A Watershed Model for Broadening Participation in the Geosciences

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National Science Foundation

Earth Institute/LDEO Fall 2011 Diversity Seminar
November 4, 2011
Brought to You by the Numbers ...

- ~100,000 Geoscientists in U.S.
  - ~50% of whom are eligible to retire in the next decade

- ~23% growth rate for Geoscience occupations (2008-2018)
  - Compared with BLS prediction of 10% average growth for other occupations

- ~700 Geoscience departments in the U.S.
  - Many facing closure or consolidation

- ~15,000 High School Earth Science teachers
  - ~75% with Certification in their field of instruction

- 4,313 Geoscience Bachelors degrees earned in 2008 (0.9%)*
  - Compare: 17,648 (Physical Sciences) & 82,387 (Biology)

- 1,552 Geoscience Masters degrees earned in 2008 (1.7%)*
  - Compare: 4,374 (Physical Sciences) & 9,563 (Biology)

- 683 Geoscience PhD degrees earned in 2008 (2.0%)*
  - Compare: 4,205 (Physical Sciences) & 7,319 (Biology)

- * % of all S&E degrees earned in 2008 [Data from: Integrated Postsecondary Education Data System, Completions Survey (2000-08), NSF/SRS & ED/NCES]
And the Numbers …

- 4,390,756 (26.5%)  
  ▫ # of URM enrolled in Undergraduate Institutions

- 85,532 (17%)  
  ▫ # of URM Science & Engineering Undergraduate Degrees earned

- 309 (7.2%)  
  ▫ # of URM Geoscience Bachelors degrees earned

- 93 (6.0%)  
  ▫ # of URM Geoscience Masters degrees earned

- 26 (6.0%)  
  ▫ # of Geoscience PhD degrees earned

- Grand total of 428 URM Geoscience degrees  
  ▫ Less than 1 per Department per year  
  ▫ ~233 Geoscientists: 1 URM student

- URM = Underrepresented Minorities: African Americans, Hispanics, or American Indians/Native Alaskans

[Data for 2008 from: Integrated Postsecondary Education Data System, Completions Survey (2000-08), NSF/SRS & ED/NCES]
Milestones by Race/Ethnicity and Gender 2009

- **Advanced Degrees in Science and Engineering**
  - Total: 169,000
  - Minority Men: 7%
  - Minority Women: 4%
  - Non-Minority Men: 51%
  - Non-Minority Women: 38%

- **Bachelor’s Degrees in Science and Engineering**
  - Total: 505,000
  - Minority Men: 10%
  - Minority Women: 7%
  - Non-Minority Men: 43%
  - Non-Minority Women: 40%

- **First Time Freshmen Interested in Science and Engineering**
  - Total: 1,178,000
  - Minority Men: 16%
  - Minority Women: 14%
  - Non-Minority Men: 40%
  - Non-Minority Women: 30%

- **First Time Freshmen**
  - Total: 3,255,000
  - Minority Men: 13%
  - Minority Women: 16%
  - Non-Minority Men: 33%
  - Non-Minority Women: 38%

- **High School Graduates**
  - Total: 2,826,000
  - Minority Men: 14%
  - Minority Women: 17%
  - Non-Minority Men: 34%
  - Non-Minority Women: 35%

**Sources:** National Center for Education Statistics, IPEDS Completions and Fall enrollment surveys; Higher Education Research Institute, American Freshman Survey; and U.S. Census Bureau, Current Population Survey.
Retention of Women & Minorities

• Women
  ▫ Marriage/Family issues dominate
  ▫ Career path decisions made as a student
  ▫ Lack of family friendly policies
  ▫ Rigor of the academic research path
  ▫ Low career expectations
  ▫ Unsupportive institutions

• Minorities
  ▫ Academic Preparation
  ▫ Access & Motivation
  ▫ Affordability
  ▫ Academic Support
  ▫ Professional Development
  ▫ Social Integration & Mentoring
Pipeline Models - Are They Right for the Geosciences?

“Unfilled & Leaky Pipeline” for Underrepresented Minorities in STEM

“Leaky Pipeline” for STEM Women in Academia

- Grad School Entry
- PhD Receipt
- Asst Prof Tenure Track
- Assoc Prof Tenured
- Full Prof Tenured

Lack of Confidence
Lack of Support
Motherhood
Spousal Constraints
Career-Life Balance
Isolation
Exclusion

Insufficient Preparation
Financial Barriers
Isolation
No Role Models
Cultural Barriers
Small Hiring Pool

Insufficient Preparation
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Many Paths Into the Geosciences...

... But Also Many Destinations
Academic Pathway of Geoscience Ph.D. Recipients

Ph.D. Recipients: Bachelor’s Degrees
- Geosciences (56%)
- Other Sciences & Math (19%)
- Engineering (12%)
- Other (12%)

Ph.D. Recipients: Master’s Degrees
- Geosciences (81%)
- Other Sciences & Math (8%)
- Engineering (6%)
- Other (4%)
- Business (1%)

Source: AGI Geoscience Workforce Program, data derived from NSF’s NSCG, 2003

<table>
<thead>
<tr>
<th>Sector</th>
<th>Percentage of Graduates</th>
</tr>
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<tbody>
<tr>
<td>Academia</td>
<td>67%</td>
</tr>
<tr>
<td>Government</td>
<td>22%</td>
</tr>
<tr>
<td>Private Sector</td>
<td>50%</td>
</tr>
<tr>
<td>Non-Profit / Other</td>
<td>3%</td>
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Goal 1: Advancing public literacy in Earth System Science

- A scientifically literate public that understands the interconnected and inter-dependent non-living and living systems of Earth, that uses that knowledge for informed decision-making, and that advances its understanding of Earth Systems through life-long learning in formal and informal educational settings.

Goal 2: Preparing a talented & diverse geoscience workforce

- A future geoscience workforce, reflecting the nation’s diversity, that is skilled in science, technology, and other relevant disciplines necessary to advance GEO-funded research and overcome critical scientific challenges in the geosciences.
Public ESS Literacy

Geoscience Workforce

Interdisciplinary Workforce

Image: http://www.conservation-ontario.on.ca/about/cross_section.html
Building a Portfolio for Education & Diversity

NASA Education Strategy

1. Inform.
2. Educ.
3. Higher Education
4. Elementary & Secondary Education
5. Employ
6. Educate
7. Engage
8. Inspire

Inform. Educ.

Higher Educ.
Building a Portfolio for Education & Diversity

- Informal Education
- Higher Education
- Elementary & Secondary Education

- INSPIRE
- ENGAGE
- EDUCATE
- EMPLOY
Inspire

- Increase access to Geoscience content in K-12
  - Foster changes in education policy
  - Improve teacher content knowledge & pedagogy
  - Establish dual credit and Honors courses
  - Development of Literacy frameworks
  - Next Generation Science Education Standards

- Raise the visibility of the geosciences through informal education and outreach

- Engage Geoscientists in education and outreach (and improve their effectiveness in doing so)

- Blend cultural context and Geoscience content

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- Biology (1 yr)
- Chemistry (1 yr)
- Physics (1 yr)
- Geology / Earth Science (1 semester)

Source: AGI Geoscience Workforce Program, data derived from NCES, Digest of Education Statistics, 2007
Elwha Science Education Project (GEO-0703676)

- Western Carolina University (R. Young, PI)
  - Partners: Olympic Park Institute, Lower Elwha Klallam Tribe

- Culturally-integrated academic enrichment for middle & high school students within the Klallam community framed around Elwha River restoration.

- Program Components:
  - Week long residential program for high school youth
  - Week long residential program for middle school youth
  - Monthly school-year field trips
  - Academic support and mentoring

- Outcomes:
  - Increased interest in science
  - Increased knowledge of Klallam culture and history
  - Better performance in High School assessments

- http://www.naturebridge.org/olympic-park/elwha-science-education-project
NIU Hispanic-Serving Teachers (GEO - 0703541)

- Northern Illinois University (K. Kitts/P. Stoddard, PIs)
  - Collaborators: CEA-CICY

- Encourage Hispanic participation & enrollment in the geosciences by preparing middle & high school science teachers serving large Hispanic populations.

- Program Components:
  - Two-year cohort program for educators
  - Intensive summer instruction in Illinois and Mexico
  - 2 wk workshop & 10-day field experience
  - Academic year follow-up workshops
  - Development & peer review of lesson plans
  - Wiki interactions

- Outcomes:
  - Improved use of inquiry pedagogy
  - Improved respect and support for students
  - Culturally-sensitive lesson plans – statewide dissemination

- http://oedg.niu.edu/
Engage

- Raise awareness about opportunities
- Link education to career paths
- Provide authentic student research experiences
- Identify role models
- Foster faculty sensitivity and capabilities
- Provide financial support
- Strengthen basic skills to enable success
- Promote development of cohorts & networks
- Promote achievement in STEM
Highlands to Piedmont Project (GEO - 0703673)

- Rutgers University New Brunswick (A. Gates, PI)
  - Partners: Newark Public Schools, Newark Museum

- Focus on training, development, & mentoring for High School, undergraduate students, & teachers.

- Program Components:
  - Dinosaur Days Open House
  - Geoscience Scholars Summer Institute (4 weeks; HS students)
    - Focus on private sector jobs; involved local professionals
  - Geoscience Teachers Summer Workshop (40 hours)
  - GeoExplorers Program (Grades 9-12)
    - Afterschool & weekend, museum-based education & research
  - Innovative undergraduate curricula (e.g., Oil Game)

- Outcomes:
  - Significant increase in student interest in the Geosciences
  - Enhanced understanding about career opportunities
  - Innovative instructional resources

- http://andromeda.rutgers.edu/~oedgro/programs.html
Geology of Mexico (GEO-0503375)

- California State University Sacramento (L. Hammersley, PI)
  - Collaborators: College Assistant Migrant Program (CAMP), Equal Opportunities Program (EOP), UNAM

- Development, marketing and offering of a new introductory Geology course framed around the Geology of Mexico as a strategy for engaging Hispanic students (17% of campus).

- Program Components:
  - Alternative place-based introductory course to Physical Geology
  - 10-day Mexico Field Trip for students who took GOM class
  - Marketed through EOP learning communities
  - Comparison with performance in the Physical Geology course

- Outcomes:
  - Greater attraction of Hispanic students in Introductory Geology
  - Better academic performance
  - Increased interest in taking more Geoscience courses
  - Better recruitment of majors
  - Improved understanding of faculty about student issues
Educate

- Build Geoscience capacity at Minority-serving Institutions (e.g., HBCU’s)
- Increase focus on Community Colleges
- Include culturally context in Geoscience education
- Promote partnerships of MSI’s and 4-Yr & research institutions
- Strengthen faculty/educator pedagogy
- Improve faculty awareness about diversity
- Leverage scientific research (especially interdisciplinary research)
- Provide early research experiences
- Encourage and engage in mentoring
- Support networking and community
- Disseminate best practices
- Provide leadership development for early career minority scientists
Manoomin Project (GEO - 0703673)

- University of Minnesota (E. Ito, PI)
- Fond du Lac Tribal and Community College (A. Wold, PI)
  - Partners: National Center for Earth Surface Dynamics (NCED), Fond du Lac Reservation Resource Management

- Collaborative project investigating the past, present, and future conditions of wild rice lakes on the Fond du Lac Band of Lake Superior Chippewa Reservation as a vehicle for engaging Native American students in Geoscience education and career pathways.

- Program Components:
  - Research on culturally-significant environment topic
  - Weekend winter camps for coring lake sediments
  - Undergraduate mentoring of Grade 5-12 students
  - Specialty camps
  - REU programs (both 2-week mini-REU & 10-week program)
  - Teacher training
  - Outreach to families

- Outcomes:
  - Helping Tribal college students with transition to 4-yr program
  - Strengthening of student math & science skills
  - Stronger collaborative research partnership between UMN and FDLCC

- [http://www.nced.umn.edu/content/manoomin](http://www.nced.umn.edu/content/manoomin)
Networking/Mentoring Programs

• Research and Education in Solid Earth Science for Students (RESESS)
  ▫ Meghan Miller & Valerie Sloan (UNAVCO)
  ▫ resess.unavco.org

• Significant Opportunities in Atmospheric Research and Science (SOARS)
  ▫ Raj Pandya (UCAR)
  ▫ www.soars.ucar.edu

• Minorities Striving an Pursuing Higher Degrees of Success in Earth System Science (MS PHD’S)
  ▫ Ashanti Johnson (Institute for Broadening Participation)
  ▫ www.msphds.org (also see: www.ibparticipation.org)
Addressing the Needs of Persons with Disabilities

Signing Earth Science Dictionary
PI: Judy Vesel (TERC)
GEO-0913675

Simulated Field Environments
PI: Don Stredney (Ohio State Univ)
Co-PI: Chris Atchison (Georgia State Univ)
GEO - 1108127
Insights from OEDG Investments

- **Common Barriers/Issues**
  - Racism & negative stereotypes
  - Cultural barriers
  - Academic isolation
  - Perceptions of ability or self-efficacy
  - First generation college students
  - Inadequate skills preparation
  - Family expectations (lack of support)
  - Lack of role models or familiarity with STEM careers
  - Financial limitations

- **Issues Unique to the Geosciences**
  - Lack of awareness
  - K-12 inadequacies
  - Limited expertise at MSIs
  - Environmental disconnect

- **Best Practices (BEST reports)**
  - Defined outcomes
  - Sustained commitment
  - Personalization
  - Challenging content
  - Engaged adults

- **Effective Strategies**
  - Strengthen academic preparation
  - Foster career awareness/professional socialization
  - Involve mentors
  - Address academic isolation (cohorts)
  - Incorporate field experiences
  - Provide authentic research experiences
  - Make culturally relevant
  - Facilitate key transitions (HS-UG-Grad)
  - Provide employment opportunities/$$
  - Encourage family support
  - Build capacity through partnerships
  - Expose students to the ‘culture’ of geoscience
Programmatic Considerations

• Reforming Earth System Science education at the K-12 level is critical for raising awareness about Geoscience opportunities among diverse communities of learners.

• As ‘top predators’ in STEM, the Geosciences may lag other STEM fields in broadening participation; but, the relevance and appeal of the Geosciences may also be a tool to encourage diversity in STEM overall.

• How should we define success? The future Geoscience workforce (i.e., advanced degrees) is certainly important, but public Earth System Science Literacy is just as, if not more, important.

• Best practices for broadening participation in STEM and the Geosciences are generally known, but they need to be scaled up and sustained.

• The Geoscience community is small and dispersed. To optimize our return on investment, we need to be smarter and work more coherently. Partnerships are a highly effective strategy.

• Institutional leadership and Geoscientist engagement are essential.
The IDEAL Watershed Model

- Awareness of the Geosciences drives the system
- The infrastructure for disseminating best practices and supporting the flow of talent is strong and efficient
- Pathways to success are clear and supported by the community
- Barriers to participation are minimized
- The products of community efforts feed back into public knowledge and engagement.
- The process is self-sustaining.
Questions?

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Status of the Geoscience Workforce

http://www.agiweb.org/workforce/reports.html