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**Report to the Assistant Director, EHR**

**Underrepresentation of Minorities in  
Obtaining Doctoral Degrees in Science,  
Mathematics and Engineering**

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## ***I. Introduction***

The country continues to suffer from a long-standing underrepresentation of minorities in the ranks of doctoral degrees in science, mathematics and engineering (SME). This loss of talent in SME fields is a problem with serious consequences for the nation's ability to compete in the technology-driven world marketplace, quite apart from the loss of opportunity for a large sector of the nation's citizens. This underrepresentation is seen in all sectors: private, public, and academic. It is particularly troubling in the academic sector, since this is the source of doctoral degree programs and since the lack of role models and mentors in the professoriate has been identified as a key barrier in the production of minority SME professionals. Thus increasing the number of underrepresented minorities in the SME professoriate is a key starting point in solving the problem of underrepresentation in the SME doctoral workforce.

## ***II. Background***

There has been some progress in remedying the underrepresentation of minority Ph.D. recipients in SME fields, particularly in the past few years, as evidenced by the recent National Research Council report that in 1996 the largest number of minority students (1,171) ever obtained SME doctorates. This continues a trend seen over the previous two years. Close examination of the situation however, reveals that this slow increase will not resolve the problem. Minority students make up 28% of the college-age population, but only receive 12% of the undergraduate degrees in science and engineering, with the percentage receiving degrees in the natural and physical sciences even lower. At the graduate level in 1996, even with the largest cadre of minority doctorates ever, only 5% of the degrees awarded to American citizens in the physical and natural sciences and engineering went to underrepresented minority students. Given the present situation, neither the numbers of doctoral degrees produced, nor the present rate of this production will result in a significant change within any acceptable time period. Only a dramatic increase in the rate of minority doctorate production will remedy the situation.

Several programs have been instituted in the past two decades to increase the number of minority students obtaining SME doctoral degrees, including NSF's Minority Graduate Research program, NIH's Minority Access to Research Careers and Centers for Research Excellence in Science and Technology (CREST) programs, and programs funded by private foundations. However, aside from a few episodic increases in numbers and progress in a small number of fields, there has been no significant change in the end result. In fact, there is a negative correlation between the amount of funding and number of degrees produced. In 1983, minority students received 1.6% of the SME doctoral degrees and in 1996, these students received only 5 % of the degrees although funding had increased severalfold.

## ***III. Consultation and discussion with the field***

In an attempt to identify and understand the root causes of underrepresentation and to craft remedies, NSF has held several discussions with a number of organizations whose goal is to increase the production of minority SME doctorates, as well as with a number of faculty who have been successful in producing minority SME doctorates (Appendix). Within the past year we have convened two external working groups to provide NSF insights and advice. This has resulted in the sponsoring of the "Graduate Education

Roundtable“ by NSF’s Human Resource Development Task Force and the establishment of an EHR Ad Hoc Advisory Group on Minority Graduate Education. The advice and suggestions from these groups have played a major role in the design of our proposed programs.

As a result of these and internal discussions and analysis, general agreement has been reached that the problem is due to several factors. These factors can be grouped under the categories of stakeholder responsibility, minority SME student pool size, graduate student recruitment, and retention:

**Stakeholder  
Responsibility**

Perhaps the single overarching factor contributing to the problem has been the lack of acceptance by many of the stakeholders (with some notable exceptions) in this area that its solution is a fundamental responsibility that they share. Thus, while NSF and other government agencies have mounted programs and expended funds, these programs have not sufficiently targeted root causes, nor have the agencies used their leverage in the most effective manner.

Graduate departments have made efforts to recruit minority students and use the funding available to support them, but they have not significantly reshaped their culture or faculty reward system to deal with the low number of admissions and low retention rates. Nor have they made much progress in increasing the diversity of their faculty.

Undergraduate institutions have not done all that they could to help minority students become aware of graduate opportunities, nor have they paid sufficient concern to making sure that the students were well prepared, both academically and affectively, for graduate school.

**Minority SME Student  
Pool Size**

The number of minority students in the undergraduate level pipeline interested in SME careers does not yet reflect the composition of the college-age student population.

This has been the subject of intense NSF programming for over a decade with very promising results. At the undergraduate level, the Alliance for Minority Participation (AMP) program has been and continues to be a major success in increasing the number of minority students who are receiving baccalaureate degrees in SME and planning for careers in SME. AMP coalitions have achieved this through a combination of student recruitment, bridge programs, undergraduate student enrichments, and curriculum revision.

**Graduate Student  
Recruitment**

Recruitment of minority students is not a high priority in many graduate institutions. While there have been sporadic and fragmented efforts to recruit minority graduate students, increasing the diversity of the graduate student pool is not seen as a core responsibility of graduate departments. Generally, they are only effective in identifying students who are already committed to graduate careers. These departments do not have connections with undergraduate institutions that could be a source of significant numbers of minority students. There is also a need to reach down to freshman and sophomore students to make sure they understand this career option is available and ensure that they are prepared to take advantage of the opportunity.

A largely untapped source of potential graduate students are those minority scientists who have received bachelor's or masters degree's in SME fields and are now employed in the private sector, particularly industry. Recruiting from this pool of scientists could be one way to make a rapid positive impact. These students should be extremely well prepared in subject material, used to working in a collaborative environment important in graduate school and have experience negotiating a political environment. Since many of these scientists may have been interested in obtaining a doctoral degree, but could not do so because of lack of financial support, one attractive possibility is to establish a partnership between a graduate institution(s) and one or several companies to support employees obtaining doctoral degrees.

**Retention in Graduate School**

Success in graduate school is due to more complex factors than simply academics and research. Graduate students must learn how to navigate the culture of the scientific research establishment. Retention is a key leverage point to increase the number of minority students obtaining doctoral degrees. In fact, the retention to degree of minority students is only about half that of white and Asian students. Solutions that increase this retention rate significantly will have a dramatic impact in producing minority doctoral recipients.

**IV. Key Suggestions and Effective Practices:**  
**A. The transition from undergraduate to graduate school**

A summary of the input from the NSF discussions is given below.

1. Identify students who are good candidates for the professoriate early in their undergraduate career and nurture them through the doctoral degree. This could include research experience, summer programs, and a bridge program between undergraduate and graduate school. An important component at both the undergraduate and graduate level is the provision of an effective mentor.

2. Form collaborative linkages between graduate and undergraduate departments so that both are responsible and accountable for graduates. These linkages should involve faculty from both sectors. One so that the graduate sector develops a better understanding of the undergraduate faculty and the student training that is offered and can provide advice and support to make sure that the academic and affective preparation the students receive is aligned with what is necessary for success in graduate school. Faculty could engage in joint curriculum review, joint research projects including the REU program, identification of undergraduates who would make good candidates for graduate school and mentoring of undergraduates. Direct support could be provided to the undergraduate school to remedy deficiencies in program. Also suggested was the provision of portable graduate support directly to undergraduates for use in graduate school. A particularly effective linkage might involve comprehensive undergraduate schools (HBCUs and HSIs) whose mission is to serve underrepresented minority students and, thus, have a large pool of such students, with graduate institutions. The linkage could also include guaranteed admission to graduate school if appropriate standards are met.

3. Develop a Web-based database through which students can identify graduate school opportunities. The database should identify particularly effective graduate programs. It also could be used by graduate programs to identify and recruit promising students.

**B. The efficiency of degree production in graduate school**

1. Focus on graduate programs that prepare students for the future and are technically outstanding. Should consider the degree to which students will be involved in interdisciplinary work and learn the skills of collaboration and manipulation of information technology which are of growing importance. Graduate training that should include a focus on career options and help students understand those factors outside of academics which are needed for a successful career in SME.

2. Award program should set expectations for graduate departments and give priority to graduate institutions that reward what we want accomplished. This means that there must be evidence of central administration buy-in and program support, including making it a high-profile program. Proposal should state how admissions strategies have been focused to enhance the recruitment of minority students; demonstrate how the department will increase the diversity of its faculty and how the faculty reward system (promotion, tenure) will be reformed to provide incentives to enhance diversity; demonstrate how curriculum will be reformed to address needs of minority students; identify what institutions/departments will do to change institutional culture and make it more conducive to minorities; and discuss what specific strategies will actually be used in preparing minority students for faculty careers, such as specific preparation for teaching and other faculty roles. Support should concentrate on institutions with strong record of performance.

3. Provide specific faculty enhancement centered on affective structures related to welcoming diversity and increasing minority participation. Graduate departments must have at least one designated faculty member who has the confidence of the minority students and can serve as a conduit for airing student concerns and obtaining a departmental response. Direct support could be given to those faculty who have demonstrated success in producing minority doctorates.

4. Institutions, departments and faculty should make use of outside experts and visiting faculty to learn about and accomplish the necessary changes.

5. Provide funds to minority institutions, particularly those with strong masters programs. Perhaps help some of these institutions develop Ph.D. programs.

6. In engineering programs skip masters degree because many students drop out of the program at that time, particularly because they are recruited by business.

7. Establish campus-based, regional and national minority graduate student networks to overcome student isolation and share experience and advise.

**C. Institutional factors**

1. At the institutional level, research grant applications should identify minority students for research assistantships and request grant supplements and facilitation awards for HRD issues. Research funds could be separated from student support dollars and only release the latter upon submission of a graduate student training/mentoring plan or hold some portion of traineeship or

fellowship "cost-of-education" allowance until students pass their qualifying examinations.

2. At the undergraduate level, give graduate student support dollars to undergraduate institutions who would then release the dollars to graduate schools which 1) successfully recruit undergraduates from their institution, and 2) have, in the opinion of the undergraduate institution, demonstrated success in the development of undergraduates to doctoral graduates.

**D. Environmental factors**

1. Use professional SME organizations and organization such as associations of college and university presidents to elevate the visibility and importance of this effort. These organizations could have an impact on the apparent lack of concern of the academic and professional community to increase the diversity of the professoriate.

2. The record of higher education in hiring minority faculty is generally poor. The academy must develop an attitudinal change to make this a priority of institutions.

3. Hire a provocateur to make the case at professional meetings. Hire a recruiter to identify students and broker deals between schools, students and schools.

4. NSF could take a number of steps to make a significant contribution. NSF review panels should make clear that this effort is an important criteria in evaluating proposals. Targets could be linked with IGERT, CREST and AMP awards. NSF program officers should be aware of the problem and use selection criteria that focus on it. NSF should make greater use of data analysis to target resources to focus on the problem. Finally, NSF should fund research on the problem.

**V. NSF Response**

**Rationale for response**

Taking into account that the key factors seem be student pool size, recruitment, and retention, making use of the five million dollars provided by Congress in our FY 98 funding NSF's response will, as a first step, develop a balanced portfolio of awards that test the impact of these perceived factors on the problem and, at the same time begins to produce a significant increase in the number of minority SME doctorates. We also seek to strengthen the research base to better understand and respond to the root causes of the problem. What is learned about the impact of each of these factors will then be used to shape formative changes in our programs to increase their efficiency and be shared with other organizations to increase the effectiveness of their programs. The first year of this program is intended to develop a number of models that will be evaluated to establish the "best practices" to be used. This knowledge will be used for formative changes in our program and then be used to scale up the program to implement significant and sustained production of minority SME doctorates.

Our initial goal then is to produce a portfolio that balances the need to uncover and develop new approaches and solutions with one that supports a significant number of new graduate students. Particular emphasis will be placed

on those solutions that appear to have the potential of significantly increasing the diversity of the professoriate.

#### **Four Award Categories**

We propose to do this by funding a portfolio of awards in four categories -- Institutional, AMP Supplementals, HBCU, and Research:

##### *a. Institutional Awards*

All awards should:

1. Be institutional or to a consortium of a doctoral degree-granting institution and partner undergraduate institutions;
2. Provide students with best knowledge and technology training available to prepare for next century, expanding the focus from quality of the graduate experience to the type of graduate experience;
3. Align with existing programs within or outside of the institution; and
4. Deal with affective components involved in obtaining a doctoral degree.

As a backdrop to all of the programs to be described is the fundamental understanding that long-term success is dependent upon a change in the culture of graduate education. That is, any institution to which an award will be made must demonstrate its real commitment to accepting the responsibility for increasing the number of minority SME doctoral recipients as a key goal of its mission to provide graduate training. While this commitment may be demonstrated in a variety of ways, it will require that the responsibility for success be beyond that of the individual department and/or faculty member.

This obligates two central features of any award: 1) there must be a clear and central role for the university's higher administration in the management and monitoring of the award, including the requirement that the provost or a higher ranking member of the administration serve as the principal investigator; and 2) there must be explicit objectives and benchmarks of progress in the management scheme relating to increasing minority student numbers and change in organizational culture. The first feature is necessary because the reward structure of the institution must be aligned with the goals of the program. That is, the departments and individuals who are involved must be assured that success will result in serious consideration for tenure, promotion and other rewards that an institution can bestow and that their success will be exhibited by the institution as a key indicator of its success. Secondly, the institution must demonstrate its award results in an increased number of matriculants above the baseline number of minority graduate students that they have; that these matriculants, in the beginning stages of the program are making reasonable progress toward a degree; and as the program matures, are receiving degrees at a rate comparable to its white and Asian students.

##### **Two Central Features of Any Institutional Award**

Predicated on our belief that the problem is only partially due to lack of funding for minority students, we will make a series of awards to institutions that propose a program that addresses the three issues of recruiting, retention and student support. While we will not prescribe the exact features of such a



program, awards will be made to institutions that deal with the factors and best practices that were discussed above. Thus review criteria for the proposals will consider the track record of the proposer in its production of minority SME doctorates. They will also consider the extent to which the institution or consortium provides evidence that the graduate program considers this effort a core responsibility, builds linkages with appropriate undergraduate institutions or has other recruiting strategies to more effectively recruit minority students, and that within its particular setting will make changes in the graduate culture aimed at increasing the retention and success of minority students. The proposal must also include reasonable benchmarks by which the success of the program can be monitored. Failure to reach these agreed upon benchmarks may result in loss of the award.

We intend to make approximately 12-20 awards (only one per institution or consortium) of approximately \$200,000-300,000 to support a minimum of five and a maximum of eight new graduate students (above the institution's present baseline) and support changes in the institutional and departmental culture and organization to increase recruitment and retention. Awards will not be made to departments. The awards will be made as cooperative agreements to be renewed yearly depending upon the effectiveness with which the institution implements the program and the degree to which evidence of institutionalization of organizational changes is provided.

*b. Supplemental awards  
to AMP Program Sites*

We will provide approximately 10 supplemental awards to Alliance for Minority Participation sites. As discussed above, the AMP program has significantly increased the number of undergraduate minority students obtaining degrees in SME fields. The programs, however, have not specifically engaged in preparing minority students for graduate school, but this pool of students obviously represents a significant opportunity to do so. All AMP awardees will be sent a Dear Colleague letter alerting them to the opportunity for a supplemental award specifically focused on activities such as increasing the awareness of the opportunity of a graduate career of their students, strengthening the research opportunities for their students, instituting seminars and other activities which help students understand the non-academic factors that are critical to success in graduate school, and making connections with graduate departments specifically to aid in recruiting students into graduate school. These activities may be developed through a partnership with a graduate institution(s).

*c. Connection to HBCU  
Program*

As mandated by the Congress in NSF's FY 98 budget, EHR will make up to three awards to HBCU institutions to build their infrastructure for SME education. In order to make most efficient use of our total funding, these awards will require that the institutions develop specific programmatic components to ensure that their students are aware of the possibility of a graduate career, are well prepared for graduate school, and that the institution develops linkages with appropriate graduate institutions as discussed above.

*d. Research*

We will make one three-year award of approximately \$250,000 to establish a research program that examines the question of the underrepresentation of minorities receiving SME doctoral degrees and to identify the critical leverage

points and best practices to remedy this situation. The research findings catalyzed by this award must be disseminated widely through refereed publications and other means so as to enable all graduate institutions to increase the effectiveness of their production of minority SME doctorates.

## ***VI. Expectations and Next Steps***

The goal of the use of these funds in the initial year is to begin to the immediate increase in the number of underrepresented minority doctoral students in SME. Consistent with our intent to catalyze significant change in the diversity of the professoriate and increase the number of underrepresented minorities receiving doctoral degrees in SME, our first-year goal is to directly support an increase in the number of minority students entering doctoral programs in SME fields by approximately 100 over the number that would enter without our new awards. When compared to the current number of minority students receiving doctorates, this represents an increase in year one of over 10% and will have an immediate and significant impact. The actual number entering graduate programs will be even larger due to the impact we anticipate from the supplemental awards we will make to AMP institutions.

We also wish to improve our understanding of the critical factors that have lead to and sustain the current situation. These understandings will lead to a reformulation of our programs to make them even more effective. We will then be in a position to scale up the number and, perhaps, size of the awards leading to a non-linear increase in the production of minority SME doctorates. This will require increased funding over a baseline of \$5,000,000 which will be necessary to continue to support our first year awards and will allow us to maximize the effect of our greater understanding of the issues involved. We seek to redress the serious shortage of underrepresented minority Ph.Ds. in SME fields. This translates to an increase in the number of the total SME doctorates being produced, not simply a change in the composition of the population of doctorates being produced. While increased retention rates will make more efficient use of the funds presently available, the present level of funding is not sufficient to drive the increased rate needed to achieve the desired results. Thus, additional funding will be proposed in our FY 1999 budget request.

The insights gained during our first year will also be used to reshape existing programs to enhance their effectiveness and will be disseminated to other Federal agencies and private foundations to enable them to increase the effectiveness of their programs.