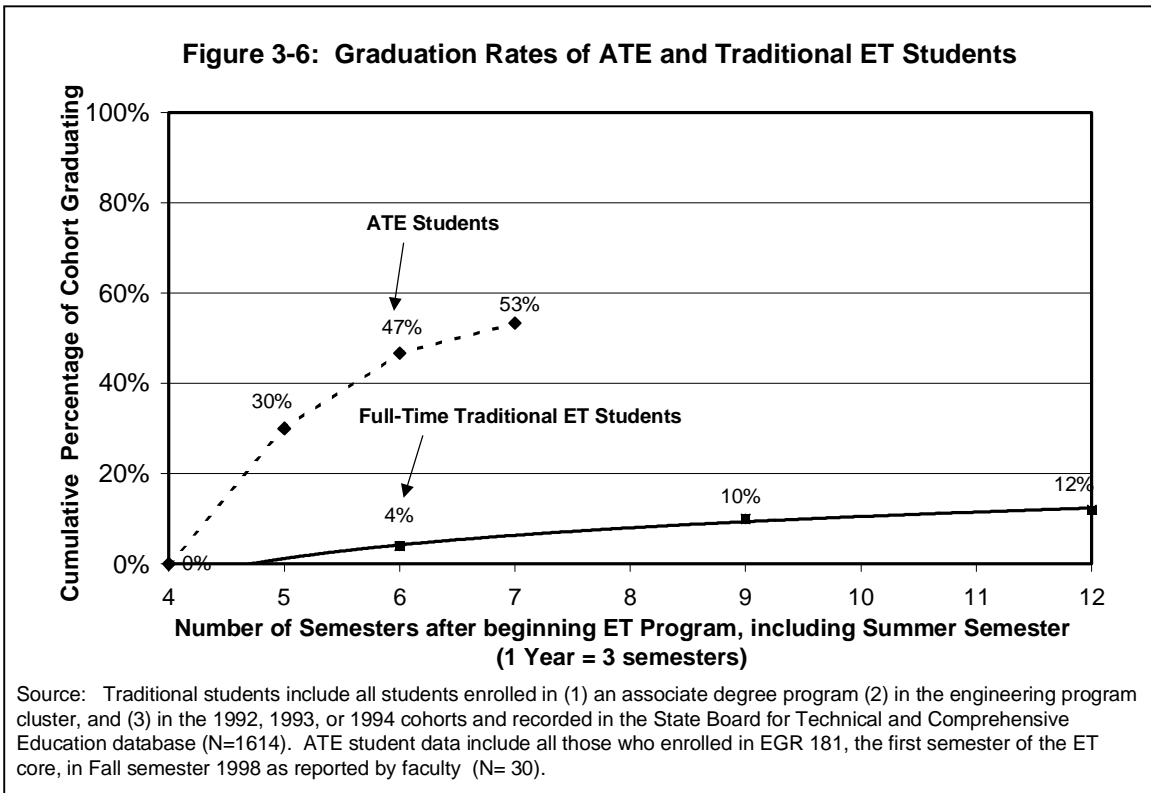


faculty indicated that ATE students are better than non-ATE students at communicating technical concepts orally and in writing, while none of these faculty indicated the reverse. (See figure 3-5, below). In interviews, faculty gave evidence of students' communication abilities. One group of students, for example, made a PowerPoint presentation to the president of the college for a class trip to Canada to raise money from industry to pay for scholarships. Several students mentioned during AED site visits that that by working in teams with other students with different learning styles, they learn to understand different perspectives. A more thorough assessment of ATE student communication and cooperation skills will be considered for the final year of Center evaluation activities.



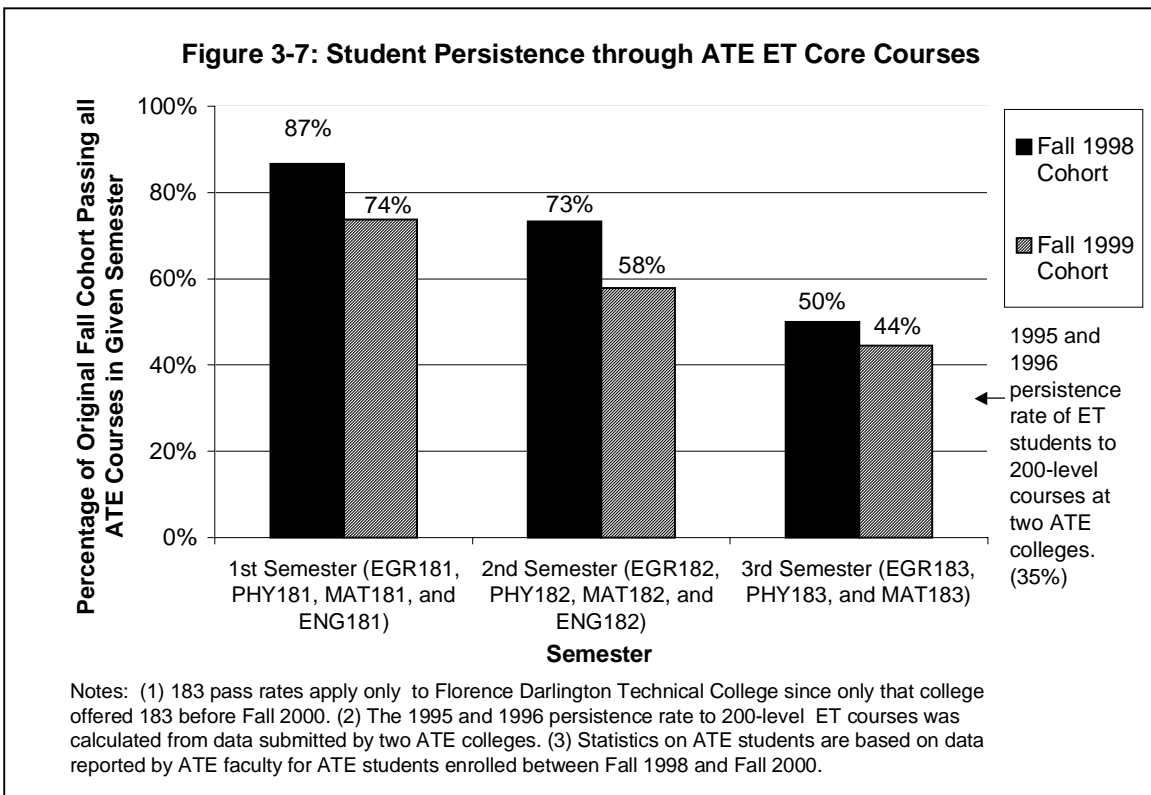
3.4. ATE students persist through program requirements and graduate at much higher rates than students in the traditional engineering technology program.

Two years after beginning the ET Core, nearly half (47%) of the Fall 1998 cohort of ET Core students graduated with associate degrees in engineering technology, a rate roughly ten times that of the traditional students. (See figure 3-6, below). This is preliminary evidence that the ATE approach boosts graduation rates by meeting the needs of ET students. It suggests that the increased levels of student engagement noted in Section 3.1, the wide availability of ATE scholarships mentioned in Section 2.3, and the applied approach to general education described in Sections 2.1 – 2.2. keep students motivated, help them to pay for college, and assist them with mastering difficult



material. Through these means, it appears the ATE approach increases the chance that ET students complete their degrees.

In spite of the tremendous difference in graduation rates, the results from a small group of students at two colleges can not be extrapolated to the entire state system. First, the Fall 1998 cohort includes only 30 students from two colleges. In order to have more precise estimates of the impact of ATE, it is critical to have a larger group of students from a greater number of colleges and participating in the program at different points in time. Students in the Fall 1999 cohort, for example, have completed ATE courses and persisted through the ATE program at lower rates than the previous cohort, an indication that graduation rates for this group will be lower. (See figure 3-7, previous page). Even so, rates may not be much lower for the second than for the first cohort



because only 6% fewer students of the second cohort passed the third semester of the ET Core.

Second, data for the baseline of historical students and data for the outcomes of ATE students were collected in different ways and should be interpreted differently. The baseline data represent the entire State Tech system while the ATE student data represent only two colleges. Baseline data were reported annually by college administrators while ATE data were reported each semester by ATE faculty members. Finally, for the baseline statistics, a student's first year is calculated from the time that he or she first enrolled in an engineering technology course. For the ATE statistics, a student's first year is calculated from the time that he or she enrolled in the first semester of the ET Core.

Although the historical baseline and the performance rate of ATE students were developed using different methods, the change in graduation rates is so dramatic that a substantial gap must exist, regardless of differences in methods of data collection.

Third, there is the question of selection bias in the ATE program. That is, are ATE students performing better, not because of the ATE program, but because they were already better students before they enrolled in ATE? Based on conversation with faculty members, evaluators have no information at this time that ATE students were selected for the program because they were high achievers. In many cases, it seems that ATE students signed up for the program because of a random conversation with an advisor who suggested the program. It is possible, however, that ATE students may be especially motivated because

they opted to try the ATE program as opposed to the regular program. Furthermore, ATE faculty may be more effective than the average technical college faculty members, as evidenced by the tremendous effort they have put into the ATE program. During the sixth year evaluation, as evaluators receive a detailed extraction of student records from the SBTCE database, any observable differences between ATE students and traditional ET students will be carefully noted and controlled. In spite of all of these caveats, the improvement in graduation rates is so dramatic that part of it must be attributed to the higher quality of the ATE program.³⁹

3.5. ATE student enrollment is not more diverse than student enrollment in traditional ET programs, except that a high proportion of minorities enroll in the Technology Gateway.

The ATE approach is designed to embrace student diversity. Nearly all faculty interviewed indicated that the ATE program is geared toward all students, without regard to a student's gender or ethnicity. As one faculty member put it, "Any average, motivated individual will be equally successful regardless of race or gender." While the ATE program is not designed to benefit one group of students over another, certain aspects of the ATE approach might particularly serve women and underrepresented minorities.⁴⁰ The extra attention afforded ATE students, through student teamwork and the presence of multiple faculty members, strengthens the connections of women and minorities to classes typically dominated by Caucasian men. Through the application of multiple

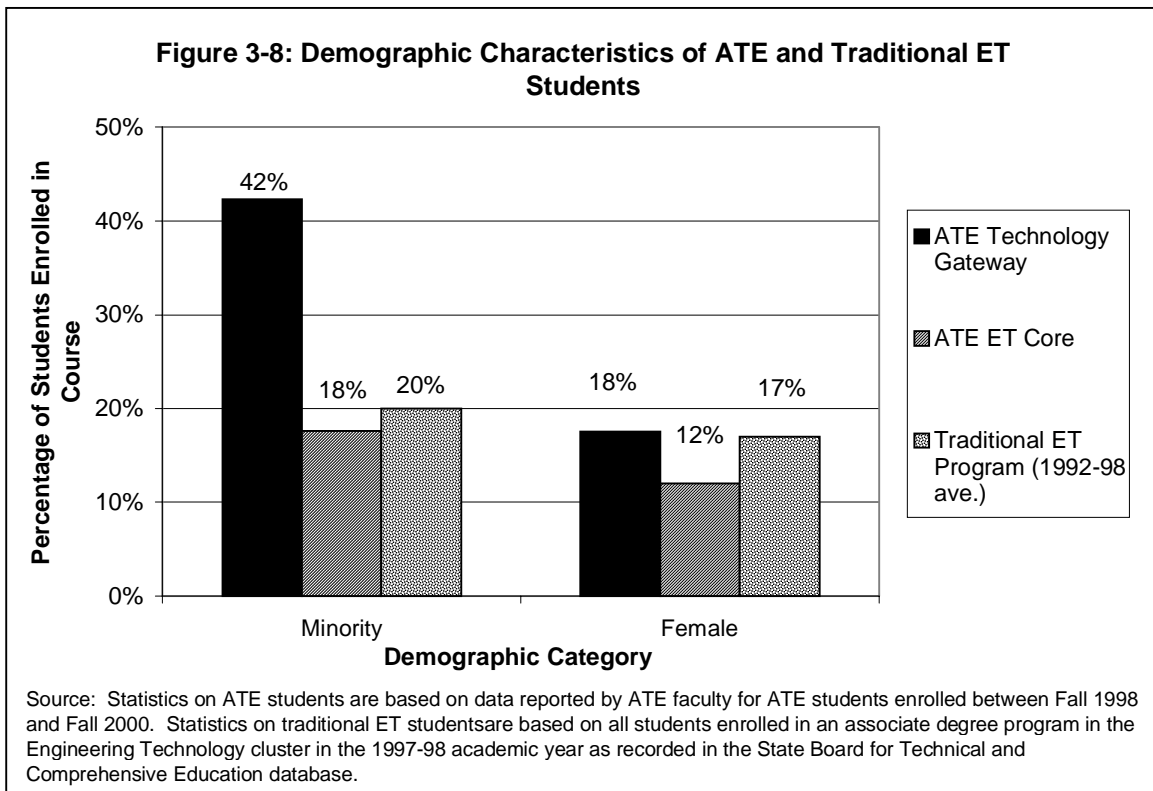
intelligences and learning styles theory, ATE lessons are designed to engage students from a variety of backgrounds. Integrating engineering courses with English and communications – subjects in which women typically outscore men – may engage more women in technical studies. As one faculty member put it, by broadening the scope of the engineering technology curriculum, the ATE program has “opened the door for women and minorities.”

In practice, however, these aspects of the ATE approach have not affected the diversity of ET enrollments, except in the Technology Gateway. When asked about the impact of the ATE program on women and minorities, one faculty member commented, “If we can’t get them into the program, we can’t teach them.” Perhaps because the ATE curriculum is only in its third year of implementation, there has not been enough time to develop systems to recruit a greater diversity of students into ET courses. Recruitment into innovative programs often depends upon a track record of positive results which ATE is just beginning to show. As the SC ATE Center staff and ATE faculty continue to improve recruitment practices, it is possible that a greater variety of students will be attracted to the ATE program and that enrollments will diversify.

3.5.1. Technology Gateway may increase minority enrollments in ET programs.

Minority enrollment in the Technology Gateway is higher than average historical enrollment in engineering technology degree programs while enrollment in the ET Core is not significantly different. Between the 1992-93 and 1998-99

academic years, an average of 20% of all engineering technology degree students were minorities. By contrast, between Fall 1998 and Fall 2000, 42% of Technology Gateway students were minorities.⁴¹ (See figure 3-8, below). Minority enrollment in the ET Core (18%) does not differ significantly from this historical average.

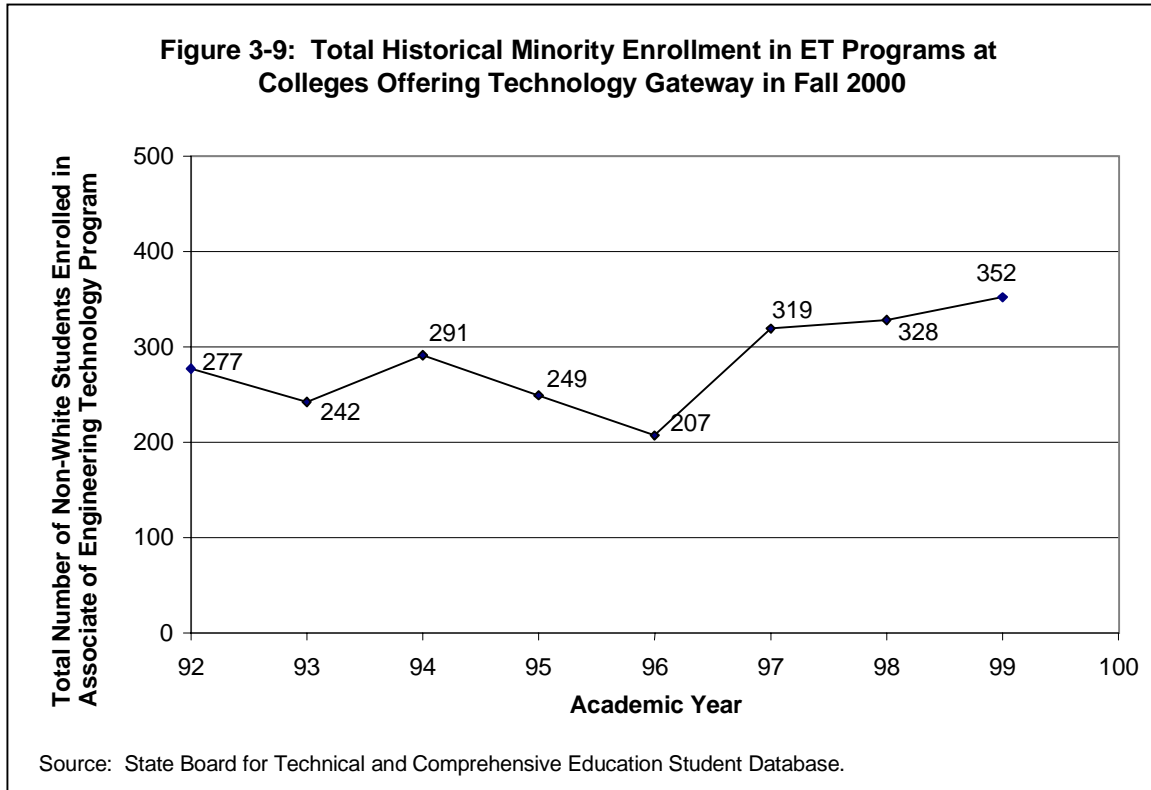


Since the Technology Gateway is not part of the engineering technology curriculum, diverse student enrollment in the Technology Gateway is not the same thing as diverse student enrollment in the engineering technology curriculum. As an onramp to that curriculum, however, high minority enrollment in the Technology Gateway implies that the Gateway could increase minority enrollment in engineering technology programs by preparing more minorities with the basic skills necessary to succeed. To assess the potential impact of the

Technology Gateway on the enrollments of minority students in engineering technology programs, consider the following projection:

1. Approximately 350 minority students were enrolled in associate in engineering technology programs in the colleges that offered it during Fall 2000.⁴² (See figure 3-9, next page).
2. Twenty-eight minority students were enrolled in Technology Gateway programs at these same colleges during this semester.
3. Sixty percent of these minority students indicated in start-of-semester surveys that they planned to complete a two-year associate degree in engineering technology.
4. Eighty-two percent of minority students passed all three Technology Gateway courses in between Fall 1998 and Fall 1999.
5. If all of the minority students who pass the Technology Gateway and who plan to earn an associate degree were to enroll in the ET program, the number of minority students at participating colleges would increase by 14 (i.e., $28 \cdot .6 \cdot .82 = 14$).
6. If 63% of these students remain in the ET program from their first to their second year⁴³, in accordance with historical averages, and if 14 minority students pass the Technology Gateway and enroll in the ET program in the subsequent year, the Technology Gateway will have increased the number of minorities in the ET programs at these schools by 23 in a “steady state” (i.e., $(.63 \cdot 14) + 14 = 23$).

7. If the number of minority students otherwise enrolled in ET programs were to remain at the 1999 level (352), an 23 additional ET students would amount to a 6.5% increase in the total number of minority students enrolled in ET programs.



The relatively low impact that the Technology Gateway may have had on minority enrollment in ET programs to date should not be understood to mean that the Technology Gateway has low potential to increase minority ET enrollment. In fact, since the Technology Gateway has a high enrollment rate for minorities, and a high success rate for minorities (as is explained in section 3.6), it is an effective bridge between minority populations and engineering technology programs. The primary barrier to increasing minority enrollments in ET programs

via the Technology Gateway has been difficulty in recruiting students to engineering technology. AED recommends that the SC ATE Center and ATE faculty continue to identify means of recruiting students into the ATE program and of identifying students at the appropriate level to place into the Technology Gateway.

3.5.2. ATE has not affected female enrollments in engineering technology.

Although a gap exists between black and white engineering technology enrollments, the bigger gap in the South Carolina technical college system exists between female and male enrollment. To date, however, female enrollment in the ATE program shows no increase over historical averages. Female enrollment in the Technology Gateway (18%) does not differ significantly from the historical female enrollment in ET degree programs (17%) while female enrollment in the ET Core (12%) is slightly lower than historical averages. (See figure 3-8, page 57). Because total enrollments of ET Core students have been small and representative of only one-fifth of State Tech colleges (See figure 2-1), however, these results do not indicate that the program is less appealing to women than the traditional program or that rates of female enrollment could not be higher in subsequent cohorts. Rather, it likely indicates that college faculty faced difficulty recruiting the initial cohorts of students into the ET Core. The evaluators recommend that the SC ATE Center and ATE faculty continue to examine ways to boost levels of female enrollment as the program enters its sixth year.

3.6. Women and minorities are as successful, if not more successful, than white males in the ATE program.

The ATE program is designed to provide an environment that encourages the success of women and minorities, as mentioned above in Section 3.5. Although this approach has not significantly affected the diversity of enrollments, it seems to have affected course performance. To date, neither gender nor ethnicity appears to affect a student's likelihood of completing ATE program requirements. This is significant because, as mentioned in Section 1, blacks are far less likely than whites to complete engineering technology degrees.

3.6.1. Women slightly outperform men in both the Technology Gateway and the ET Core.

Historically, women in the South Carolina technical college system have been more likely than men to graduate with ET degrees once enrolled in an ET program. After four years of enrollment in an associate degree program in the engineering technology cluster, 10% of women graduate, compared to just 8% of men.⁴⁴ Thus, it should be no surprise that women in the ATE program outperform men, especially since the program is designed to meet the needs of a diverse range of students. Seventy-eight percent of women enrolled in the Technology Gateway between Fall 1998 and Fall 1999 passed the course compared to 70% of men. Likewise, 88% of women passed the first semester of the ET Core during the same time period compared to 83% of men. (See table 3-1, below). It should be noted, however, that with the small sample size (only

18 women enrolled in the Technology Gateway and 8 in the Core), it is difficult to compare the performance of the two groups with a high level of statistical confidence and that these differences are not statistically significant.

| Table 3-1: ATE Course Pass Rates by Gender | | | | | |
|---|-----------------|----------|-----------------|----------|-----------------------------------|
| | Female | | Male | | P-Value of Chi-Square Test |
| | % Passed | N | % Passed | N | |
| Technology Gateway | 76% | 17 | 66% | 71 | 0.41 |
| ET Core First Semester | 62% | 8 | 81% | 60 | 0.20 |

Source: ATE student rosters submitted by faculty.
 Universe: Technology Gateway and ET Core first semester (181) students between Fall 1998 and Fall 1999.

3.6.2. Minorities outperform whites in the Technology Gateway but slightly under-perform in the ET Core.

Historically, minority students have been far less likely to graduate with an ET degree. (See figure 1-5 in section 1). While 10% of white students historically graduated with an associate in engineering technology degree within four years, only 6.5% of black students did. Since students from the first cohort of the ATE program are just starting to graduate, there are not enough data to compare graduation rates of minorities to those of whites. A sufficient number of ATE students have passed through the Technology Gateway and the ET Core, however, to permit a preliminary estimation of the relative performance of whites and minorities in ATE courses. Of the ninety-nine students enrolled in the Technology Gateway between Fall 1998 and Fall 1999, 49 were minority and 50 were white. Of the minority students, 81% passed while only 62% of white

students passed. Pass rates of minorities and whites in the ET Core differ slightly, but not in a way that is statistically significant. (See table 3-2, below).

Since a large portion of enrollments in the Technology Gateway consisted of students in a historically black college, the population of students in this sample does not accurately reflect the population of students in the State Tech system at large. The unique conditions of this college likely affected overall pass rates for

| | Minority | | White | | P-Value of Chi-Square Test |
|-------------------------------|-----------------|----------|-----------------|----------|-----------------------------------|
| | % Passed | N | % Passed | N | |
| Technology Gateway | 77% | 47 | 59% | 41 | 0.07 |
| ET Core First Semester | 70% | 10 | 81% | 58 | 0.42 |

Source: ATE student rosters submitted by faculty.
 Universe: Technology Gateway and ET Core first semester (181) students between Fall 1998 and Fall 1999.

minority students. Thus, the results of these tests cannot be extrapolated beyond the ATE students in this sample to imply that minority students will likely outperform non-minority students in the Technology Gateway in the future. Even with this caveat, however, the performance of blacks and whites in the ATE program, particularly in the Technology Gateway, show that the ATE approach may help to equalize learning opportunities for students in engineering technology degree programs.

4. Conclusions: Preliminary evidence indicates the SC ATE Center is having a positive impact on the quantity, quality and diversity of ET students.

The goal of the SC ATE Center has been to increase the quality, quantity, and diversity of South Carolina engineering technology graduates. Preliminary evidence indicates that the Center is succeeding, to varying degrees, in meeting these goals. During the coming year, AED evaluators will collect and review additional qualitative and quantitative data to further explore these initial indications.

The ATE program may have a significant effect on graduation rates of engineering technology students. Graduation rates of the first cohort of ET Core students are roughly ten times higher than those of students in the traditional program. These rates may be caused by increased levels of student engagement in ATE courses which were noted by faculty and students. Although data from subsequent cohorts of ATE students and comparable cohorts of non-ATE students are necessary to corroborate this claim, and although ATE students and instructors may be superior in certain ways to non-ATE students and instructors *a priori*, the stark contrast between ATE and traditional graduation rates is initial indication that the program is succeeding in achieving its primary goal of increasing the quantity of engineering technology graduates. In order to provide more definitive estimates of the impact of the ATE approach, evaluators will analyze a detailed database of ATE and traditional student records provided by SBTCE during the coming year.

ATE seems to develop students' "workplace readiness skills" better than the traditional approach to engineering technology education. Students seem to develop greater problem-solving skills, probably because of the ATE emphasis on problem-based learning. Most faculty indicate that ATE students are better problem-solvers than non-ATE students while most ATE students are confident in their own problem-solving ability. Students also seem to develop greater communication and cooperation skills, probably because of the integration of communications with technical courses and the emphasis on student teaming. Faculty rate ATE students as superior to non-ATE students and ATE students are confident in their own ability in these "soft skills." These perceptions, however, have not been corroborated by a standardized assessments or by surveys of non-ATE students or faculty. Evaluators suggest that SC Center staff, college administrators, and ATE faculty consider such measures during the final year of the project.

ATE has demonstrated no initial effect on the diversity of ET student enrollment, except for high minority enrollments in the Technology Gateway. Since a large proportion of these students were enrolled in one historically black college, the higher rates of minority enrollment does not mean that the Technology Gateway is more appealing to minority students generally. At the same time, such a high enrollment may indicate that the Technology Gateway continues to hold promise for boosting minority enrollment in engineering technology programs. Enrollment of women in both programs is lower than historical averages but small overall enrollment levels means that these

differences are not statistically significant. As data from more students become available during the next year, evaluators will be able to better determine any impact ATE has had on the diversity of student enrollment.

ATE may be having an impact on minority persistence rates. In the Technology Gateway, minorities out-perform whites, although as mentioned above, the high enrollment of students from a historically black college means that results cannot be extrapolated further. In the ET Core, in contrast to what is implied by the ethnic gap in historical graduation rates, there is no statistically significant difference in course pass rates by race. Through student teaming, faculty teaming, and alternative instructional methods, ATE may be leveling the playing field between black and white engineering technology students. As evaluators collect data on more students over the coming year, they will be able to verify this initial observation.

In order to continue to improve the ATE program, evaluators recommend that the SC ATE Center continue with its excellent progress to date, while addressing a few critical issues. ATE faculty and Center staff should enhance the ATE Scholars program as much as possible in order to recruit and retain more students, specifically minorities. ATE faculty and Center staff should review procedures for placing students into the Technology Gateway and conduct a session to determine how ATE methods can better be applied to this crucial stage of the ATE approach. By enhancing the delivery of the Technology Gateway, ATE faculty and Center staff may boost retention and the number of students, particularly minorities, prepared for ET core courses. Finally,

evaluators suggest that ATE continue to experiment with part-time versions of the ATE approach and continue to encourage faculty to use ATE methods in non-ATE courses in order to make the ATE approach accessible to more students and to boost student enrollments.

Appendix A – Evaluation Methodology

AED researchers conducted the following activities between Fall 1999 and Fall 2000 to evaluate the initial impact of the ATE approach:

1. Student surveys – AED, in cooperation with the SC ATE Center, drafted beginning and end-of-semester surveys for both Technology Gateway and ET Core students. In Fall semester 1999, these surveys were administered by ATE faculty members in ATE classrooms using paper questionnaires. By the end of Fall semester 2000, AED converted these surveys to Internet forms supported by MS Access databases. That administration of the survey was supervised by faculty with students completing the survey in computer labs or at computer stations in ATE classrooms. During that administration, 27 of the 86 students enrolled in the Technology Gateway completed the survey for a response rate of approximately 31%. (Note that the actual response rate is likely higher because some of the 86 students may have dropped out by the end of the semester). Of the 57 students enrolled in the first semester of the ET Core, 22 (39%) responded to the survey.
2. Faculty survey – The SC ATE Center, with support from AED, developed a survey of all ATE faculty members. This survey was administered via the Internet in October 2000. Of the 34 ATE teaching faculty, 32 completed the survey. An additional 27 of the roughly 100 non-teaching ATE faculty members responded.

3. Site visits – AED researchers Paul Bucci and Mark Braza visited seven colleges implementing the ATE curriculum during five days in October 2000. At each college, they observed ATE classes, conducted informal focus groups with faculty members, interviewed administrators, and conversed with ATE students.
4. Faculty-reported ATE student data – For each semester between Fall 1998 and Fall 2000, ATE faculty members submitted to the SC ATE Center, via MS Excel spreadsheets, basic demographic and course achievement data for each of their ATE students. AED compiled and analyzed these data to track ATE student progress.
5. State System Database – Under the supervision of AED, analysts at JBL Associates in Bethesda, Maryland analyzed the performance outcomes and demographic characteristics of engineering technology associate degree students in the State Tech system between 1992 and 1999. These analyses form the basis of the historical baselines used in this report.
6. Faculty Interviews – In November 1999, AED researchers Mark Braza and Elizabeth Dooley conducted 60-minute interviews with 17 of the roughly 20 faculty who taught the ATE curriculum during Fall semester 1999. These interviews were transcribed and organized according to topic for analysis.

7. Literature Review – AED researcher Mark Braza, with help from graduate assistant Casey Goode, reviewed over 50 articles and reports pertaining to engineering education and South Carolina industry, in addition to reviewing ATE program and curriculum materials.

Endnotes

¹ "Skills that Work 2000: A Comprehensive Analysis of South Carolina's Workforce, Critical Jobs and Necessary Skills." South Carolina Chamber of Commerce. Engineers were the 12th most difficult position to fill.

² Persons, Tom. *The Tera-Byte*. South Carolina Technology Alliance, Vol. 1, No. 1, 1999.

³ G. Andrew Bernat, Jr. and Eric S. Repice. "Industrial Composition of State Earnings in 1958-98." *Survey of Current Business*. February 2000. Manufacturing accounts for 23.6% of earnings in South Carolina compared to only 17.4% of earnings in the U.S

⁴ South Carolina Department of Commerce "Facts about Manufacturing" available at www.scchamer.net/About.

⁵ South Carolina Department of Commerce 1999 Annual Report.

⁶ This figure likely underestimates the total demand for engineering technicians: it is based on employer requests for workers to One-Stop and other placement centers yet many employers do not recruit workers through these means.

⁷ W. Douglas Evans. "Recruitment and Retention of Engineering Technology Students." Monograph. South Carolina Advanced Technological Education Center of Excellence. South Carolina Technical College System. June 2000.

⁸ Statistics are based on an Academy for Educational Development analysis of records of engineering technology students from the State System of Technical and Comprehensive Education database.

⁹ These students had neither completed a degree nor remained enrolled.

¹⁰ Note that the 12% graduation rate reported above is lower than the 14% rate reported here because the first rate only includes the number of students graduating within four years of study whereas the second rate does not impose a time limit.

¹¹ "Program Evaluation Report." State Board for Technical and Comprehensive Education. March 2000.

¹² Two colleges offering the ATE program during the 1999-2000 academic year submitted selected information for students who began their engineering technology studies in either 1995 or 1996 at their college. Of the 240 students, only 84 had persisted to 200-level ET courses by the fall of 1999.

¹³ AED researchers conducted telephone interviews with 20 ATE teaching faculty in November 1999 and conducted on-site interviews with students, faculty and administrators at seven ATE implementation colleges in October 2000.

¹⁴ National Center for Education Statistics. Research and Development Report. "Entry and Persistence of Women and Minorities in College Science and Engineering Education." September 2000. The figure reported is for 1996.

¹⁵ In the 1995-96 academic year, for example, there were 3153 students enrolled in associate degree programs in the engineering technology cluster, according to the Technical Education System Program Evaluation Report for that year. Approximately 19% of these students were black, according to AED analysis of the state system database. If these 599 students persisted and completed according to historical rates, 39 would graduate within four years. If this rate were brought into parity with graduation rates of white students (10%), an additional 21 students would graduate.

¹⁶ These gaps are correlated with levels of parental education and levels of school resources. Nearly twice as many black as white South Carolina students have parents whose highest level of education is a high school diploma, according to the "1999 South Carolina SAT Report" available at www.state.sc.us/sde/reports. Ninety-five percent of South Carolina public school teachers indicated in a recent survey that education resources were not distributed fairly across public schools, according to "What our Children Need: South Carolinians Look at Public Education," a 1997 Report from Public Agenda prepared for the South Carolina Department of Education.

¹⁷ National Center for Education Statistics. "Entry and Persistence of Women and Minorities in College Science and Engineering Programs." Washington, DC: US Department of Education. September 2000.

¹⁸ Ibid. See Evans, see supra note 7.

¹⁹ See www.census.gov/cdrom/lookup/.

²⁰ Ibid. See NCES supra note 14.

²¹ National Science Foundation. (2000) "Women, Minorities, and Persons with Disabilities in Science and Engineering: 2000." Washington, DC: National Science Foundation. The figure reported is for 1997.

²² In the 1995-96 academic year, for example, there were 3153 students enrolled in associate degree programs in the engineering technology cluster, according to the Technical Education System Program Evaluation Report for that year. Approximately 19% of these students were women, according to AED analysis of the state system database. If female enrollment were to increase by 50%, from 18% to 27%, an additional 284 students would enroll in ET programs, assuming male enrollment remained constant. If these 284 students persisted and completed according to historical rates for females, 28 would graduate within four years.

²³ NCES and Hanson, Sandra L. *Lost Talent: Women in Sciences*. Philadelphia: Temple U. Press, 1996.

²⁴ These figures are based on an AED analysis of State Tech data. See supra note 8.

²⁵ Ibid. See NSF supra note 21.

²⁶ South Carolina Technical Education System 1997 Factbook.

²⁷ This report refers to these faculty members as "non-teaching ATE faculty."

²⁸ Note that rates of involvement of non-teaching ATE faculty are likely overestimates. While 94% of teaching faculty responded to the faculty survey, roughly one fourth of non-teaching faculty members did. Those that did respond likely were probably the ones who were more likely to have participated in curriculum-writing events.

²⁹ SC ATE Center of Excellence. "Peer Review Report." State Board for Technical and Comprehensive Education. 1999.

³⁰ See supra note 28. It could be precisely the faculty members who were dissatisfied who did not respond to the survey.

³¹ The smallest annual value of an ATE scholarship (\$2,800) multiplied by the number of ATE scholarships awarded in 2000-01 (36) equals \$100,800. See Section 1 for a discussion of the importance of financial aid to an engineering technology student's chances of graduating with an associate's degree.

³² Quote by Jeffrey Helton, Honda manager of administration from SC ATE Center news brief.

³³ Quote from Eugene Grant of Bosch Corporation from SC ATE Center news brief.

³⁴ Craft, Elaine L. and Lynn G. Mack. 1999. "Developing and Implementing an Integrated, Problem-Based Engineering Technology Curriculum." Paper presented to the American Society of Engineering Educators National Conference.

³⁵ This description is based on AED evaluators November 2000 site visits and review of curriculum materials.

³⁶ It is possible that some of this difference is random fluctuation caused by uneven response rates to end-of-semester student surveys.

³⁷ Based on an AED analysis of State Tech data.

³⁸ Although faculty did not report a higher incidence of ATE students visiting them during office hours, many indicated that their offices were located far from the ATE classrooms and were not easily accessible.

³⁹ Although the baseline statistics are not strictly comparable to the ATE statistics, they are the best available at the time of this report. For the final evaluation report of the ATE program, evaluators will construct a more precise baseline based on a more detailed extraction of data from the SBTCE student records.

⁴⁰ Faculty members at one college mentioned that their colleagues were concerned that the ATE program was "some kind of affirmative action program."

⁴¹ The high minority enrollment is in part due to high Technology Gateway enrollments at Denmark Technical College, a historically black college.

⁴² The colleges that offered the Technology Gateway in Fall 2000 were Aiken, Denmark, Florence-Darlington, Newberry, Northeastern, Piedmont, Spartanburg, and Tri County. Northeastern Technical College and Newberry High School were removed from this analysis, however, because neither offer associate in engineering technology degrees. Note that these enrollment figures are unofficial and were calculated by AED from the SBTCE student database. Because of differences in the time that data were reported and criteria used to select student records, these figures may differ from figures reported by the colleges themselves. In spite of their limitations, however, they give a rough order of magnitude of the effect of ATE enrollment on overall engineering technology enrollment.

⁴³ Based on an AED analysis of SBTCE student records. See note 8.

⁴⁴ These statistics are based on an AED analysis of all students enrolled in associate degree programs in the Engineering Technology cluster in the 1992, 1993, and 1994 cohorts (N=1614). Both full-time and part-time students are included.