Think Global, Act Local

Demographics of Space Sciences

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Boulder

We've come a long way, but......

~2001 I started thinking about why there were so few women......

Women In Physics & Astronomy

Moving beyond "the woman problem"

“how to help these poor women”

“how to train/hire/retain the talent we need to do the job”

Women are "the canaries in the mine" – generally, addressing gender issues improves things for all....

2020 .....but not necessarily ALL

Outline

• First, the numbers.....
  – International
  – National
• Where are the worst leaks?
• How to fix them?
  – Think globally, Act locally

The acronym soup of professional organizations

Statistics - buyer beware!

• First, there's the numbers
• Then, there's the interpretation

What's going on here?

• Statistics can often reveal interesting sociology... or politics... or....?
• or maybe it's just a change in the way they are gathering the numbers.....
International View

Many countries missing – India? China?

Comparing Across Countries

Percentage of Undergraduate Physics Degrees Awarded to Women
Probably not what you expect....

Percentage of Undergraduate Physics Degrees Awarded to Women

Germany, USA, Canada, Austria, Italy, Argentina, India, Albania, Iran

(UPAP International Conference on Women in Physics Proceedings, 2005-2013)

International

Percentage of Degrees to Women

1999-2000

Physics Bachelor's Degrees

Physics PhDs

Numbers sometimes test our pre-conceived notions

The Gender-Equality Paradox in Science, Technology, Engineering, and Mathematics Education

Beware of preconceived notions!

Global Gender Gap Index

Women Among STEM Graduates (%)

Stoet & Geary 2018, Psychological Science https://doi.org/10.1177/0956797617741719

2020: Perils of Complacency
Norm Augustine & Neal Lane

Compiled by the AIP Statistical Research Center


2020: Perils of Complacency
Norm Augustine & Neal Lane
STEM in the US
"The Leaky Pipeline"

Why do people choose different paths?
We know very little – shouldn’t we ask?

Starting with 4 million 16-year-olds in 1977

1 in 1000 women obtained Ph.D.s in Nat. Sci. & Eng.
5 in 1000 men obtained Ph.D.s in Nat. Sci. & Eng.

US Physics Undergraduate Education
Physics Education – input to our profession

National

Physicists numbers flat

All Bachelor’s

Physics Bachelor’s

College education

Up, Up, Up!

±20%

1955 60 65 70 75 80 85 90 95 00 05 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 00 05 10 15 20

All Bachelor’s*

Year of bachelor’s degree

1955 60 65 70 75 80 85 90 95 00 05 10 20 16

Class of

Students got the message...

You can get a job with a physics degree!

AIP Statistics

www.aps.org

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Percentage of Women in Physics

~15% by 2021?

Source: National Center for Education Statistics and APS

Women Physics Bachelors Increased but slower than men

Women, Physics Bachelors Increased but slower than men

Source: AIP Statistical Research Center: Enrollments and Degrees Survey

AIP Statistics

aip.org/statistics

Did women not get the message...

8600

3646

20

2017

21
Fraction of college (BA/BS) degrees to women

Bachelor's Degrees Earned by Women

- All Bachelor's
- Biology
- Chemistry
- Math & Stats
- Earth Sciences
- Engineering
- Physics
- Computer Science

Source: PEDS and APS

US Physics Graduate Education

Percentage of Women in Physics

Source: National Center for Education Statistics and APS

~50% PhDs Non-US

Coming from countries with higher %-age of Bachelors to women?
Percentage of Women in Physics

Sources: NCES/IPEDS, AIP-SRC, HERI

Confirms my 2004 finding that post-PhD the pipeline is not differentially leaky

Where majors start-end
- What does this look like separated by years?
- When do students move? Why?
- Gender? Minorities?
- What does this look like at your institution?

Let’s do the research
2021
Talking about Leaving Revisited: Dysfunction of the STEM weed-out system

Example:
• Weed-out course experiences cited by 43% of all switchers, 18% of persisters
• 69% of women switchers left with GPAs of 3.5 or higher, half of these women of color

1990s Studies
It’s not just about grades....
• women and men equally likely to change their major in response to poor grades
• Women more likely to switch out of male-dominated STEM majors
• Poor teaching, attitudes, culture.
• Other subjects more appealing

Is this still true at your institution?
Got the stats?

Under-Represented Minorities
Good news:
• Proportions of Physics Bachelors to Hispanic Americans is increasing
  • 2% -> 9% over 24 years
  • Still below US population

Bad news:
• Proportions of Physics Bachelors to African Americans is dropping
  • ~5% -> 3%

Top 10 Majors by Concentration of African-American Bachelor's Degrees

<table>
<thead>
<tr>
<th>Major</th>
<th>Percent White</th>
<th>Percent African-American</th>
<th>Percent Hispanic</th>
<th>Percent Asian</th>
<th>Other Races &amp; Ethnicities</th>
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</thead>
<tbody>
<tr>
<td>School Student Counseling</td>
<td>56</td>
<td>38</td>
<td>&lt;0.5</td>
<td>6</td>
<td>&lt;0.5</td>
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<tr>
<td>Human Services and Community Organization</td>
<td>65</td>
<td>21</td>
<td>11</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Counseling Psychology</td>
<td>72</td>
<td>20</td>
<td>3</td>
<td>5</td>
<td>1</td>
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<tr>
<td>Health and Medical Administrative Services</td>
<td>71</td>
<td>18</td>
<td>6</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Public Administration</td>
<td>67</td>
<td>18</td>
<td>10</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Social Work</td>
<td>71</td>
<td>16</td>
<td>9</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Miscellaneous Social Sciences</td>
<td>77</td>
<td>16</td>
<td>3</td>
<td>4</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>General Medical and Health Services</td>
<td>71</td>
<td>15</td>
<td>7</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Public Policy</td>
<td>72</td>
<td>15</td>
<td>6</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Community and Public Health</td>
<td>73</td>
<td>14</td>
<td>4</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

Doing good things for society... not the best paid

Number of PhD Degrees for Latinx/Hispanic & Black/African Americans in Physics and in Astronomy

Increasing Participation of Historically Minoritized Communities in STEM

Past year—organizations are making statements, delivering webinars, doing studies, publishing reports, ....

What’s EFFECTIVE? National and/or local initiatives?
Some Experiments and Ideas for the Classroom.....

Group Learning
- more interaction
- practical questions
- more social

Impressive retention!!

MEN
WOMEN

Florida International University
Hispanic-Serving University
Active learning physics classes 2005-2014

Impressive retention!!


Effects of Interventions


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Physics Education Careers
(Teaching – rather than research)

46% of Physics Bachelors enter the workforce on graduation
Let’s get them the right skills & career advice!

- Graduate Studies 54%
- Unemployed 15%
- Full Time Job 34%

Initial Employment Sectors
Physics Bachelors 2013 & 2014

- Active Military
- Civilian Gov’t, National Lab
- High School
- College & University
- Private Sector 65%

9% become teachers
Could we get more to go into teaching?
More Phys. Ed. degrees?
Better pay?!

Degrees of Physics High School Teachers in 2013

Thought Experiment:
What would it take to put a teacher with a physics bachelor in every high school in the US?

- 45,000 high schools
- 15 years "Typical career length" – survival span (optimistic)
  = 3000 Physics bachelors per year going into teaching

- Currently 9% of 8000 = 720
- Crank up production another factor 4
- Incentivize? Pay better?
- Change "Physics" to "Natural Sciences"? to "Phun"?!
- Placement at local schools?

Only 47% of physics classes are taught by a teacher with a degree in the subject, compared with 73% of biology classes and about 80% of humanities classes.

Solutions - 1

Think Globally
Act Locally
– Keep the UGs going

0 – Get the numbers when students drop out & why
1 – More interactive classes, less "chalk&talk"
2 – Affirmation exercises (they're cheap!)
3 – The Sophomore Roadbump
   – provide undergraduate "study buddies"
   – don't put most traditional teachers
     in E&M 1!
4 – Socialize (safe) study spaces – university wide
5 – Involve students in research

Solutions - 2

Think Globally
Act Locally
– Keep the UGs going

6 – Invite Physics Education Researchers to give a Dept. Seminar
7 – Expand Physics Education degrees & careers
   – Direct pathway to high school teaching
   – Masters students TAs in service classes as training for community college teaching
8 – More joint degrees with biology, environmental science, communication, journalism, computing....
9 – Dept/AGU/AAS/APS needs to provide more non-academic career advice

Solutions – 2

Think Globally
Act Locally
Grad School

Recruitment:
• what are the realistic predictors of success in grad school?
• cast a broad net – makes a better environment

Program
• set fair, consistent, expectations
• design a program that supports and encourages a broad spectrum
• evaluate and articulate progress in a fair, consistent manner – so students know where they are early & often

Get people from the real world out there to come give advice on real-world careers

National Surveys:

Astronomy
Planetary Science
Solar & Space Physics

Usually motivated by a Decadal Survey

None for space-related Earth Science workforce
Planetary and Astrobiology Decadal 2023-2032

Statement of Task

#9 - The report should provide a clear exposition of the following:

The state of the profession including issues of diversity, inclusion, equity, and accessibility, the creation of safe workspaces, and recommended policies and practices to improve the state of the profession. Where possible, provide specific, actionable and practical recommendations to the agencies and community to address these areas.

AIP Planetary Workforce Surveys – 2011 & 2020

Funded by NASA

<table>
<thead>
<tr>
<th>2011</th>
<th>Attendees/Members of Planetary Conference/Section</th>
<th>LPSC</th>
<th>AGU</th>
<th>DPS</th>
<th>All Three</th>
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<td>AGU</td>
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<tr>
<td>DPS</td>
<td>156</td>
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<tr>
<td>All Three</td>
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Funded by DPS of AAS

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<th>2020</th>
<th>Attendees/Members of Planetary Conference/Section</th>
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<td>GSA</td>
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<td>DPS</td>
<td>587</td>
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<tr>
<td>All Three</td>
<td></td>
<td></td>
<td></td>
<td>23</td>
<td></td>
</tr>
</tbody>
</table>

Missing: – Astrobiology
- American Meteoritical Society
- Exoplanets, space physics, .....
Planetary Science is very interdisciplinary

2011 Planetary Survey

Respondents limited to having PhD & working in US & identify as planetary scientist

Planetary, Astrophysics, Space Physics

Astrophysics: 2018 AAS Survey by AIP
60% response = 2018 Respondants (including students)
  -> 2040 PhD astrophysicists in US

Solar & Space Physics: 2011 NRC Decadal Survey
AGU-SPA, AAS-SPD, Space Weather Week
51% response = 1305 Respondants
  -> 2300 PhD solar, space & upper atmos. in US

62% Response = 2622 Respondants
  -> 1140 PhD planetary scientists in US

2020 AIP Survey – LPSC, DPS, GSA
47% Response = 2400 Respondants
  -> 1100 PhD planetary scientists in US

EMPLOYMENT

Contrary to public viewpoint, relatively few planetary scientists work at NASA labs.

Workforce

Percent

Male
Female
Other/non-respondent
White
Asian / Asian American
Black / African American
Latino / Hispanic
Other / non-respondent

Astrophysics
Heliophysics
Planetary
Earth
Academic Department Surveys 2011 & 2018

**Planetary Science:**
- 54 Departments >1 PS faculty
- 250 faculty
- 100 Undergraduates / year
- PhDs: 50-65 / year
  - 40-45% women
  - 30% non-US
  - 8% minority

**Astronomy (AIP)** For comparison:
- 93 Departments (40 Astro, 53 Astro+)
- 550 faculty
- 666 Undergrad degrees / year
- 159 PhDs / year

| Note: These surveys were ad hoc – initiated and carried out by a small group. Needs to be developed as a systematic evaluation of the production of planetary scientists and astrobiologists. |

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In parallel to the Decadal Survey I am co-chairing this NASEM committee that is happening right now – across all 4 divisions of NASA’s Science Mission Directorate

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**NASA Office of the Chief Scientist**
- analysis of NSPIRES Personal Profile Data
- Public Presentations by Louis Barbier

**NSPIRES Gender Participation:**
All PIs & Co-Is 2014 - 2020

- **Astrophysics**
  - Man: 72%
  - Woman: 19%
  - Prefer Not to Answer: 19%

- **Heliophysics**
  - Man: 68%
  - Woman: 22%
  - Prefer Not to Answer: 9%

- **Earth Science**
  - Man: 69%
  - Woman: 23%
  - Prefer Not to Answer: 18%

- **Planetary Science**
  - Man: 65%
  - Woman: 10%
  - Prefer Not to Answer: 25%
NSPIRES Race/Ethnicity Participation: All PIs & Co-Is 2014 - 2020

- **Astrophysics**
  - White: 18.4%
  - Asian: 4.3%
  - Black/African American: 1.3%
  - N = 11,198

- **Heliophysics**
  - White: 22.4%
  - Latina/Hispanic: 2.5%
  - Other: 0.8%
  - N = 11,859

- **Earth Science**
  - White: 45.6%
  - Latina/Hispanic: 2.3%
  - Other: 1.3%
  - N = 25,684

- **Planetary Science**
  - White: 18.0%
  - Latina/Hispanic: 4.5%
  - Other: 1.3%
  - N = 31,172

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**NASA HQ**

- Analysis of Competed Mission Proposals 2010-2019
- Public Presentations by Michael New

- **Mission Size**
  - Small
  - Medium
  - Large

- **Number of Proposals**
  - 0
  - 20
  - 40
  - 60
  - 80
  - 100
  - 120
  - 140
  - 160
  - 180
  - 200

- **Astrophysics**
- **Heliophysics**
- **Earth Science**
- **Planetary Science**

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**NASA HQ**

- Analysis of Competed Mission Proposals 2010-2019
- Public Presentations by Michael New

- **PI Inferred Gender: 2010-2019 Accepted Mission Size**

- **PI Inferred Gender: 2010-2019 Acceptance Rate Mission Size**

- **PI Inferred Gender: 2010-2019 Submitted Academic Age of PI**

- **PI Inferred Gender: 2010-2019 Accepted Academic Age of PI**
White Papers to Decadal Survey

Before the start of the Decadal Survey of Planetary Science and Astrobiology, the community was invited to submit White Papers on related topics.

Related to the State of the Profession there were a total of 36 White Papers submitted.

On the gender axis, 52.5% of white paper authors were women, 37.9% were men, and 9.6% were non-binary.

About 28% of papers did not offer substantial evidence or propose recommendations; these were mainly “views” and treated as such: 48% of white papers offered light evidence and did propose recommendations. About 23% of papers offered reliable and substantial evidence, most of these also offered recommendations. 50% of papers mentioned race, 41.7% focused on multiple groups and raised concerns of general interest, 30.6% discussed issues concerning gender, followed by 16.7% on aspects of ability (e.g., disability, neurodiversity), 13.9% on socioeconomic class, specifically the loss of talent from groups that today have little opportunity, and 13.9% on issues of sexual identity and orientation.

White paper contents were categorized into 17 broad topics. These topics concern the work produced by planetary scientists and astrobiologists (e.g., education, grants, tenure) as well as issues concerning quality of life that impact work (e.g., childrearing, service work, awareness of bias, workplace culture). Many of the most concerning issues are at the core of the profession (e.g., grants, collaboration, conferences).

Solutions – 5 - National

Sponsor AIP to do the demographic surveys, SMD-wide, every 3-5 years

- How are workforce numbers changing?
- How is the field changing?
- What fraction of researchers are non-US born?
- What workforce is needed for next decade?

Make physical science education a priority – high school, college, graduate

- Especially in historically minoritized communities
- Do the research – why do students drop out?
- Surely we can do better than 8600 physics majors out of 300 million people!
Family & Career

The 2-Body Problem

Two-Body Problem

Institutions need Dual-Career Programs