

# Attracting, Retaining, and Preparing a Diverse Academic Engineering Workforce:

## *The AGEP Model for Success*

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**Abstract—** *The National Science Foundation (NSF) has recognized that the Nation's need for a technical workforce is in conflict with the changing demographics facing the nation. Our nation is rapidly becoming more diverse due to growth in groups that have traditionally been underrepresented in technical fields. Nowhere is this underrepresentation more evident than in academia. It was determined that one potential way to attract more underrepresented students to pursue engineering careers was to increase the diversity of the engineering faculty, proving powerful role models to potential technical students. Therefore, over 10 years ago, NSF began a program that sought to*

*diversify the Nation's faculty in engineering, science and mathematics fields, called the Alliances for Graduate Education and the Professoriate (AGEP). The AGEP Program is now a national network of multi-institution alliances. Nationally, the AGEP program has recorded significant gains in doctoral degrees awarded to underrepresented minorities in engineering. The Southeast Alliance for Graduate Education and the Professoriate (SEAGEP) Program includes the University of Florida, Clemson University, and the University of South Carolina. SEAGEP is the top producer of Hispanic PhDs in the country and is third in the production of African American PhDs in engineering. Best practices in recruiting, retention, and preparation for the professoriate are detailed.*

**Keywords** *retention, professional development, engineering faculty, diversity*

I. Introduction The United States is facing changing demographics that have potentially important implications for engineering education in the future. Today, the U.S. workforce includes 20.8% African Americans and Hispanics, according to W. Lance Haworth of the NSF Office of Integrative Activities [1]. Projections are that these two groups will grow to comprise 29.8% of the total workforce of 2020 [2]. Additionally, it is estimated that by 2050, a full

50% of the U.S. college-age population will be from underrepresented minority groups [2].

However, despite the increase in the workforce pool, these groups have not traditionally pursued engineering and science academic careers. In 2003, less than 17% of those earning science, technology, engineering and mathematics doctoral degrees planned to pursue an academic career [3]. Underrepresented minorities accounted for only 7.9% of all science and engineering doctorate-held academic positions in universities and four-year colleges in 2003 [3].

As Figure 1 shows, the number of underrepresented minorities receiving doctoral degrees in science and engineering has risen in the period from 1990 to 2006, but remains low, at only 10% of all doctoral degrees awarded in science and engineering to U.S. citizens [4].

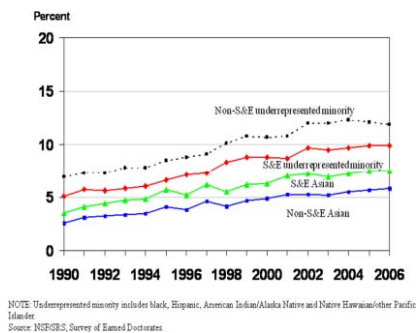


Fig. 1. Minority share of science and engineering and non-science and engineering doctoral degrees to U.S. citizens: 1990–2006.

Figure 2 illustrates the dramatic disparity between employment of majority and underrepresented minority faculty [4].

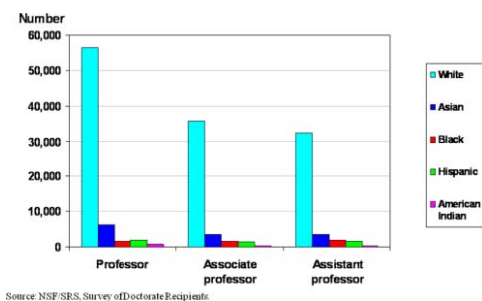


Fig. 2. U.S. citizen science and engineering doctorate faculty employed in universities and four-year colleges, by race/ethnicity and rank: 2006.

If no changes are made in science and engineering education that result in more representation from these groups, predictions are that the disparity will widen [5].

To address this issue, the National Science Foundation established a program in 1998 designed to diversify the student population pursuing doctoral degrees in science, engineering and mathematics. The Alliances for Graduate Education and the Professoriate (AGEP) program was designed to increase the number of domestic students receiving doctoral degrees in science, engineering and mathematics with special emphasis on those population groups underrepresented in these fields to prepare them for careers as faculty and research professionals.

The goals of all AGEPs include developing infrastructure that substantially changes the graduate school experience for underrepresented minority students and catalyzing institutional change. One of the major obstacles faced by underrepresented minorities that must be addressed if an institution wants to attract and retain a diverse student population is the lack of

culturally appropriate student support systems. AGEP institutions address this obstacle directly. This national network of programs now includes 21 alliances that represent over 80 institutions [6].

NSF collaborates with the American Association for the Advancement of Science (AAAS) to evaluate the effectiveness of the AGEP program. A recent AAAS report provided an analysis of doctoral degree recipients from participating AGEP universities and revealed that in the first ten years of the program, the annual number of doctoral degrees awarded to underrepresented minorities in science and technical fields increased by 33.9%. The natural sciences and engineering fields reported an increase of 50%. In 2005-2006, the AGEP alliances produced 56% of all science, technology, engineering and mathematics doctoral degrees awarded to underrepresented minorities in the United States [5].

The University of Florida was awarded an AGEP in 1998, and five years later the project grew to include Clemson University and the University of South Carolina in the South East AGEP (SEAGEP). This group has implemented a variety of measures to develop a robust recruiting, retention and doctoral degree completion program impacting graduate programs in science, technology, engineering and mathematics. Additionally, professional preparation for academic careers is part of the program. The University of Florida has developed a mature program and is now the fourth-highest producer of Hispanic PhD graduates in engineering and the third highest producer of African American PhD graduates in engineering [7]. Both Clemson University and the University of South Carolina have been working to implement a similar infrastructure to enhance the diversity of their graduate programs in science, technology, engineering, and mathematics. The key elements in the SEAGEP program are described below.

## II. Key Elements

The most essential component of a diversity program is support from top university administrators. Diversity at all levels should be a visible part of an institution's mission. However, beyond mere recognition of the need for inclusivity in institutional mission statements, some type of accountability structure should be in place. For example, at one of the SEAGEP institutions, the Graduate Dean has implemented a policy whereby graduate program reviews will include a diversity dimension; i.e., a department's record of awarding degrees to

underrepresented minority students will, in part, determine allocation of resources from the Graduate School.

At Clemson University, oversight of the diversity mission of an institution rests with a Chief Diversity Officer. The Chief Diversity Officer reports directly to the President and provides leadership in implementing Clemson University's first Diversity Plan. The Chief Diversity Officer leads all efforts designed to foster a learning and workplace environment that is welcoming and supportive for all students, faculty, and staff. The Chief Diversity Officer supports existing diversity activities and develops and implements new initiatives and programs to provide focus and accountability for equity and inclusion across the university. Among the tasks of the Chief Diversity Officer is sponsoring of the annual National Conference on Best Practices in Black Student Achievement at Clemson University. Each year administrators, staff, and faculty who help universities recruit, retain and graduate African-American students at academic institutions across the country attend this conference, which provides a venue for dissemination of SEAGEP best practices.

At the University of Florida, Dr. Bernard Machen established the President's Council on Diversity, which has been charged with the mission of gathering and analyzing diversity data at the college and departmental levels. The Council on Diversity has been formed to further the University's commitment to equal opportunity. The President's Council on Diversity is also charged with identifying ways to increase the diversity of the faculty, staff and students. The council is currently working to review the practices of each college and department within the University of Florida to determine whether improvements could be made to increase student, staff, and/or faculty diversity and to propose policies that serve to increase/retain underrepresented minority students, staff, and/or faculty.

The University of South Carolina has instituted a new set of Family Friendly policies, which is an initiative of the Office of the Provost. All science and engineering units have been encouraged to increase the number of female and underrepresented minority faculty. The new Assistant Dean for Women and Minorities in the University of South Carolina College of Engineering and Computing is tasked with assisting departments with identifying and recruiting underrepresented minority faculty.

The second component of a successful diversity program is comprehensive data

collection capability. Defining an institution's historical baseline as well as tracking current students requires a robust dataset that is not necessarily collected systematically by departments and graduate schools or readily obtainable from offices of institutional research.

AGEP institutions collect and report the following numbers annually: applications, admissions, new enrollees, total enrollees, admit to candidacy, and degrees awarded. These are disaggregated by field (engineering, chemistry, physics, mathematics, computer science, biological and agricultural, earth, atmospheric, and ocean science), race, ethnicity, and gender for a total picture of the graduate student population.

Pre-AGEP, this annual institutional snapshot was not collected at the University of Florida, Clemson University, or the University of South Carolina. The data not only can be used to identify trends, but also may indicate fields that are performing below national standards. Furthermore, the data may also indicate where interventions are needed. For example, if the data show that numbers of applications and admissions are increasing, but that this increase is not reflected by numbers of new enrollees, it would be appropriate to identify ways to increase the yield of admitted students.

Additionally, these data can serve whatever accountability systems are put in place, because they reveal departments that are performing below institutional standards. The data are shared with Deans to allow them to monitor their programs. This data collection and analysis effort also provides critical information for PIs seeking funding for diversity-related proposals.

Third, a highly visible office on campus should be established that includes space for students to meet. This legitimizes the program on campus and provides a physical presence that demonstrates the instruction's commitment to students' success. It also supports regularly scheduled professional development seminars and other student activities. A program budget to support program activities is critical. This should include funds to maintain the office as well as providing funds to support student travel and other student activities.

A Program Director who reports to upper administration is the final infrastructure requirement. This person has significant student advising responsibilities in addition to project management duties.

## II. Program Activities: Recruiting

Recruiting for diversity is a critical first step, but one not always conducted or understood at the graduate student level. Unlike centralized undergraduate admission, graduate admission is a decentralized, often faculty-driven activity. At large institutions, some faculty do not actively recruit, but rely on students who contact them or who are already admitted into the department. These methods tend to exclude those outside of traditional engineering groups.

An active diversity recruiting program is needed, but to be successful it must be based on personal connections with those institutions and programs that support underrepresented minority undergraduates in the science, technology, engineering and mathematics disciplines. Including current underrepresented minority graduate students as recruiters is a powerful tool. SEAGEP has established a recruiting network that includes the National Science Foundation keystone program for underrepresented minorities, the Louis B. Stokes Alliances for Minority Participation in Science, Technology, Engineering, and Mathematics (AMP). SEAGEP participates in recruiting events at both the Florida-Georgia and South Carolina AMP programs, as well as at the University of the Virgin Islands.

In addition, a unique recruiting tool has been the establishment of a dual-degree program in engineering between the University of the Virgin Islands, the University of Florida, and soon the two South Carolina institutions. These programs allow the students from the University of the Virgin Islands to obtain an engineering degree that would otherwise not be available to them on their home campuses.

A major component of preparing undergraduate students for graduate school is undergraduate research. SEAGEP institutions therefore have supported a variety of undergraduate research efforts. These include academic year research at a student's home institution as well as summer residential research experiences. These experiences provide undergraduates with laboratory skills and graduate student mentors to increase their awareness of the graduate school experience. In addition, SEAGEP has sponsored several international undergraduate research experiences in Finland and Costa Rica.

### III. Retention

Too often, it is assumed that once underrepresented minority students have been accepted, the process of diversifying the student population is over. Without a strong retention

program, however, many of these recruits will be lost before they earn the doctoral degree. This component requires both human and financial resources. Underrepresented minority students often face unique challenges in science, technology, engineering and mathematics fields, including isolation and lack of awareness of the doctoral degree process, which require mentoring by program administrators. Having support outside of the department can be instrumental to a student's success. In addition, many of these students face greater financial obstacles than do majority students, and consequently seek outside employment that detracts from their academic responsibilities.

It proved critical to the retention of a significant number of SEAGEP students to provide short-term stopgap funding to bridge other funding opportunities. These retention awards were a key factor in maintaining an overall retention rate of over 80% to the Ph.D, a rate significantly better than the retention rate for non-SEAGEP students.

### IV. Professional Development

In order to prepare students for academic careers, the AGEPE program provides a portfolio of professional development activities. This includes both in-house and national preparation for the professoriate seminars and workshops. SEAGEP not only funds development, coordination, archiving, and online delivery of the professional development programs at the alliance institutions, but it also provides considerable travel funding to send students to professional society meetings. Participation in professional meetings is especially important for underrepresented minority graduate students as it gives them critical networking opportunities and provides entrée to an extended discipline-specific community.

SEAGEP funds are allocated to support development, archiving, and online delivery of the Clemson University Engineering and Science Education certificate and the associated seminar series. The graduate certificate program, one of only a handful in the United States, is designed for graduate students who seek experience in preparation for an academic career, who wish to further their understanding of the education process in engineering and science, or who are interested in engineering and science education research. The Engineering Science and Education seminar series is a one-credit course designed to bring contemporary issues in engineering and science education research into

the classroom. Experts from academia, industry, and the corporate world are invited to make presentations on engineering and science education research issues including recruitment of minorities, retention issues, technology integration into engineering curricula, distance learning, engineering content into K-12 curriculum, learning theories, and education policy issues.

Global research experience is also a critical component for students' professional development. SEAGEP has been able to help support students with international research awards to conduct research in Bolivia, Columbia, Costa Rica, and Honduras.

To provide students with critical leadership skills, a SEAGEP Student Leadership Council has been developed. This group assumes the responsibility for planning student events such as the fall new student orientation and the annual student meeting, which features several days of professional development workshops and a scientific poster session.

#### V. Post Doctoral Project

To support the AGEP mission of diversifying the professoriate, SEAGEP provides funding for postdoctoral positions. Faculty partnered with SEAGEP to recruit underrepresented minority postdoctoral researchers in Zoology, Materials Science and Engineering, Chemistry Botany, Astronomy, and Microbiology and Cell Science at the University of Florida.

Feedback regarding this aspect of the program includes:

*This post doc has been critical for his development. His writing and presentation skills have improved immensely and instead of giving up on a career in academics, he is now poised to land a nice professorship at a small college in the south.*

*Having a longer postdoctoral study period really allowed her to develop her own unique research program. She was hired as a faculty member at Colgate College last Fall, and from what she has told me, she has hit the ground running with an active research program.*

Both the University of South Carolina and Clemson University participate in a Minority Postdoctoral Academic Career Training Program that is managed and funded by the State EPSCoR/IDEA program. In 2007, two of the five postdoctoral students supported were from the University of South Carolina, and one was

from Clemson University. These students were provided a full year of support, and spent part of the year teaching at either a minority-serving institution or a primarily undergraduate institution.

#### VI. SEAGEP Alumni

To date, University of Florida SEAGEP has graduated 38 PhD students representing 28 departments in engineering and science. Of these, 8 are in academic positions, 14 are currently in postdoctoral positions, 8 are in government, and 8 are in industry. Of those not currently in academic positions, several have indicated an interest in joining academia at a later date. Interviews with this group indicated their belief that without the SEAGEP program they would not have successfully completed their degrees.

#### VII. Evaluation

The national data collection effort described earlier has shown an increase of 40% in PhD enrollments in the Biological & Agricultural Sciences in SEAGEP in the past 5 years and a 13% increase in PhD enrollments in Engineering. This was accompanied by a 27% increase in PhD degrees awarded in the Biological & Agricultural Sciences and a 20% in Engineering. In addition to this national data, the SEAGEP program has been extensively evaluated on several levels to determine what program components are most beneficial to the students, what the overall student experience is, and how this experience differs from other graduate students' experiences. Both quantitative and qualitative data has been collected. Mixed methods including focus groups, surveys, and interviews have been used. This methodological triangulation approach has produced a rich body of data that points to the success of the program at supporting and graduating increased numbers of underrepresented PhDs in science, engineering, and mathematics.

As mentioned earlier a significant obstacle to student success is the lack of appropriate support structures. SEAGEP students who were interviewed noted that the greatest benefit of the program came from the support they received as members of the SEAGEP community. Such support came through (a) monthly SEAGEP meetings, (b) dedicated SEAGEP administrators and staff, and (c) peer support, both academic and social.

The monthly meetings provide a forum for students to get to know each other, develop friendships, get advice from their peers, develop peer mentoring relationships. The meetings also provided them with a group of students that they encountered on campus at other functions. As one student explained:

*So the only real support system I have from people from similar backgrounds is basically AGEP and some friends that I have, but mostly just AGEP. It's not that it's a problem having friends of different racial backgrounds, but I think you need to have that blend. Without this particular program I wouldn't have had that blend. It is not always easy or convenient to stop what you're doing and come over [to the monthly meetings], but it is definitely beneficial for me.*

As for the importance of dedicated personnel, students commented that they are

*people you can call on to say you are having a problem and get advice. And that is probably the most invaluable part of the program. A lot of programs offer money but they don't try to help to see your way through the program. You are pretty much left on your own. Here they try to cover all your bases.*

With respect to the importance of helping students overcome isolation, comments included:

*Since I am the only AGEP student in my department, I get to see other students in other majors and see what they are doing, see how their programs work and have the advantage of being able to know how other departments do their thing.*

*Some of the other programs, organizations, their meetings don't have that continuity, you don't have the family environment – you don't get that feeling, you don't know everyone in the same program. You can talk to someone on a given day and they will say, "Oh, I'm a member of that too."*

As important participants, Deans, Department Chairs, and faculty advisors were also surveyed to determine the effect of the program on them. Sample comments included:

*The program has greatly enhanced our ability to recruit and to nurture minority women for engineering education; in my case for the rapidly growing biomedical materials field where they will have the opportunity to become leaders in this field in R&D or education and become role models for a new and more diverse generation of women in*

*biomedical engineering . . . The program has allowed us to focus on recruitment to strengthen diversity.*

We also have added the outcome of placement of our PhD graduates into the professoriate as an important measure of success. Many of our departmental graduate staff members are using this opportunity to recruit students from these groups.

*Indirectly, the Program has helped intensify our recruitment of students from traditionally underrepresented groups in ---. The Department now supports faculty visits to the national meetings organized by [National Societies for Underrepresented Groups].*

To gain a richer picture of the graduate student experience in SEAGEP, a recent study was completed that included a survey of both SEAGEP students and a matching group of majority students to allow for comparison of the graduate school experience of the two groups. These results will be reported elsewhere, but preliminary analysis indicates that the difference between the graduate experience of SEAGEP students and the graduate experience on non-SEAGEP students is not statistically significant with regard to a wide range of issues concerning satisfaction with their program and quality of life issues. Those areas that do show a difference will be used to improve mentoring, advising and other areas as appropriate.

## VIII. Summary

As the National Science Board notes,

Governments throughout the world recognize that a high-skill science and engineering workforce is essential for economic strength. Countries beyond the United States have been taking action to increase the capacity of their higher education systems, attract foreign students and workers, and raise the attractiveness to their own citizenry of staying of staying home or returning from abroad to serve growing national economies and research enterprises. [8]

While it is critical to the United States that the diversity of its research enterprise reflects the diversity of thought and opinion of all of its peoples, this is equally important across the globe. Reports from Australia, Canada, and Kenya indicate demographic changes in the student populations pursuing advanced degrees, and an awareness that these changes require a closer look at issues related to diversity.

Researchers in Canada have noted that increases in the non-White population are significant and that this makes it increasingly important to understand the factors of attrition and retention as they are related to racial origins and campus climate [9,10]. Researchers in Kenya have also studied ethnic diversity as it is affected by policy decisions in higher education [11]. In Australia, the growth from 8,563 doctoral students in 1988 to 39,531 in 2004 resulted in significant increases in the heterogeneity of students [12] and prompted studies of the impacts of policy on diversity. Diversity enriches the research and teaching enterprise, and it is clear that the increase in diversity of students pursuing advanced degrees is a global phenomenon. It is also clear that research into the issues faced by specific groups of students can result in programming and policy decisions that will enhance rather than hinder the success of these students who were previously not part of this enterprise. While diversification of the student population is a global experience, as conditions and obstacles vary from country to country, it will be up to education researchers in each to determine what the specific challenges faced by minority students are, and to make recommendations to ameliorate them. With respect to programming specifically designed to ensure retention and graduation of underrepresented students in science, engineering, and mathematics in the U.S., the AGEP program has demonstrated that achieving an increase in the diversity of students pursuing advanced science and engineering degrees requires dedicated personnel and a comprehensive approach that supports the students throughout the entire process. The model developed by the institutions in the Alliances for Graduate Education and the Professoriate is being used effectively in the production of doctoral degrees in engineering and science fields.

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