Broadening Participation in the Earth Sciences

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Recent studies have demonstrated that the Earth and space sciences have the lowest participation rate of underrepresented minorities compared with all other physical sciences (e.g., NSF Publication 04317, 2004). Only 1-2% of the undergraduate student population enrolled in geoscience degree programs is African-American or Hispanic and only 1% of the PhDs produced in these disciplines in recent years have gone to minorities (Czujko, R., 2005). As the American population becomes increasingly diverse and minority populations expand, continued failure to interest minority students in the geosciences will likely have several negative consequences for the research community. At a time when undergraduate enrollments in the geosciences have declined and foreign graduate students have increasingly attractive options outside of the U.S., developing new strategies for attracting talented students from all possible sources will be essential for the future health of the geoscience workforce.

In the last few years, the issue of recruiting underrepresented students into the geosciences has become a front-burner concern. The National Science Foundation Geosciences Directorate and NASA Earth and Space Science enterprises have established major programs to fund projects aimed at delineating both effective and ineffective strategies for recruiting and retaining minorities in the Earth and space sciences; and for building the infrastructure, partnerships, and networks necessary to help these programs succeed. This investment has reached the point where many of these projects are nearing completion and have concrete results. Growing interest in the topic of diversity and the large number of mature programs with results worth sharing are evidenced by the increasing number of diversity-related programs being offered at annual scientific society meetings. Clearly, the community working on effective strategies for broadening participation has reached critical mass and now is the ideal time to collect this body of work and share it with the broader geoscience education community. With the publishing of this Special Edition of the *Journal*, we share the successes, techniques, approaches and occasionally failures of many of these programs. The papers presented in this volume (called out as references below) illustrate the many dimensions of this work.

The problem of reaching an underserved population is not confined to the United States. A report contributed by Nir Orion and his research group in Israel (Orion, et al.), mirrors the problems of reaching out to under-represented minorities all over the world, but also points out the compelling nature of the earth sciences to reach groups not normally attracted to the sciences. This international example, and others (e.g. Gilligan, M.R., et al.; Mannel, S., et al., show that the very nature of the earth sciences lends it a concreteness, a relevance and an immediacy that is very attractive to minority students who might not otherwise be drawn to the geosciences. Water resources, environmental quality, energy, disaster prediction and mitigation, ocean and fisheries health, space weather and communications are just a few examples of aspects of the field that are relevant to all of humanity.

The origins of the problem, and the solutions required to fix it, are quite complex. In the past, conventional wisdom has focused attention on the lack of exposure to the geosciences among underserved populations; inadequate teacher preparation in secondary schools serving high minority populations; lack of relevance/lack of a clear career path; isolation and alienation of minority populations in traditionally white institutions. Nevertheless, in forty years of data collected by the National Science Foundation and the American Institute of Physics, the low numbers of minorities graduating in the geosciences has not changed in any significant way, despite decades of programs put in place to address the problem (see Robinson, L., et al.).

In this volume, three main themes emerge in the lessons, features, and management structures of the most recent spate of programs:

- The success of many programs rests on the realization that one size does not fit all when it comes to making the earth sciences relevant to specific ethnic and cultural audiences. Programs that take one approach and attempt to apply it to a wide variety of educational backgrounds, ethnicities, economic situations and living conditions are bound to miss critical ingredients that result in raising the matriculation numbers. An educational and recruitment approach that focuses on those aspects of the geosciences most relevant to audiences in their area and most appropriate to the expertise of the scientists involved, can have high efficacy (see, for example, Sedlock, R., and Metzger, E.).
- The most successful programs take pains to account for culturally-specific learning styles, cultural issues with pedagogy, community preferences and priorities. A robust, grassroots connection to underserved communities is very important to the success of the program. Cultural literacy and community familiarity and connections on the part of the geoscientists involved in projects is critical. Social connections and social sensitivity and awareness are central to success (Pandya, R.E., et al.; Hanks, C.L., et al.).
- Top-down efforts to increase diversity on the part of science agencies, funding agencies and universities, while a necessary component to any successful program, are not sufficient to ensure success (see Sedlock, R., and Metzger, E.). The efforts of individual researchers and scientists to connect to communities they wish to serve are likewise crucial, but risk failure and isolation without institutional support. The strongest programs enjoy a local synergy of grassroots, personal, "labor of love" commitment from individual scientists, and the vision and high-level support of the institutions and agencies in which they work. Common failures in programs over the decades have included a lack of synergy between top-down and bottoms-up approaches. The greatest gains and successes consistently emerge where the energy and passion from the grassroots is met with support and

encouragement from local institutional administration (Robinson, L., et al.; Pandya, R.E., et al.).

The papers in this volume are organized to reflect what we see as a natural progression through the array of issues. The volume begins with a large scale overview of the current state of diversity in the earth sciences, complete with the latest compiled statistics showing gains made to date and the magnitude of the challenges that remain (Huntoon, J.E., and Lane, M.J.). The volume then moves to three papers which highlight theoretical and practical approaches to geoscience education research in diversity-related work, providing methodological approaches and quantitative and qualitative data that show how and why we can be most successful in adapting the earth sciences to a more diverse audience worldwide (Levine, R., et al.; Orion, N., et al.; Riggs, E.M. et al.).

From this overview, the volume presents programs that involve multiple institutions and agency-wide efforts. These reports all focus on the successes of the largest scale style of intervention on the part of institutional consortia and science agencies (Walter, D.K., et al.; Robinson, L., et al.; Pandya, R.E., et al.). We are also pleased to present reports that highlight the work of individual institutions that far predates organized efforts by geoscience funding agencies to diversify the workforce in the geosciences, presenting in a few cases programs that have been operating for upwards of a quarter century with a long legacy of success (Hanks, C.L., et al.).

We then turn to regionally focused programs, which make up the bulk of programs currently supported by the Geosciences Directorate of the National Science Foundation and other agencies. Papers focused on the South Atlantic Region, where fisheries and petroleum production coexists with sizeable minority populations, include Pyrtle, A. J., et al.; Pyrtle, A.J., and Williamson-Whitney, et al., 2007; Gilligan, M.R., et al.; Chigbu, P., et al.; Serpa, L., et al.; Pride, C.J. and Olsen, M. M. A paper focused on the West Coast of the United States, where a sizeable Asian and other underserved populations exist is found in Sedlock, R., and Metzger, E.. All of these reports highlight the importance of program designs in which cultural assumptions, preferences, and regional issues are addressed. Furthermore, these regionally-focused programs highlight the strength of university consortia and the importance of developing regional partnerships between institutions of higher learning in our efforts to diversify the geosciences. These partnerships derive strength from the realization that one university can rarely be all things to all students, but a few universities working together in a region can offer a comprehensive education and provide many attractive paths into the earth sciences for the broadest range of students. These articles highlight specific examples of best practices, complete with supporting data. Since appropriate metrics and tracking of data is an integral component of any contemporary educational program. In this volume, Gilligan, M.R. et al., Chigbu, P., et al.; Miller, K.C. and Carrick, T., present specific examples of surveys that were part of a successful program.

Most of the papers stress the significance of a robust mentoring effort (Pandya, R.E., et al; Pyrtle, A.J., et al.; Pyrtle, A.J., and Williamson-Whitney, V.A.; Gilligan, M.R., et al.; Chigbu, P. et al.; Serpa, L., et al.; Pride, C.J., and Olsen, M. M.), or the pitfalls of the lack of a sufficiently strong one (Sedlock, R., and Metzger, E.). Pyrtle, A.J., and Williamson-Whitney, V.A., specifically discuss ways in which to structure a mentoring program. The human component is particularly important for the high school to undergraduate transition, which is a critical juncture in the earth science education pipeline.

The undergraduate to graduate transition is important as well, but at this point most students are already well in to a mentorship system that provides for much personal support and guidance as they move away from their home regions and schools. But, for many students at the earlier phase of their geoscience education, that transition from grade school and high school into university, staying close to home and family is often crucial to success. To maximize recruitment into the earth sciences at this important decision point in students' lives and to ensure their success, and a tightly-knit consortium of regional geoscience departments and teachers reaching from high school through community college to undergraduate degree-granting departments is a very successful approach, as suggested by the last group of paper in this volume (Mannel, S., et al.; Stokes, P.J., et al.; Pecore, J.L., et al.; Miller, K.C., et al.). Successful networks actively track and "hand-off" students to one another, and are much more likely to succeed in serving the broadest array of students and also gain the support of their home communities. This is especially true with specific ethnic groups, and with other non-traditional students, for whom staying engaged locally with their families and communities is crucial to their academic interest and success. The earth sciences as a discipline can only benefit from this attention to the human dimension of our work and our recruitment strategies.

This special issue of the *Journal of Geoscience Education* represents a milestone in collaboration among three entities deeply concerned about broadening the participation in the practice of the earth sciences, the National Association of Geoscience Teachers (NAGT), the American Geophysical Union (AGU), and the National Science Foundation (NSF). The NAGT - publisher of the *Journal of Geoscience Education* - an organization that exists to promote and improve the teaching and learning of the earth sciences, is committed to the goal of broadening the range of ethnic and cultural perspectives and intellectual skills brought to bear in the study of the earth system. The AGU, a worldwide scientific community that exists to advance the geosciences by catalyzing and supporting - through unselfish cooperation - the efforts of individual scientists, has an obligation to improve the workforce by engaging the community to ensure diversity in the Earth and space sciences. NSF joins the NAGT and the AGU in these aims, and contributed funds to support the creation and distribution of this volume. Additionally, the NSF has supported programs across the nation to broaden the participation of under-represented minorities in the gesociences, many of which are featured in this volume. The response of the broader geoscience community as the urgency of the issue increases, from agencies through colleges and universities of all sizes, to increased diversity in geoscience is undeniable and impressive. We are heartened by these efforts, and it is our pleasure to present them in this volume.

REFERENCES

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