Preparing Graduate Students for Non-Academic Careers

American Association of Physics Teachers Meeting

Orlando, FL

January 6, 2014

Panel DC02

Dr. Lawrence Woolf
General Atomics Sciences Education Foundation
General Atomics Aeronautical Systems, Inc.
San Diego, CA 92121

Goals for this talk

- **Describe key findings of the Second Graduate Education in Physics Conference relevant to preparing students for non-academic careers**
  - Participant stories/comments
  - Conference findings

Conference program for Preparation for Non-Academic Careers

- **Panel session 1 with 3 panel members (75min)**
- **Breakout session 1 (75min)**
  - Non-academic careers
  - Improving the graduate curriculum: multi/inter disciplinary courses
  - General professional skills: leadership/team building/communication
- **Breakout session 3 (75 min)**
  - University, industry and national lab partnership for graduate education

Panel Session 1: Preparation for Non-Academic Careers

- Zelda Gills (Lockheed Martin Corp.)
- Alex Panchula (First Solar, Inc.)
- Kathy Prestridge (Los Alamos National Lab)

- Moderator: Larry Woolf (General Atomics Aeronautical Systems, Inc.)

Prestridge (LANL) take-aways

- **Technical research skills**
  - Collaborations across experiment, theory, modeling, simulation
  - Intellectual agility: applying existing knowledge to new situations
- **Communication skills**
  - Technical results to other technical experts and program managers
- **People skills**
  - Listen to/respect/value: technicians to senior management

Prestridge summary

- **Project management skills**
  - Define project scope, set schedules and budgets
  - Report incremental/monthly progress to management
- **Evolution of skills**
  - Should begin in graduate school and not be a step function

“Agile, out-of the box thinking, communication, management, and people skills are hard requirements for future researchers”

Panchula (First Solar) Take-Aways

- **Gaps in physics education**
  - Exposure to toolsets used in industry: software, programming, statistics
  - Business methods
- **Need to train physicists to write "the how" not "the what" in resumes**
  - Instead of "Magnetotransport in Magnetic Nanostructures"
  - Use: "Experimental design, execution, data analysis and mathematical models of complex systems"
- **Invite alumni in industry to speak to students**

Interesting Comments – Panel Session 1

- Nobody makes an effort to teach stat mech for physicists and chemists and engineers
- Courses should provide connections to multiple scientific and applied topics – interdisciplinary
- Need to change culture that students who go into industry are failures

Breakout Session 1: Non-academic careers Take-Aways (Zollner)

- Most graduate students will not have academic careers – students should be informed about employment statistics
- Lack of tracking of career paths of PhDs
- Lack of knowledge of skills that PhDs find valuable in their jobs
- Need to set realistic educational objectives and then survey alumni to demonstrate they have been met

Interesting Comments – Improving the Graduate Curriculum: Multi/Inter Disciplinary Courses

- **Need to show students connections to modern applications**
  - Too many theorists teach graduate courses
  - Experimentalists more likely to make connections
- **Make students active participants in learning**
- **Core curriculum should be updated to be relevant but each department should decide how to do that**

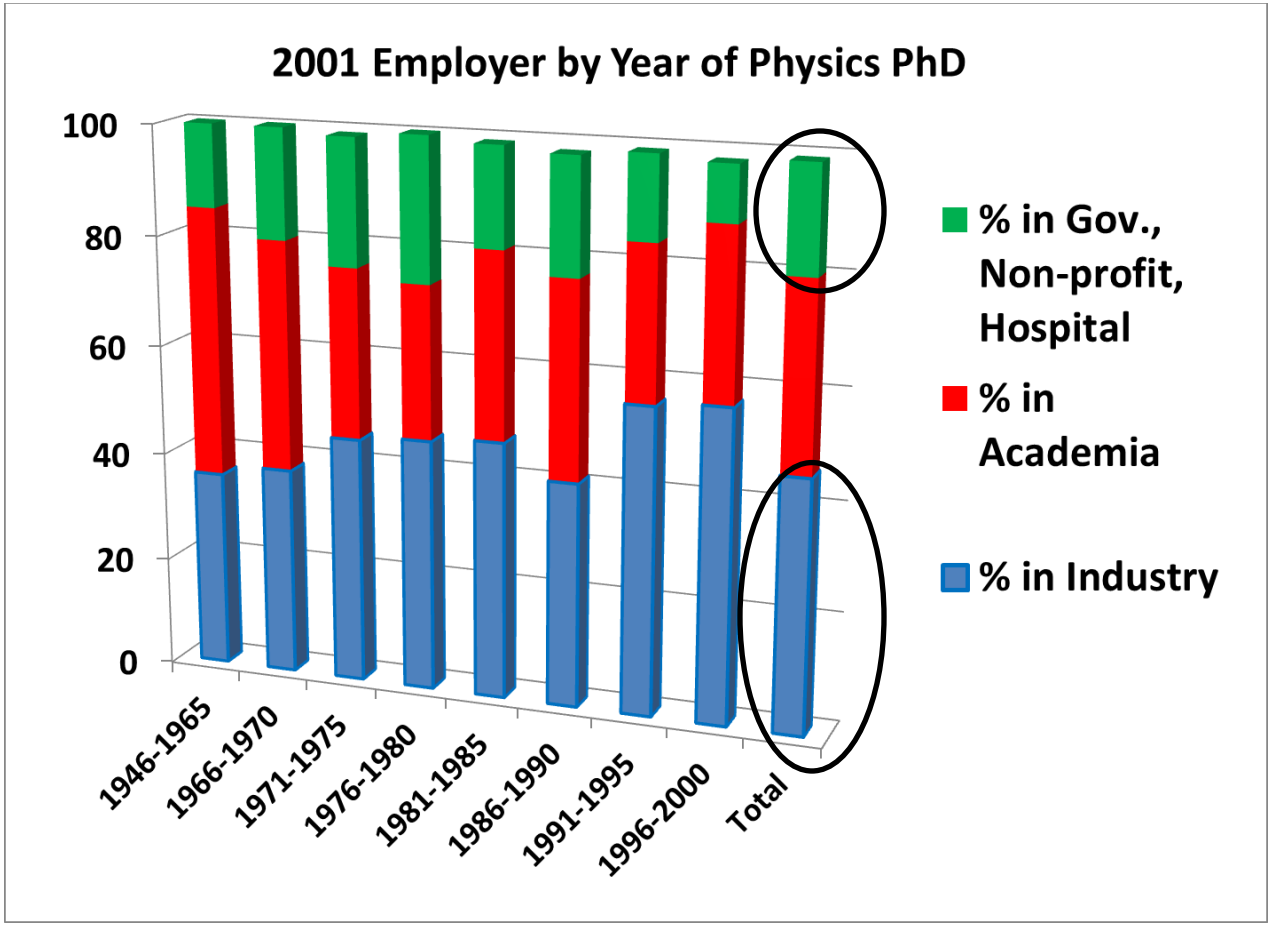
Interesting Comments – Professional Skills

- **Does use of term soft skills imply low priority?**
  - Better to use critical or professional skills
  - Need APS statement on professional skills
  - Skills training should be intentional, not accidental

Conference Findings

- **Most physics PhDs will have non-academic careers**

Majority of Physics PhDs are in Industry



Career Outcomes for PhD Physicists – Information from the NSF's Survey of Doctoral Recipients, by Michael Neuschatz and Mark McFarling (AIP Statistical Research Center report)

2006 NSF Survey of Employed Doctoral Scientists and Engineers

- Physics:
  - Total employed: 34,310
  - **Teaching as primary or secondary work activity: 8,270 (24%)**

Table 15 of the 2006 NSF survey: Characteristics of Doctoral Scientists and Engineers in the United States: 2006

http://www.nsf.gov/statistics/nsf09317/content.cfm?pub_id=3920&id=2

2008 NSF Survey of Doctorate Recipients (SDR)

- **34,900 employed physicists**
- **13,000 at educational institutions (37%)**
  - 9,700 are post-secondary physics teachers (28%)
- **21,900 at non-academic institutions (63%)**
  - 17,200 at private (49%)
  - 3,500 at government (10%)
  - 1,200 self-employed (3%)

Characteristics of Doctoral Scientists and Engineers in the United States: 2008; Tables 2, 8
http://www.nsf.gov/statistics/nsf13302/pdf/nsf13302.pdf

Physics Doctorates Initial Employment

- **Potentially permanent positions accepted by PhD classes of 2009 & 2010**
  - Academic: 23%
  - Private sector: 57%
  - Government: 16%
  - Other: 4%
  - N=365

Table 1 at:
http://www.aip.org/sites/default/files/statistics/employment/phdinitemp-p-10.pdf

Conference Findings

- **Expert learning and innovation skills**
  - Apply existing knowledge to new situations – engineering/applied focus
  - Solve well defined and ill-defined problems
  - Use software, toolsets common in industry, statistics
  - ***Graduate classes can include more modern applications and connections***

Conference Findings

- **Leadership**
  - Conceptualizing and planning projects
  - Focus team on attaining goals
  - Keep team and stakeholders informed
  - ***Graduate students can develop leadership***
    - *Mid to late in graduate career in their research*
    - *Mentor junior graduate students and undergraduates*

Conference Findings

- **Project Management**
  - Define project scope
  - Develop and follow schedule
  - Develop and follow budget
  - ***Graduate students can begin using their thesis research as the project***

Conference Findings

- **Communication Skills**
  - Verbal
    - Co-workers, technicians, program managers, upper management, funding sources
  - Written
    - Monthly reports, proposals, white papers, test plans, test results, final reports
    - Graphs and tables for technical and non-technical audiences
  - ***Graduate students can hone these skills via thesis updates to advisors and graduate students***

Conference Findings

- **Interpersonal skills**
  - Work productively with a team as leader or member
  - Listening skills
  - Interact with customers
- ***Later stage graduate students can lead early stage graduate students and interact with funding sources***

Conference Findings

- **Proposal Writing**
  - Proposals to internal customers
  - Proposals to external customers
  - Develop planning, research, and writing skills
- ***Graduate students can:***
  - *Assist their professors in proposal writing early in their research*
  - *Take leadership role in proposal writing later in their research*

Conference Findings

- Connections with industry: research collaborations/internships provide students with better understanding of non-academic careers
- Need to value a broad range of career paths
- Include modern applications/engineering aspects/connections to other areas in graduate classes
- Connect with engineering or business schools for professional skills training

Conference Findings

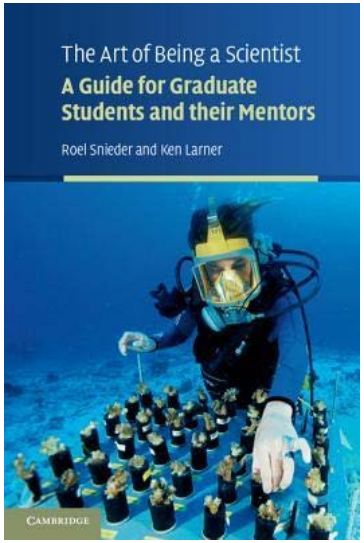
- Professional masters programs include many business/soft skills
- PhD programs could use professional masters programs as template

Primary Resources

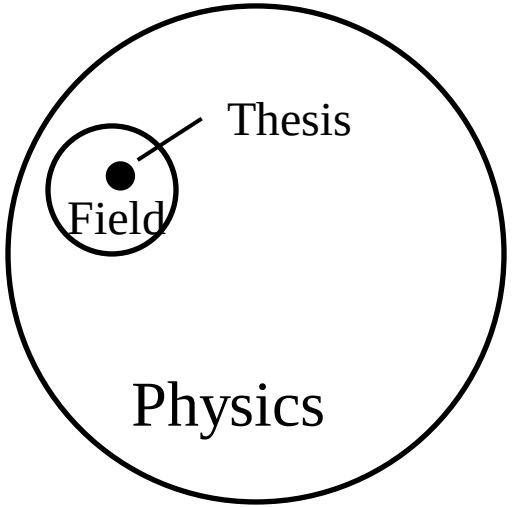
- **Conference Resources (background readings)**
  - http://www.aps.org/programs/education/graduate/conf2013/resources.cfm
- **Conference Program (session goals, questions to be considered)**
  - http://www.aps.org/programs/education/graduate/conf2013/program.cfm
- **Presentations and Notes (scribe notes for each session, presenters opening remarks, presentations)**
  - http://www.aps.org/programs/education/graduate/conf2013/presentations.cfm
- **Conference web site**
  - http://www.aps.org/programs/education/graduate/conf2013/index.cfm

Other resources

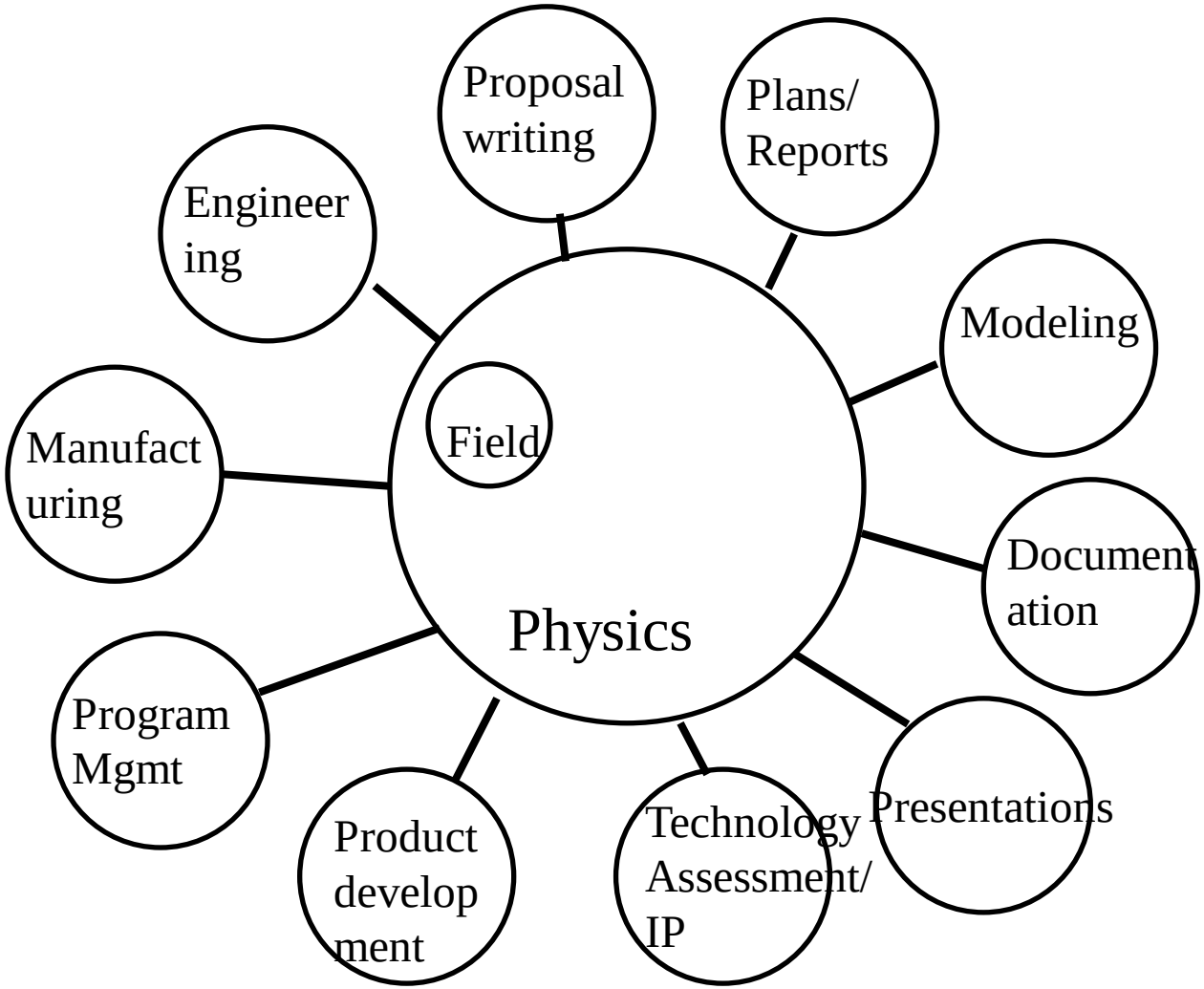
- **“Things your adviser never told you: Entrepreneurship’s role in physics education” by Douglas Aron**
  - Physics Today, August 13, 2013, p. 42-47
- **“The Art of Being a Scientist: A Guide for Graduate Students and their mentors” by Roel Snider and Ken Larner**
- **“Preparing Graduate Students for Careers in Industry” by Larry Woolf**
  - **http://www.aps.org/units/fed/newsletters/spring2013/industry.cfm**
- **Is Industry Really a "Nontraditional" Career? by Jeffrey Hunt, Boeing Corporation**
  - **http://www.aps.org/units/fiap/newsletters/201311/**
- **Best practices for Educating Students about Non-Academic Jobs**
  - **http://www.aps.org/careers/guidance/advisors/bestpractices/**



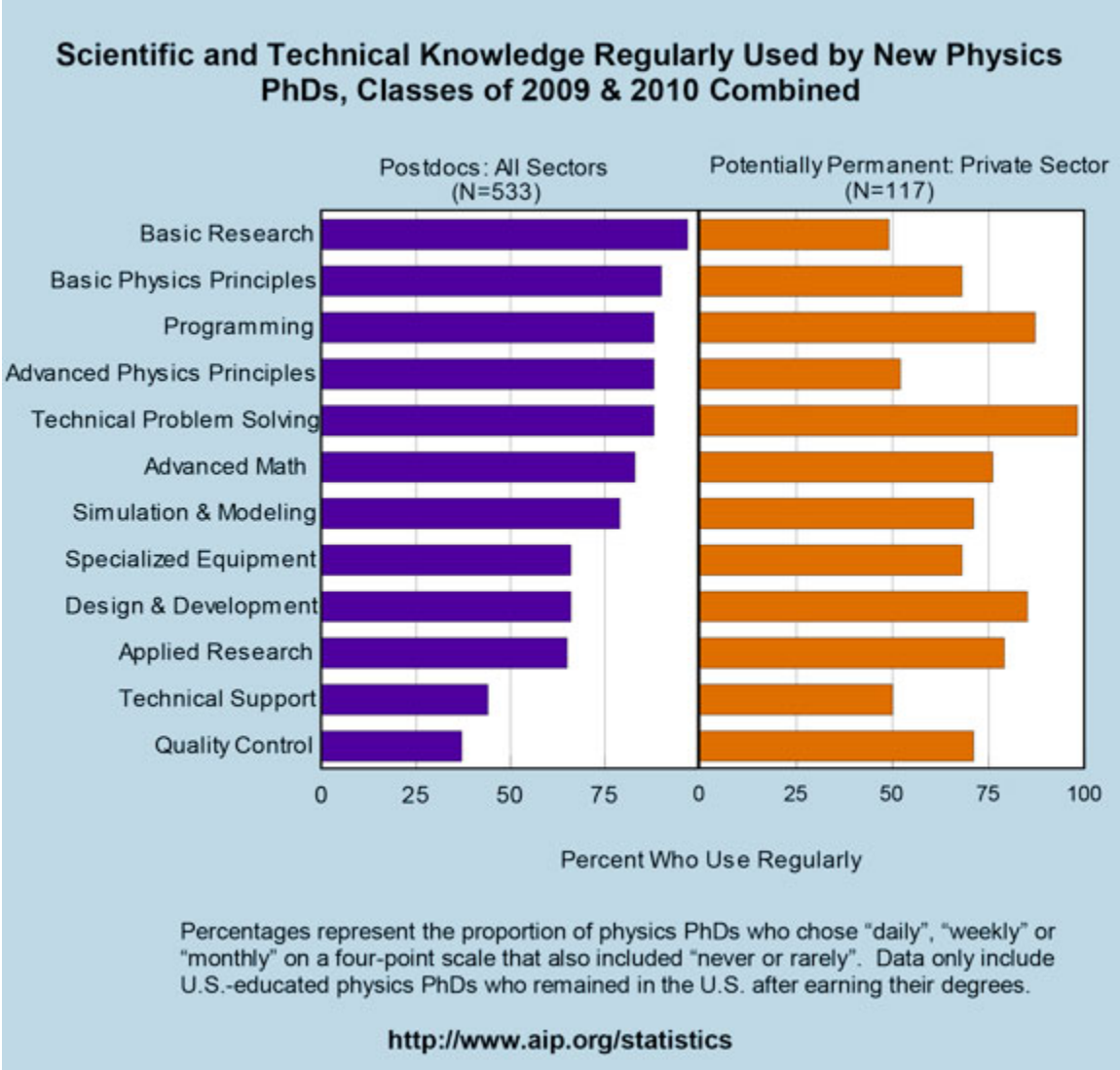
PhD Physicist: View from Graduate School



PhD Physicist: View from Industry

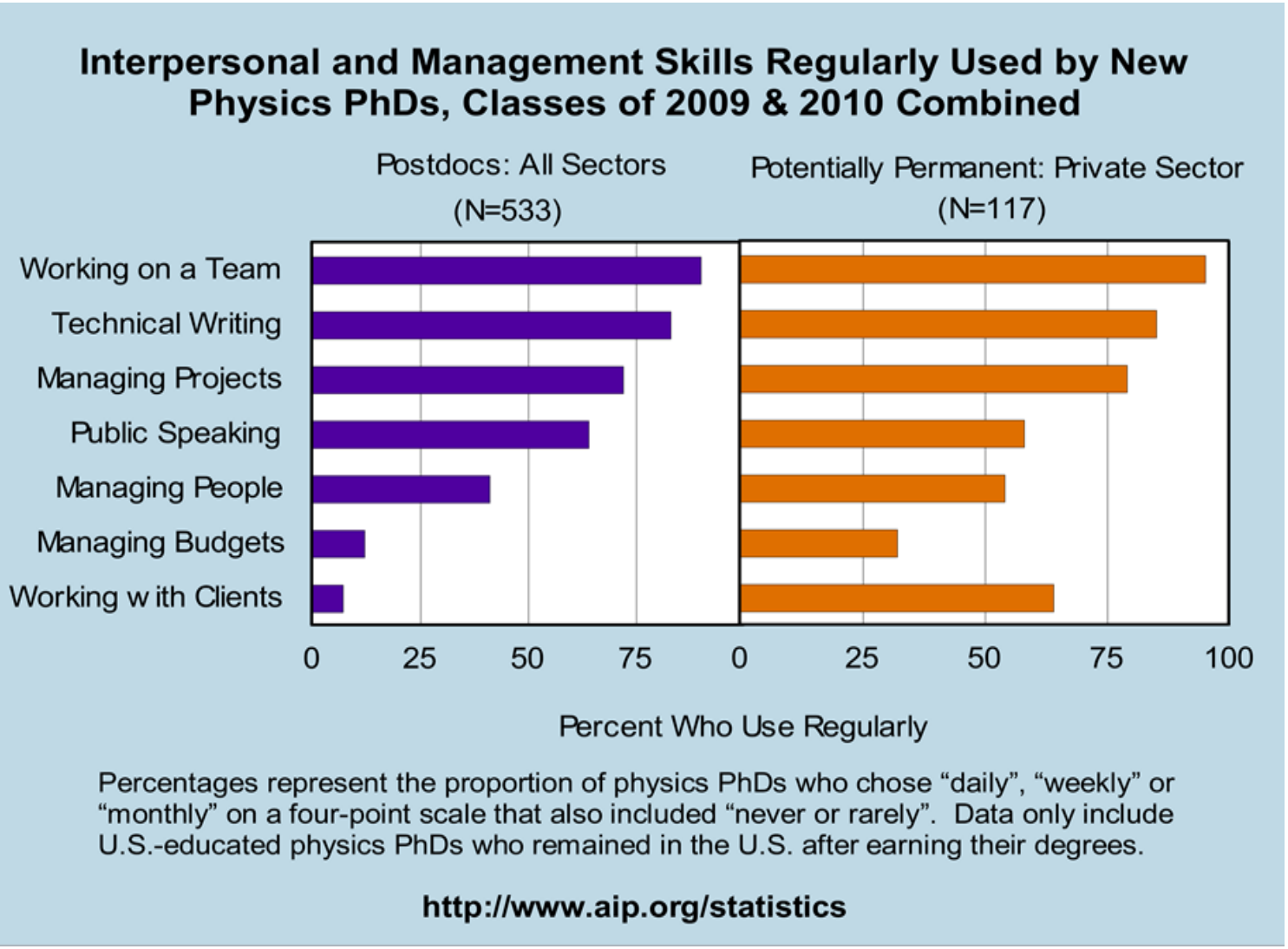


Scientific and Technical Knowledge Used



Recent Physics Doctorates: Skills Used Satisfaction with Employment
Data from the degree recipient follow-up survey for the classes of 2009 and 2010
Garrett Anderson and Patrick Mulvey
http://www.aip.org/statistics/trends/reports/physdoctorates0910.pdf

Interpersonal and Management Skills



Recent Physics Doctorates: Skills Used Satisfaction with Employment
Data from the degree recipient follow-up survey for the classes of 2009 and 2010
Garrett Anderson and Patrick Mulvey
http://www.aip.org/statistics/trends/reports/physdoctorates0910.pdf

Conclusions

- Majority of physics PhDs will have non-academic careers
- Students need professional skills
- Courses should include connections and modern applications
- Need to engage non-academic physicists

Back-up slides

Topics covered in ScienceWorks at Carthage College

D. N. Arion, "Things your adviser never told you: Entrepreneurship's role in physics education," Physics Today, August 13, 2013, p. 42-47

Intelligence

- **Actionable: can be used and applied to novel situations**
- **Connective: connects to other areas**
- **Robust: widely applicable in most situations**

Largest employers as of 1998 – most recent AIP survey

Largest 19 Employers*

Raytheon Corporation	Northrop Grumman Corporation
IBM	AT T
Lockheed Martin Corporation	Schlumberger Limited
Lucent Technologies	Motorola Incorporated
Boeing Company	Rockwell International Corporation
Eastman Kodak Company	Seagate Technologies
Science Applications International Corporation	*Osram Sylvania*
General Atomics	Maxwell Optical Industries
Hewlett-Packard Company	Varian Associates
	3M Company

** The above companies employ 30% of industrially-employed PhD physicist members.*

SOURCE: AIP Membership Sample Survey, 1998