New Directions for Broadening Participation in MPS
Submitted by the Advisory Committee Broadening Participation Working Group

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Diversity is a fundamental tenet of innovation.

> *"There is no more fertile ground for innovation than a diversity of experience. A successful scientific endeavor is one that attracts a diversity of experience, draws upon the breadth and depth of that experience, and cultivates those differences, acknowledging the creativity they spark."*
> *J. M. DeSimone*

Scott E. Page in *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools and Societies,* makes a compelling argument that in solving complex problems, diversity is powerful contributor to the attainment of effective solutions. Page goes on to say that diversity doesn't always trump ability, but it does so far more often than we'd expect. Does this logic imply that we should abandon the meritocracy? No! Ability matters. But—here's the catch—diversity matters too!

Given the importance of innovation for the National Science Foundation to maximize its return on investments, whether these returns are breakthrough concepts pertaining to basic knowledge or technologies that are forming the economies of tomorrow, it is important that we unleash the power of diversity to maximize these returns. As such, in addition to the traditional mantra that "...a mind is a terrible thing to waste...", we see improving our nation's economic outlook by providing research teams with the distinct competitive advantage of a diverse workforce as an equally compelling reason to demand improvements in broadening participation. Indeed, in many ways unleashing diversity is a particularly American talent that positively impacts our society in many areas, but is doing so to a lesser degree in science, technology, engineering and mathematics (STEM) disciplines. Ironically, these disciplines are most important to the future economic well-being of our society.

Since Congress passed the Science and Engineering Equal Opportunities Act in 1980, the Foundation has developed formal programs designed to increase the participation of underrepresented groups (URG) in the US STEM enterprise. In 2003, the US Supreme Court declared its expectation that within 25 years racial/ethnic preferences would no longer be necessary. Assuming linear trajectories in recent Ph.D. and faculty post attainment trends, the goal of full participation without preferences could not be met. This admittedly crude modeling demonstrates that the current pace of broadening participation does not serve the nation's scientific or economic needs. In the face of this challenge, how can the Mathematics & Physical Sciences (MPS) Directorate (Directorate) promote participation of URG while bolstering interest in STEM fields in the population at large? The Advisory Committee Broadening Participation Working Group (ACBPWG) has considered this question and identified several potential activities. This report outlines the ACBPWG's motivations and recommendations for these activities.

Reframing BP program incentives around innovation culture development

There is compelling evidence that diversity is a powerful force in solving complex problems. The National Science Foundation, in its mission to advance innovation and

discovery, should take a leading role in promoting diversity as a vital tool for confronting our most important scientific challenges. We see this as a fundamental reframing of the arguments for diversity in our scientific endeavors. We believe that this rationale for demanding improvements in broadening participation is just as compelling as rationales founded on social justice. Doing so would provide our research teams with a crucial and uniquely American scientific advantage.

Reframing the incentives in broadening participation programs (BPPs) to emphasize the centrality of diversity to complex problem solving is a major task that may require a range of revisions in directorate documents and policies. **The ACBPWG recommends that the Assistant Director appoint a blue ribbon panel, giving it the charge to analyze the Directorate's documents and programs, then make recommendations for an orderly systematic revision of the language and policies the Directorate uses to convey its goals and priorities to the scientific community**.

Promoting better BP evaluation & assessment

The short timeline for achieving broadening participation goals set by the Supreme Court opinion and slow rate of increase in the participation of many under-represented groups at the highest levels of the scientific enterprise have led a number of analysts to conclude that current broadening participation approaches are inadequate to effect the kind of significant participation increases that are needed. Based on the premise that broadening participation is a complex problem that requires conceptual clarity as well as political will and financial resources (George, *et al.* 2001), one approach that has emerged to make broadening participation programs more effective is to apply the scientific method to understanding their design and implementation (Poodry, 2006). An important element of this strategy is to expand the role and type of assessment and evaluation in the review and monitoring of broadening participation programs. It has been compellingly argued that a myopic focus on patterns of under-representation detracts from the development of studies on interactions of factors that influence quality of URG experience in STEM fields (George, *et al.* 2001).

The ACBPWG recommends that the Assistant Director appoint a panel of professional portfolio evaluators to review current MPS practices and integrate them into a framework of data collection guidelines for BPPs which all MPS funded programs would then adopt. Establishing data collection guidelines will promote comparison and aggregation of data across programs. The guidelines should cover several types of inquiries monitoring participation across various scales using several types of instruments, e.g., surveys, interviews, indicator compilations, etc.

Promoting MPS/SBE broadening participation collaborations

A second element of the strategy to apply the scientific method to understanding the design, implementation and efficiency of broadening participation programs is to embrace the inherent multidisciplinarity of the broadening participation challenge. Broadening participation programs have been implemented across the MPS portfolio, but most originated from physical scientists' conceptualization of extracurricular or

remedial education rather than efforts to translate relevant research. Increasing and strengthening the linkages between physical scientists implementing broadening participation programs and social scientists studying the issues that are important to understanding why women and racial/ethnic minorities are under-represented in STEM fields can contribute to new initiatives and better dissemination and adaptation of effective innovations in existing programs.

Clearly, physical and social scientists have overlapping interests in the development of BPPs that funding from the NSF could enhance and promote. In 2008, the Social, Behavioral, and Economic Sciences Directorate (SBE) sponsored a day and half long workshop on the Science of Broadening Participation to discuss issues of access, opportunity and inclusion in STEM fields. SBE has not formalized this initial work in the form of a program, therefore MPS has an opportunity to suggest a partnership with SBE to develop a BP program that would be grounded in relevant research. This initiative would include applying established and emerging social science results to BPPs in the physical sciences. **The ACBPWG recommends that the Assistant Director suggest to the Assistant Director of SBE that they jointly appoint a panel of scientists who are very accomplished in relevant social science research or mentoring underrepresented students in STEM disciplines, who will work with NSF staff to develop a new program in this area.**

Promoting BP program sustainability

A significant issue for ongoing, successful diversity programs is the lack of funding available to support them. Both the NSF and universities emphasize promoting new, innovative programs rather than supporting programs that are already in place.

A case in point is the Pre-Major in Astronomy Program (Pre-MAP) at the University of Washington. This program began in 2005 with a President's Diversity Initiative grant for $20K over two years, matched by a combination of Department and College funds. It costs about $20K/year in actual cash to run Pre-MAP (this does not include the roughly $80K/year of in-kind effort that is contributed by volunteer labor from graduate students, post-docs and faculty). The money goes primarily to support a TA position for the focused seminar that introduces freshmen to research in their first quarter at the UW. Monetary funding is also required for field trips, social events and mentoring activities that contribute to building a cohort among Pre-MAP students. The combination of research exposure and sense of community has been very successful in retaining these students in Astronomy and other STEM majors. Fortunately, in the third year, the Pre-MAP faculty advisor received an NSF CAREER grant and through the education and outreach part of that grant, he is able to fund Pre-MAP for another five years. However, this is not a sustainable model for the program in the future.

The ACBPWG recommends that MPS implement a program to support small, successful, ongoing projects, which have been fully evaluated and assessed. For small projects such as Pre-MAP, five year grants at the level of $200K (i.e. about $40K per year including overhead) would make the difference between continuation and fading into oblivion. Supporting projects that are already working

can be an additional, effective way of achieving BP goals. Strengthening the sustainability requirements for BPPs in initial grants could also increase funding for BPPs. For example, funds could be designated for follow-up reports after the main project activities have ended, in order to assess the success of the sustainability plan of the original proposal. We note also that supporting projects for longer terms provides a much better baseline for longitudinal evaluation.

Increasing participation in innovative programs

It is a sad reality that many of the most innovative programs developed to promote research by scientists outside the primary research infrastructure are under-utilized relative to their funding levels. For example, CAREER awards in AST typically have award rates around 10%, but Partnerships in Astronomy & Astrophysics Research and Education typically have award rates around 20%. In general, most minority-serving institution (MSI)-based broadening participation programs are advertised and disseminated using the same mechanisms that are used for programs targeting the broader scientific community. This strategy presupposes that scientists at MSIs form information dissemination/expertise networks around these programs that parallel the networks scientists in the broader community have formed. Research investigating this supposition has not been reported, but assuming this is not the case for the sake of argument, a strategy that seeks to understand and ameliorate any structural differences scientists at MSIs face could broaden utilization of the most innovative programs.

We propose a proactive dissemination strategy with three initiatives. In the first, **MPS conducts a survey** to elucidate the causes of the apparently lower participation in MSI-based BPPs. We can speculate about these factors, but asking the target audience rather than speculating about their circumstances is likely not only to provide better information, it may engender more confidence in the solutions that MPS constructs to improve participation rates. In the second, **MPS deploys Program Directors** who supervise MSI-based BPPs **to promote awareness of innovations in BPPs** and open a dialog that promotes and refines solutions to the challenges identified by the survey. We propose "Traveling Road Shows" that would visit some number of institutions that are positioned to participate in MSI-based BPPs and conduct workshops at conferences MSI-based scientists are likely to attend. Program Directors who supervise MSI-based BPPs would use these meetings to describe recent innovations in their programs, discuss the survey and emerging strategies for submitting successful grants in spite of structural barriers. In the third, **Program Directors** who supervise MSI-based BPPs **build a corps of mentors** from experienced applicants who would support potential PIs as they seek solutions to the particular challenges to successful grant submission they face. This sort of personal support will be a source of information for potential PIs as they improvise and innovate to craft solutions to the challenges they face in submitting a successful, large-scale grant. This type of engagement and mentoring is not free in effort or expense. NSF must be willing to support Program Directors by allocating the resources to include this work in their portfolios. This initiative also will increase feedback to MPS about potential PIs and reviewers, and foster formation of grant submission information networks among MSI-based scientists.

Strengthening community college to four-year institution transitions

In 1960, the California Master Plan for Higher Education established "a coherent system for postsecondary education" that includes the California Community Colleges (CC), the California State University (CSU) and the University of California (UC) systems. While specifics of the plan have evolved and adherence to it has varied over the years, the comprehensiveness of the plan made it a national model for public higher education. Consequently, the California Higher Education System reflects both the challenges and opportunities community college students present to the STEM enterprise. In terms of total students enrolled, the California Community College system has more than 7.7x the number of under-represented students enrolled than the UC System and a little more than 2.3x the number in the State College System. Only about 60,000 students of any ethnicity (8.4%) transfer from the CC system into either the State College and UC systems. Of these, only about 4,000 of 13,000 CC transfer students enter a UC with the intent of pursuing a degree in a STEM related field. These trends indicate that CC students represent an untapped reservoir of potential STEM students.

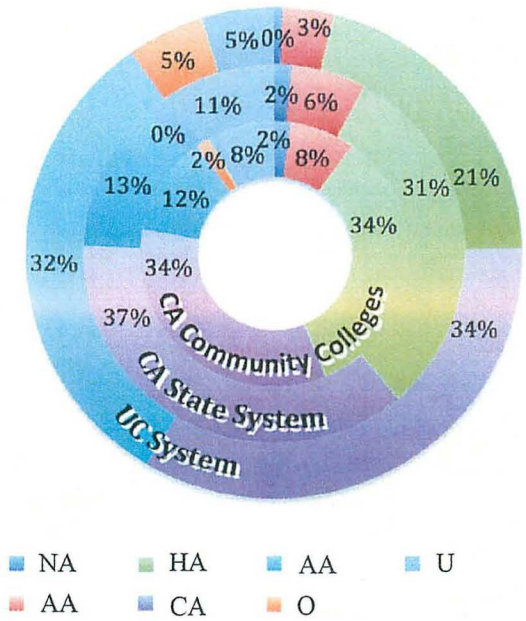

Fig. 1: Student demographics in CA Higher Ed.*

*Non-resident aliens and international students not counted
Undergraduate Student Populations:
CC: 713,100; CSU: 349,845; UC: 168,382
NA: Am. Indian, Pac. Islander, Alaska Native; AA: African American; HA: Latino, Filipino, Hispanic; CA: White: AA: Asian; O: other; U: unknown

A body of literature shows that almost half of the CC students leave higher education before achieving their educational objective (Hoachlander, Sikora, & Horn, 2003) and that CC students need robust opportunities to experience belonging, competency, and autonomy in order to engage and succeed in higher education (Schuetz, 2008). Given the relative low enrollment of underrepresented group students coupled with attrition figures after enrollment, we recommend intervention strategies that provide strong engagement opportunities prior to transfer. As reported by the Community College Survey of Student Engagement study, carried out by the University of Texas Austin (McClenney, K.M. & Marti, C.N, 2006), key engagement factors include: (1) designing engaging instructional efforts that capture students from the moment of their first interactions with the institution; (2) setting goals and providing the support to meet them; (3) setting and communicating high expectations (in high-expectation cultures, students start to believe, some of them for the first time, that they are capable of college-level work); and (4) making engagement inescapable (investing in strong opportunities for student-mentor interaction). The more actively engaged students are — with faculty and staff, with other students, and with the subject matter they study — the more likely they

are to learn and to attain their academic goals. In light of these conclusions, **the ACBPWG recommends the establishment of new REU-like programs specifically targeted to CC students to engage them in research internship programs (short- and long-term) at their intended four-year institution, before transferring**.

Promoting more effective mentoring & role-modeling

Mentoring is a complex activity that takes many forms. Consequently, there is some debate around definitions and the impact of factors such as the role of the mentor. For example, a study of the effect of undergraduate research experiences (Russell, 2006) found no statistical correlation between the role of the research mentor and the success of the undergraduate student. However, most faculty and students surveyed indicated that faculty guidance plays an important role in student success. This study suggests that the lack of statistical correlation reflects the complexity of the mentor-student relationship rather than an actual lack of influence. Clearly, information and other resources dedicated to promoting effective practice in scientific mentoring (e.g., http://ehrweb.aaas.org/sciMentoring/index.php) can be more widely disseminated.

The America Competes Act now requires that all post-docs receiving NSF support have a well-defined mentoring plan, and this plan is now part of the peer-review process for proposals requesting post-doctoral support. **The ACBPWG recommends that MPS examine how such mentoring plan requirements could be implemented at the graduate student level**. The group charged with this examination would also investigate how NSF could provide incentives to foster such activities, particularly as they involve women and underrepresented minorities. This group would collaborate with the evaluation panel (see above) to determine what type of metrics can be used to assess the effectiveness of the mentoring programs that are now being required for post-docs, especially in terms of their impact on women and underrepresented minorities in MPS disciplines. These could then be developed for Ph.D. students.

Summary

The ACBPWG has recommended MPS take a number of specific steps to strengthen broadening participation programs in the Directorate. All of them reflect our conviction that the Directorate's current efforts in broadening participation are inadequately focused, monitored and adapted. We've suggested a new framework that intimately links broadening participation to the Foundation's core mission to spawn innovation and deploys the tools of the scientific method and interdisciplinary research to increase the effectiveness of MPS programs in tackling the challenges of broadening participation.

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