What Works for Thriving Undergraduate Physics Programs

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American Association of Physics Teachers

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Support from
American Association of Physics Teachers
American Physical Society
American Institute of Physics
The ExxonMobil Foundation
Outline

I. Some Motivation and History

II. Why do some physics programs thrive and others don’t – lessons from SPIN-UP 2002-3.

III. What has happened since.

IV. Take home messages.
Why focus on undergraduate STEM education?

- Fewer than 30% of undergraduates who start in STEM programs graduate.
- Only 20% of students from under-represented groups who start STEM programs graduate.  
  \textit{(Science, 14 January 2011, p. 125)}
- Future K-12 teachers – where do they learn science?
  - Business Higher Education Council
  - Association of American Universities
  - President’s Council of Advisors on Science and Technology
National Task Force on Undergraduate Physics (2000-2006)

SPIN-UP

Strategic Programs for Innovations in Undergraduate Physics

American Association of Physics Teachers,
American Physical Society
American Institute of Physics
The ExxonMobil Foundation
National Task Force
on Undergraduate Physics (2000-2006)

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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”? 

- Number of majors and graduates well above national averages
- Sense of community among majors
- Well-regarded by other science departments
- Strong program for non-science majors
- Department supports overall mission of the university
- Well-regarded by upper administration
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
Essential Findings for Thriving Undergraduate Physics Programs

- The department is the crucial unit for change. The department must “own” the undergraduate program. “No Excuses!”

- The program is more than courses.

- Change takes time and energy (but not necessarily a lot of money).
Essential Findings: What makes an undergraduate Physics program thrive?

- Strong and **sustained** departmental **leadership**.
- Well-defined **sense of mission** (correlated with mission of the institution).
- **Large fraction** of the faculty engaged.
Essential Findings

- A challenging but supportive program
- Many opportunities for student-faculty interactions
- Continuous evaluation and refinement
Recruit and retain students

- Understand how students find out about your program
- Introductory courses
- Build "physics identity"
- Multiple-tracks/options
- Research and outreach experiences — early and often
- Career information - alumni
- Professional development and mentoring
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
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>Washington-U of</td>
<td>78</td>
<td>81%</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>
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NSF-funded SPIN-UP Regional Workshops: R1s June, 2010

- Harvard, MIT, Stanford, Illinois, Princeton, Michigan State.....(17 total)
- All have efforts focused on improving their undergraduate programs
- Almost all are following the “SPIN-UP Model”
- Almost all have evidence of improvements in numbers, student enthusiasm and engagement
Other Workshops

- HBCU SPIN-UP May 2011
  - Council of HBCU Physics Dept. Chairs
- Building a Thriving Undergraduate Physics Program, American Center for Physics, June 10-12, 2012
More information:

- Google “SPIN-UP Report” (#1 out of 47,800,000 hits) - included are reports about applying these principles to other disciplines
- AAPT Guidelines for Self-Study and External Evaluation of Undergraduate Physics Programs
- President’s Council of Advisors on Science and Technology – Feb. 2012: *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*
SPIN-UP TYC

- Funded by NSF to understand physics programs at TYCs
  or Google “SPIN-UP TYC”
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.