SPIN-UP and the Recent Increase in the Number of Undergraduate Physics Majors

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The Big Questions

- Why do some undergraduate physics programs “thrive” while others are less successful?

- How do undergraduate physics programs move from “good” to “great”?
Outline


II. Some examples and a counter-example.

III. What has happened since.

IV. Take home messages.
Why Should We Care?

The skeptic: “People have succeeded in physics with education from many different kinds of departments. Those good enough to do physics will succeed no matter what.”

- We need more people with strong STEM backgrounds. (Scientists, teachers, lawyers, legislators, ...)
- Understanding what makes programs thrive helps improve education across the board.
Recent Physics Bachelor’s Degree Production

Source: AIP Statistical Research Center: Enrollments and Degrees Report, and NCES Digest of Education Statistics
National Task Force on Undergraduate Physics (2000-2006)

**SPIN-UP**

Strategic Programs for Innovations in Undergraduate Physics
National Task Force
on Undergraduate Physics (2000-2006)

J. D. Garcia (U. Arizona)
S. James Gates (U. Maryland)
Robert Hilborn (UT Dallas), Chair
Ruth Howes (Marquette), Co-Chair
Ken Krane (Oregon State)
Liz McCormack (Bryn Mawr)

Laurie McNeil (U. North Carolina-Chapel Hill)
Jose Mestre (Illinois)
Tom O’Kuma (Lee College)
Doug Osheroff (Stanford)
Joe Taylor (Princeton)
Carl Wieman (U. Colorado, U. British-Columbia)

Ex Officio:
AIP- J. Stith, J. Hehn
APS-J. Franz, T. Hodapp
AAPT-B. Khoury, W. Hein
PKAL – J. Narum
**SPIN-UP**

- Site Visits to 21 “thriving” undergraduate physics programs.
- Survey (with AIP) of all 761 bachelor’s degree-granting physics programs in the US (74% response).
- Report and Analysis. 2002-2003

What do we mean by “thriving”?
Site Visit Departments
visits carried out by 65 physics volunteers + Task Force members

- Angelo State University
- University of Arizona
- Bethel College
- Brigham Young University
- Bryn Mawr College
- Colorado School of Mines
- Cal State San Luis Obispo
- Carleton College
- Grove City College
- Harvard University
- University of Illinois
- University of Wisconsin-LaCrosse
- Lawrence University
- North Carolina State Univ.
- North Park University
- Oregon State University
- Reed College
- Rutgers University
- SUNY Geneseo
- University of Virginia
- Whitman College
- Trial Site Visit 2000
- PhysTEC Site Visit 2000
- SPIN-UP Site Visit 2001-02
Essential Findings for Thriving Undergraduate Physics Programs

- The department is the crucial unit for change. The department must “own” the undergraduate program.

- The program is more than courses.

- Change takes time and energy (but not necessarily a lot of money) and is an on-going process.
What Makes an Undergraduate Physics Program Thrive?

*Physics Today, September, 2003*

- Strong and *sustained* departmental *leadership*.

- Well-defined sense of *mission* (correlated with mission of the institution).

- Emphasis on the *entire program* of the department, large fraction of the faculty engaged.
Details

- Recruit and retain students
  - Challenging and supportive program
  - Career information - alumni
  - Introductory courses
  - Prof. development and mentoring
  - Multiple-tracks/options
  - Research experiences – early and often
What makes an undergraduate program thrive?

- A widespread attitude among the faculty that the department has the primary responsibility for improving the program – not a bunch of whiners

- A challenging but supportive program with many opportunities for student-faculty interactions

- Continuous evaluation and experimentation

- Strong and sustained leadership (worth mentioning again)
What is not on the list?

- Major interdisciplinary efforts (except through multiple-tracks)
- Radically different curricula
- Watered-down curricula
- Extraordinary use of IT – almost everybody uses some – no big deal
- Lavish new buildings and equipment
An Apparent Counter-Example

- What went wrong?
The SPIN-UP Report and Departmental Guidelines

Report: http://www.aapt.org/Projects/ntfup.cfm

AAPT Guidelines for Self-Study and External Evaluation of Undergraduate Physics Programs
Consulting Site Visits

- Available upon request
- Department pays travel and local expenses
- Contact Bob Hilborn
  rhilborn@utdallas.edu
What has happened since the SPIN-UP study?

- Data from departments that have had large increases in the number of undergraduate physics majors since 2000.
  - Average 1997-1999
  - Average 2003-2005
  - N > 15 in 2005
## Top Increases

1997-99 -> 2003-05

Research Universities (N>15 for 2005)

<table>
<thead>
<tr>
<th>University</th>
<th>2005</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA-U of, Davis</td>
<td>33</td>
<td>big</td>
</tr>
<tr>
<td>Michigan State U</td>
<td>26</td>
<td>164%</td>
</tr>
<tr>
<td>CA-U of, Santa Barbara</td>
<td>34</td>
<td>163%</td>
</tr>
<tr>
<td>CA-U of, Riverside</td>
<td>15</td>
<td>153%</td>
</tr>
<tr>
<td>Cornell U (Appl Sci)</td>
<td>37</td>
<td>151%</td>
</tr>
<tr>
<td>AR-U of, Fayetteville</td>
<td>19</td>
<td>148%</td>
</tr>
<tr>
<td>New York U (NYU)</td>
<td>15</td>
<td>142%</td>
</tr>
<tr>
<td>South Florida-U of</td>
<td>16</td>
<td>131%</td>
</tr>
<tr>
<td>NM Inst of Mining &amp; Tech</td>
<td>17</td>
<td>130%</td>
</tr>
<tr>
<td>Georgetown U</td>
<td>25</td>
<td>121%</td>
</tr>
<tr>
<td>CA-U of, Santa Cruz</td>
<td>25</td>
<td>119%</td>
</tr>
<tr>
<td>Maryland-U of, Coll Park</td>
<td>31</td>
<td>118%</td>
</tr>
<tr>
<td>MA-U of, Amherst</td>
<td>30</td>
<td>107%</td>
</tr>
<tr>
<td>Arizona-U of</td>
<td>39</td>
<td>100%</td>
</tr>
<tr>
<td>Minnesota-U of, Minnpls</td>
<td>27</td>
<td>95%</td>
</tr>
<tr>
<td>Florida-U of</td>
<td>17</td>
<td>92%</td>
</tr>
<tr>
<td>Brown U</td>
<td>19</td>
<td>92%</td>
</tr>
<tr>
<td><strong>Washington-U of</strong></td>
<td><strong>78</strong></td>
<td><strong>81%</strong></td>
</tr>
<tr>
<td>IL-U of, Urbana/Champaign</td>
<td>48</td>
<td>75%</td>
</tr>
</tbody>
</table>
Primarily Undergraduate Institutions (N > 15 for 2005)

<table>
<thead>
<tr>
<th>Institution</th>
<th>BS05</th>
<th>Chge</th>
</tr>
</thead>
<tbody>
<tr>
<td>James Madison U</td>
<td>17</td>
<td>371%</td>
</tr>
<tr>
<td>Cal Poly St U-San L.O.</td>
<td>30</td>
<td>243%</td>
</tr>
<tr>
<td>Williams Coll</td>
<td>19</td>
<td>104%</td>
</tr>
<tr>
<td>WI-U of, River Falls</td>
<td>15</td>
<td>94%</td>
</tr>
<tr>
<td>Dickinson Coll</td>
<td>16</td>
<td>90%</td>
</tr>
<tr>
<td>Charleston-Coll of</td>
<td>16</td>
<td>87%</td>
</tr>
<tr>
<td>Gustavus Adolphus Coll</td>
<td>16</td>
<td>74%</td>
</tr>
<tr>
<td>Harvey Mudd Coll</td>
<td>21</td>
<td>37%</td>
</tr>
<tr>
<td>Bethel Coll (MN)</td>
<td>15</td>
<td>34%</td>
</tr>
</tbody>
</table>
Why Isn’t Every Program Thriving?

- Melba Phillips: “The problem with physics education problems is that they don’t stay solved.”
- Albert Einstein: “We can’t use the same kind of thinking to solve problems as we did when we created them.”
- John Russell: “All reform is ultimately local.”
Sustaining Enhancements

Planning
Thinking

Dissemination
and
Feedback

Experimentation

Individuals, departments, institutions, disciplines...
Theory

- Lev Vygotsky
  - Cultural mediation
  - Situated learning
- Jerome Bruner – Narrative Construction of Reality
Hitting the target

- Institution-wide programs are often too “dilute.”
- Individual investigator efforts are hard to sustain and to spread.
- Curriculum-only projects do not build the political infrastructure.

➤ The department is the political unit that can make things work.
  - Cf. NSF efforts in the 1960s
Other Connections

- Sheila Tobias, “Revitalizing Undergraduate Science: Why Some Things Work and Most Don't” (1992)
- Jim Collins, From Good to Great (HarperCollins, New York, 2001)
Take Home Messages

- SPIN-UP provides 21 “existence proofs” that real STEM departments can build thriving programs. Many more since then.
- There are several models of successful programs. (Build on local strengths.) One size does not fit all.
- Meaningful change requires that you understand your entire undergraduate program and your students and keep working.