Preparing STEM Students for 21st Century Careers

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Workshop Learning Outcomes

- Consider how the actual career paths of STEM graduates must inform undergraduate curricula, and how to convey that information to other faculty, students, and the students’ families.

- Understand the difference between “vocational” skills and critical professional skills and how to convey that difference to faculty, students, and student’s families.

- Identify critical professional skills most highly valued by employers, the evidence for that list of skills, and how to enhance those skills in an undergraduate STEM program.

- Begin to develop plans for enhancing one or more of those skills in their home departments.
Make a list of the skills students need in order to succeed in a STEM career that is outside of academia.
Core Competencies from Vision and Change

1. ABILITY TO APPLY THE PROCESS OF SCIENCE
2. ABILITY TO USE QUANTITATIVE REASONING
3. ABILITY TO USE MODELING AND SIMULATION
4. ABILITY TO TAP INTO THE INTERDISCIPLINARY NATURE OF SCIENCE
5. ABILITY TO COMMUNICATE AND COLLABORATE WITH OTHER DISCIPLINES
6. ABILITY TO UNDERSTAND THE RELATIONSHIP BETWEEN SCIENCE AND SOCIETY
PHYS 21 identified four categories of Knowledge and Skills that programs should offer to meet the needs of its graduates:

1. *Physics(Discipline)-specific knowledge*
2. *Scientific and technical skills*
3. *Communication skills*
4. *Professional and workplace skills*
Pair with the person next to you review the skills on your lists. Determine if each skill on your list is a:

Vocational Skill (V) or Professional Skill (P)
Share one skill labeled as a Professional Skill
STEM workforce is still growing

Figure 6

Jobs for STEM majors are projected to continue growing

- Mathematical Science occupations: 34 / 23
- Physical scientists: 81 / 42
- Engineering technicians, except drafters: 99 / 26
- Life scientists: 69 / 75
- Life, physical, and social science technicians: 129 / 44
- Social scientists and related occupations: 158 / 117
- Engineers: 353 / 178
- Computer specialists: 621 / 763

Number of Job Openings (thousands)

President’s Council of Advisors on Science and Technology: “Engage to Excel,” 2012
Where do our STEM graduates end up?

https://www.census.gov/dataviz/visualizations/stem/stem-html/
Most Biology graduates leave STEM

https://www.census.gov/dataviz/visualizations/stem/stem-html/
Learning Goals to Support Diverse Career Directions (Phys21 report)

**Discipline-specific Knowledge (V&C, ACS, J-TUPP)**

**Scientific and Technical Skills**
- Problem-solving and analysis
- Instrumentation competency
- Software competency
- Coding competency
- Data analytics competency

**Communication Skills**
- Effective communicating to diverse audiences
- Evaluate information
- Develop an informed argument
- Effective written communication
- Appropriate use of data, equations, and graphs
- Self-reflective teaching

**Professional/Workforce Skills**
- Collaborating in diverse team environments
- Independent learning
- Generating new ideas
- Understanding technological context
Our program/curriculum include specific learning objectives in the following areas:

- Discipline-specific Knowledge and Science and Technical Skills
  - Code: 528700

- Discipline-specific Knowledge, Science and Technical Skills and Communication Skills
  - Code: 528713

- Discipline-specific Knowledge, Science and Technical Skills, and Professional/Workforce Skills
  - Code: 531983

Yes, we have learning objectives for all of the skills listed above.

Start the presentation to activate live content.

If you see this message in presentation mode, install the add-in or get help at PollEv.com/app
What metrics do you use to monitor student outcomes in Sci/Tech, Com, Prof/Workforce skills?

<table>
<thead>
<tr>
<th>Metric</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course completion</td>
<td>533887</td>
</tr>
<tr>
<td>Portfolio</td>
<td>533915</td>
</tr>
<tr>
<td>Capstone project</td>
<td>533919</td>
</tr>
<tr>
<td>Co-curricular project</td>
<td>534195</td>
</tr>
<tr>
<td>Post-graduate placement</td>
<td>534197</td>
</tr>
<tr>
<td>All of the above</td>
<td>534518</td>
</tr>
</tbody>
</table>

Start the presentation to activate live content.

If you see this message in presentation mode, install the add-in or get help at PollEverywhere.com/app.
How do you use these data to improve your program?

- Limited capacity to collect data on program outcomes
  - 533025
- Data collection and analysis is part of regular program evaluation
  - 533026
- Data collection and analysis occurs intermittently
  - 533036
- Data is collected but not regularly analyzed
  - 533160

Start the presentation to activate live content
If you see this message in presentation mode, install the add-in or get help at Poll Everywhere.com/app
Career Paths of Students With STEM Degrees

Status of Physics Bachelors One Year After Degree, Classes 1995 through 2014

- Employed
- Physics or Astronomy Graduate Study
- Graduate Studies in Other Fields
- Unemployed

http://www.aip.org/statistics
Career Paths of Students with STEM Degrees

Physics Bachelors 1 Year Later

7,430 Recent Degree Recipients

- Workforce: 46%
  - Private Sector: 26%
  - High School Teaching: 4%
  - College & University: 4%
  - Active Military: 3%
  - Government: 2%
  - Other: 2%
  - Unemployed, Seeking: 5%

- Graduate Study Astronomy or Physics: 32%
  - Physics: 26%
  - Astronomy: 6%

- Graduate Study Other Fields: 22%
  - Engineering: 10%
  - Other Science & Math: 5%
  - Medicine & Law: 3%
  - Education: 2%
  - Other: 2%
Common Job Titles of Bachelors

Engineering
- Systems Engineer
- Electrical Engineer
- Design Engineer
- Mechanical Engineer
- Project Engineer
- Optical Engineer
- Manufacturing Engineer
- Manufacturing Technician
- Laser Engineer
- Associate Engineer
- Application Engineer
- Development Engineer
- Engineering Technician
- Field Engineer
- Process Engineer
- Process Technician
- Product Engineer
- Product Manager
- Research Engineer
- Test Engineer
- General Engineer
- Technical Services Engineer

Computer Hardware / Software
- Software Engineer
- Programmer
- Web Developer
- IT Consultant
- Systems Analyst
- Technical Support Staff
- Analyst

Research and Technical
- Research Assistant
- Research Associate
- Research Technician
- Lab Technician
- Lab Assistant
- Accelerator Operator
- Physical Sciences Technician

Education
- High School Physics Teacher
- High School Science Teacher
- Middle School Science Teacher
Are students industry aware and industry ready?

Sandeep Giri, Advanced Technology Manufacturing Engineering Group, Google, Inc
1. X (formerly GOOGLE [X])
2. LESSONS LEARNED IN THE INDUSTRY BY A PHYSICS MAJOR
3. X INTERVIEW PROCESS

Sandeep Giri, Advanced Technology Engineering, X
San Francisco
Nov 4, 2017
Invent and launch moonshot technologies that make the world a radically better place.
What is a moonshot?
Principles we value

• Fall in love with the problem, not the technology

• 10% better is often harder than 10x better

• Audacity can be the path of least resistance

• Tackle the hardest part of every problem first

• Innovation is a team sport
Moonshot Factory Process

- **Stage 2**: Rapid Eval Research (Hundreds per year)
- **Stage 3**: Rapid Eval Investigation (3 months, 60 per year)
- **X Project**: 2-5 years
- **Foundry**: 6-18 months, 2-4 per year
- **Alphabet Company**: Other Exits (Several options)
Lessons Learned by Physics Major in the Industry
Career Path

• Undergrad
  ○ Coe college  (Physics, Math, CS)
  ○ Fermilab  (Top quark)
  ○ Oak Ridge National Lab  (MEMS device characterization)

• Grad
  ○ Stanford university  (M.S. Materials Science, quit my Ph.D.)
  ○ Nano-particle growth via ALD for Fuel cells, with LLNL

• Industry
  ○ Qualcomm  (MEMS displays for MP3 players, E-readers, Smartwatch)
  ○ Qualcomm  (Thin film solar and Silicon solar technologies)
  ○ Qualcomm  (Expat in Asia building Gen 4.5 fabs)
  ○ Google  (Google Glass, optics engineering)
  ○ Google  (Project Loon, multiple industries)
Lessons from Building Products

- R&D in academia and industry are different styles
- Full lifecycle of product goes much past R&D (next slide)
- Most ideas do not fail in R&D phase, rather later phases
- Tech manufacturing left the US in 80s/90s, difficult to get that skill set back
- Manufacturing requires immense rigor and $ commitment
Sample Product Phases within various Industries

SIMPLIFIED
- Concept
- Development
- Commercialization

ELECTRONICS MANUFACTURING
- Concept
- Prototyping
- Engineering validation
- Design validation
- Production validation
- Ramp
- Mass production
- Service & Support

MEDICAL DEVICE & DRUG DEVELOPMENT
- Discovery / Ideation
- Pilot and prototyping
- Engineering validation
- Pre-clinical testing
- Clinical trials
- Regulatory decision
- Ramp
- Launch
- Monitor

AEROSPACE & AUTOMOBILE SYSTEMS
- Concept
- System requirements
- Design
- Development
- Prototyping
- Integration
- V&V
- Production
- Service & Support

R&D OR INNOVATION DEVELOPMENT SITE
- Opportunity Identification
- Concept Screening
- Solution Prototyping
- Analysis
- Product development
- Enterprise scaling
- Launch

...and other terminology variations by industry
What Happens in each Product Phase?

<table>
<thead>
<tr>
<th>PHASE</th>
<th>INVESTIGATION</th>
<th>CONCEPT</th>
<th>DESIGN</th>
<th>PROCESS</th>
<th>VERIFICATION</th>
<th>SCALING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Descriptive terms used in association</td>
<td>Pilot Prototyping Screening Demonstration Proof-of-Concept</td>
<td>Product Definition Product Specification Product Design Engineering Validation EVT</td>
<td>Process Development Detailed Specification Design Validation DVT</td>
<td>Pre-Manufacturing Verification &amp; Validation Pre-launch Production Validation PVT</td>
<td>Volume Manufacturing Mass Production Scaling activities Launch Ramp</td>
</tr>
<tr>
<td>Objective</td>
<td>Define the opportunity</td>
<td>Prove and pilot the conceptual solutions</td>
<td>Develop basic engineering and manufacturing design</td>
<td>Lock design and lock specs for manufacturing</td>
<td>Establish baseline process in manufacturing tools</td>
<td>Meet yield, throughput and reliability targets at scale</td>
</tr>
<tr>
<td>Gate exit criteria</td>
<td>Business plan</td>
<td>Project roadmap IP landscape Basic architecture and system requirements Risk mitigation plan</td>
<td>Subsystem specs Test and Verification plan Manufacturing plan (draft) Bill of Materials etc..</td>
<td>Detailed process flow Final product specifications DFM report Unit cost estimates (finalized) BOM etc..</td>
<td>Manufacturing Readiness Reliability test results Design and Engineering Change Orders open items Marketing &amp; Service plans (released) BOM etc..</td>
<td>Engineering Closure plan Service Readiness report</td>
</tr>
</tbody>
</table>

Academia likely will only cover Concept, how rapidly can you learn Development and Commercialization?
Technical Skills and Industry Awareness

- Hands-on research experience is valued. Hard skills matter. Internships matter.
  - Optical: Zeemax, Code V, Oslo, TFCalc
  - Electrical: Spice, P-Spice
  - Mechanical: CAD, 2-D prints, Fabrication
  - Material: Overview of metals, composites, organics
  - Physics: Comsol Multiphysics

- Several technical career tracks
  (ME-Design, ME-Analytics, EE, MFG Process, Optical E, Opto-mechanical E, Rel&FA, Quality, TPM)

- Know key industries out there
  (e.g. Auto, Semiconductor, Displays, Consumer electronics, Battery, Renewable Energy, Medical, Products for developing world)

- Start-ups vs. Mid-Size vs. Large companies

- Ask key questions about a particular industry
  (Who makes this? Who do they compete with? Who supplies manufacturing equipment? What are rough cost numbers? What are the key hubs? Tech blogs and alumni network)
Interviewing, Resume Writing, and Networking

- Physics majors should sell their ability to understand fundamentals of a new field and rapidly acquire new skills
  - Make a “problem solver” resume
  - Demonstrate you can teach the basics
  - Practice sketching out the hardest problem you’ve solved
  - It’s not whether you know the answer, rather how you think when you don’t

- Demonstrate with examples how you utilized coursework knowledge towards a research or internship project
  - Sell yourself with concrete stories of independent problem solving

- Networking
  - Alumni network
  - Professional networking (e.g. Linkedin)
Values

- Ensure you choose a career path that aligns with your values
  (What are you good at? What drives you? What you know you know, what you know you don’t know? Avoid being in don’t know what you don’t know territory.)

- Industry does demand immense flexibility
  (rapidly changing program schedules, rapidly changing budget allocations, re-organization, travel, mobility, layoffs)

- Do not become “excellent sheep”
  - (Essay by William Desresiewicz in American Scholar)
  - Hoop jumping - you could close doors for yourself
Phys21:
Preparing Physics Students for 21st-Century Careers

A report by the Joint Task Force on Undergraduate Physics Programs
Paula Heron and Laurie McNeil, Co-chairs
Other Lessons

- Be a giver
- EQ often moves you ahead more than IQ
- Patience wins
- Know that you will always have biases
- Motivation beats intellect
- There are teachers out there who might not have your ideal skill set
Process of Getting Hired at Google [X]
Hiring Process

- Calibrate to the responsibilities, minimum qualifications, and preferred qualifications. Tailor your resume/CV and apply

- Interviews:
  - Phone interview with hiring manager or team member
  - Onsite interview with 4-5 team members with lunch
  - Hiring Committee review
  - Offer review

- solveforx.com/join, google.com/careers, stanleygo@x.team
Thank you

Questions?
How can you integrate a missing skill/competency?

Take a few minutes and write down some ideas on how to integrate a missing skill/competency into the curriculum.
PULSE Products and Services

● Six Regional Networks

● Ambassador’s Program that provides facilitators for department retreats/workshops

● Rubrics to measure progress and recognize accomplishments

● Online tools and resources

www.pulsecommunity.org
Questions & Discussion

Vision and Change:  [http://visionandchange.org](http://visionandchange.org)

Thank you!

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