Introducing a Framework for Physics Innovation and Entrepreneurship (PIE) Education

Bahram Roughani
Professor of Physics & Associate Dean of Natural and Applied Sciences
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Outline:

- Background
- Paradigm Shift
- Managing Change
- Physics Innovation & Entrepreneurship (PIE)
  - Framework
  - Implementation
  - Agile Change Principles
- Questions / Reflections / Discussions
Background

Physics

How Should We Interpret These Data?
What is the frame of reference /context?

Higher Education

Source: AMERICAN EXCEPTIONALISM, AMERICAN DECLINE?
The Task Force on American Innovation Research, The Knowledge Economy, and the 21st Century Challenge
Higher Education: Physics Trends
The Good News – The Bad News

How Should We Interpret These Data?
What is the frame of reference /context?

Ratio of Physics to STEM graduates
47 years (1966 to 2013) trend

Created using APS/Source: IPEDS Completion Survey
To address the challenges of growing undergraduate Physics programs we need to manage change &

This may mean changing what we have done so far.

“If we want something we’ve never had, then we’ve got to do something we’ve never done”
Undergraduate Physics Curricular Emphasis?

Thriving Undergraduate Physics Programs

What should / could be the 3rd path / key area of focus for Undergraduate Physics Education?
The Optics of Physics Data:

* Strengths?
* Insights?
* Improvement?

Figure 3

Initial Employment Sectors of Physics Bachelor’s, Classes of 2011 & 2012 Combined.

- Private Sector: 61%
- High School: 8%
- College & University: 13%
- Civilian Gov’t, National Lab: 5%
- Active Military: 6%
- Other: 7%

61% of employed physics bachelor’s degree recipients from the combined classes of 2011 and 2012 worked in the private sector.

Data does not include degree recipients from the three military academies (US Naval Academy, US Military Academy, US Air Force Academy).

** Data include two- and four-year colleges, universities, and university affiliated research institutes.

http://www.aip.org/statistics
The Optics of Physics Data:

* Strengths?
* Insights?
* Improvement?

Doubling Initiative:
“An essential area of increase is in the number of highly-qualified high school physics teachers”

Any initiative(s)? To address the needs of 61% of physics bachelors working in the private sector?
Physics Curriculum & Career Skills

Is physics curriculum designed to enhance the career confidence of physics majors?

Figure 5

Knowledge and Skills Regularly Used by Physics Bachelor's Employed in the Private Sector, Classes of 2011 & 2012 Combined.

- Solve Technical Problems
- Work on a Team
- Technical Writing
- Design & Development
- Use Specialized Equip.
- Perform Quality Control
- Manage Projects
- Knowledge of Phys. or Ast.
- Programming
- Work with Customers
- Advanced Math
- Simulation or Modeling
- Manage People
- Manage Budgets

Employment in Engineering

Employment in Computer Science or Information Technology

Percent Regularly Using Knowledge or Skill

Nearly all of the respondents employed in Engineering or Computer Science fields regularly worked on teams and solved technical problems.

Percentages represent the physics bachelor's who chose "daily," "weekly," or "monthly" on a four-point scale that also included "never or rarely."

http://www.aip.org/statistics
Undergraduate Physics Education & “Paradigm Shift”
Paradigm Shift?

Industrial Innovations
R&D Lab-Based Creation

Open Innovation
Collaborative Creation
Paradigm Shift?

Funding Sources

Federal Founded Projects

Crowd Founded Innovation

20 Century

21 Century

NSF
NATIONAL INSTITUTES OF HEALTH
DARPA
DREAMIT
Y
techstars
Paradigm Shift?

Space Industry

20 Century

NASA

SpaceX

21 Century
Paradigm Shift?

Auto Industry

Big 3

Tesla
Paradigm Shift?

Energy Industry

20 Century

Fossil Fuel

21 Century

Renewable Energy
Paradigm Shift?

Physics Education

To address the Growth Challenges for Undergraduate Physics and To Prepare Students For The Paradigm Shift

We have committed to the “Pathways to Innovation” As A Framework For Managing Change.
Why Do We Need A Framework To Manage Change?
&
What Are The Main Elements in Managing Change?
&
What Will Happen If We Miss one of the Elements?
  Frustration?
  Confusion?
  Resistance?
  Anxiety?
  False Starts?
A Perspective on Managing Change

Vision + Skills + Incentives + Resources + Action plan = Change

Vision + Skills + Incentives + Resources + Action plan = Confusion

Vision + Skills + Incentives + Resources + Action plan = Anxiety

Vision + Skills + Incentives + Resources + Action plan = Resistance

Vision + Skills + Incentives + Resources + Action plan = Frustration

Vision + Skills + Incentives + Resources + Action plan = False Starts

Adopted after: A framework for thinking about systems change,
A Perspective on Managing Change

Adopted after: A framework for thinking about systems change,
Introducing a Framework for Physics Innovation and Entrepreneurship (PIE) Education

Pathways to Innovation (P2I) Collaborative Initiative At Loyola University Maryland

Loyola University Maryland joined as a 2nd cohort school in 2015

1st Cohort: 12 schools (2014)
2nd Cohort: 25 schools (2015)
3rd Cohort: 14 Schools (2016)
The First Step of P2I to set up a Baseline for Measuring Progress - Landscape Analysis:

- Vision & Goals (First Draft)
- Definitions & Dashboard
- Course Inventory
- Programs Inventory
- Extra-Curricular Inventory
- Spaces
- Catalysts
  - Leadership And Institutional Governance
  - Academic Culture & Careers:
  - Student-led And Grassroots I&E Activity
  - Connections With Regional, National Or International I&E Activity Outside The University
- Champions
Physics Innovation And Entrepreneurship (PIE) Strategy Should Answer The Following Questions:

- Where are we now? (Landscape)
- Where are we going? (Goals)
- How are we going to get there? (Action Plan)

Methodology: Agile Change Process: “Strategic Doing”
“Strategic Doing” as an Agile Change Process:

1. What COULD we do?
2. What SHOULD we do?
3. What WILL we do?
4. What is our 30/30

“Strategic Doing” as an Agile Change Process: Described in Physics Terms

The Divergent (Idea Generation) & Convergent (Idea Selection) Phases

What Could We Do?

What Should We Do? (Convergence Phase)

What Will We Do? (Focus Phase)

Next project

Project “A”
“Strategic Doing” as an Agile Change Process:

Steps Involved:
- Identify Idea / Opportunities
- Narrow down option
  - Individual Ranking
  - Team Ranking
- Select action Item that are:
  - High Impact
  - Easy to implement

Question to Ask: What is the one Pathway Project that gets us to our desired outcome (fastest) and has measurable outcome(s).
We Asked: What is the one Pathway Project that gets us to our desired outcome (fastest) and has measurable outcome(s).

Answer: Start a new course “Technical Innovation & Entrepreneurship” (Cross-Listed as: CS-491 / EG-491 / PH-491)

More on this later…

But for achieving Change we need to have:

- Vision
- Skills
- Incentives
- Resources
- Action plan

So we developed (redefined) a shared Vision as a team…
Imagine if...
Loyola University Maryland will be nationally recognized as an institution that provides innovation and entrepreneurial learning for all its undergraduate students based on a foundation of liberal arts education and the commitment to social justice.

“Strategic Doing” exercise (February 2015 workshop in Arizona) – Revised Statement (Fall 2015)

Goal:
To transform the experience of our undergraduates through curricular, co-curricular and extra-curricular learning opportunities that cultivates an innovative and entrepreneurial mindset.
Pathways to Innovation Change Process

Pathways to Innovation Program

- Develop a community of practice
- Understand the value of I&E education
- Commit to institutional change
- Implement I&E & create change

Faculty expands I&E content, extra-curricular activities & institutional infrastructure

Pathways teams become more motivated to adopt new I&E practices

Developing an I&E mindset becomes integral part of the undergraduate education
Broader Perspective On Change: What Should Integration of I&E Look Like?

**Strategy**
- University-led I&E Activities
  - Formal Courses
  - Programs
  - Spaces
- Leadership & Institutional Governance
  - Stated Mission
  - Presidential Initiatives
  - Strategic Plan
- Academic Culture
  - T/P policies
  - Faculty development
  - Faculty recognition
- Student-led & grassroots I&E activities
  - Student clubs
  - Pitch competitions
  - Student leaders
- Regional & National I&E Activities
  - Support the OPEN conference and similar mtgs.
  - Building connection with other Universities in Baltimore

**Examples & Ideas**
- CS/EG/PH 491 Makerspace / Ideation labs
- I&E Certificate or Minor
- Digital Badges (mini-courses)
- President’s letter
- Leadership ppt.
- IP policies
- Strategic Plan?
- All Deans
- Annual updates / T&P / faculty time / Endowed chair / Summer workshop
- I&E Immersion
- Community (faculty, students)
- Pitch competition
- Pecha-Kucha
- U. I. Fellows
- App competition
- Hack-a-thons
- V-LINC (devices for people with disabilities)

Suggested reading: Graham, R. *Creating university-based entrepreneurial ecosystems evidence from emerging world leaders.* (Massachusetts Institute of Technology, 2014).
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Regional & National Innovation & E-ship Activity
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- (faculty, students)

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The First Project: Technical Innovation and Entrepreneurship Course

- User Innovation
- Design Thinking & Human Centered Design
- Technical Feasibility Analysis
- Ideas / Concepts Development / Opportunities
- Business Model Canvas
- Innovation and Innovation Strategies
- Innovation Startups
- Local Tech Startups
- IP / Patents
- Course Portfolio / Individual and Team
- Course Team Projects / Team Reports / Team Presentations
- Etc.
PIE: Empowering Deep Learning by Connecting Cs:
- Curiosity
- Creativity
- Critical thinking (problem solving)
- Communication (with diverse audience)
- Collaborations (teams / groups)
- Connections (ideas / people / disciplines)

<table>
<thead>
<tr>
<th>Emphasis</th>
<th>Delivery</th>
<th>Type Of Learners</th>
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</thead>
<tbody>
<tr>
<td>Facts / Information / Concepts</td>
<td>Books / Instruction / lectures</td>
<td>Surface Learner</td>
</tr>
<tr>
<td>Procedures / Operations</td>
<td>Exercise / Examples</td>
<td>Procedural Learner</td>
</tr>
<tr>
<td>Problem Solving Tools / Strategies</td>
<td>Solving Problems (Beyond Examples)</td>
<td>Procedural Learner</td>
</tr>
<tr>
<td>Authentic Cases / Application</td>
<td>Real-world Cases, Case Studies</td>
<td>Deep /Adaptive Learner</td>
</tr>
</tbody>
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Suggested Reading for types of learners: “What the Best College Teachers Do” by Ken Bain
Feasibility Analysis Activities Provides:

- Real world physics example
- Context for physics (human & social)
- Open ended and meaningful problem(s) to solve
- Opportunity to think of multiple approaches & solutions
- Combining creativity & scientific problem solving
- Learning opportunity for dealing with ambiguity
- Creating greater purpose in learning physics
- …
PIE Authentic Learning Example:
CS 491/ EG 491 / PH 491 Course

- Classroom Activities:
  - Starting with physics principles / concepts
  - Each group of students decide on:
    - Questions to ask / Assumptions / Analysis / Calculation / Conclusion
  - Class discussions based on group work
  - Technical Feasibility / Calculations (e.g., work-energy)
  - Open ended problem / multiple options / solution
  - Authentic learning opportunity!

- Does this support enhancing innovative and entrepreneurial mindset in our students?
Case Activities

- Workshop Approach: Team Work & Effective Feedback
- Varies Conditions: Open Ended Problem
- Starting Assumptions: Multiple Solutions
- Technical Assumption: Problem Solving Strategies
- Human / Social Factor: Context & Purpose
- Open Ended Problem: Scientific Thinking
- Multiple Possibilities: Creativity / Dealing With Ambiguity
- Human / Social Factors: Desirability & Viability
- Overall Approach: Design Thinking (Matches NGSS)
PIE Authentic Learning Example:
Teaching Physics Through Design Thinking Model

**Kickstart Irrigation**
Physics analysis through Design Thinking Model:
Is this Feasible?
Is this Desirable?
Is this Viable?
Epicenter Opportunities:
University Innovation Fellows (UIF):

https://vimeo.com/92977644
Summary: Implementing Change (PIE) May Require:

| Empower The Change          | Develop a Vision  
|                            | Complete a **Landscape Analysis** first  
|                            | Conduct **Strategic Doing** / Agile Change Management  
| Build a Team               | Form The **Core Team**  
|                            | Add **Collaborators** / Allies (Within & outside the University)  
|                            | Build **cross-disciplinary** relationship (e.g. PIE, OPEN)  
| Plan and Implement         | Select / Implement the **1st project** & **Measure success**  
|                            | Select / implement the **next project**  
|                            | Develop **Collaborative** efforts (Eng., Arts, Business, etc.)  
| Develop Curriculum         | **Develop** a course / Module / Activity  
|                            | **Build** a minor / focus / concentration  
|                            | Engage in a **community of practice** (PIE, OPEN, PER, etc.)  
| Support Co-Curriculum      | **Student** organizations / clubs / etc.  
|                            | University **Innovation Fellow**  
|                            | Pop-up courses / maker spaces / **student competitions**  


Thank You For Your Interest!

QUESTIONS?