To Be or Not to Be: Major Choices in Budding Scientists

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State of the STEM Pipeline

- Perennial interest in state of U.S. Education particularly in STEM fields
- Recent concern that STEM Pipeline is weak
  - Hart-Rudman (2001): “... a greater threat to U.S. national security over the next quarter century than any potential conventional war...”
  - National Academy of Science (2007): “... the scientific and technological building blocks critical to our economic leadership are eroding...”
Concern Up and Down the Pipeline

- Perception that NAEP Scores in Math & Science are flat or growing slowly
- US Rank on International Tests
  - 2003 TIMSS
    - 4th Grade Math => 12th of 24; 6th of 10 OECD
    - 8th Grade Math => 19th of 44; 10th of 12 OECD
    - Better ranks in science although still lagging
- High School Students Lack STEM Coursework (ACT 2006)
Concern Up and Down the Pipeline (cont.)

- Percentage of College Freshmen w/ Intent to Major in S&E is Stagnant
- Number of Majors Increased Slightly
- Number of US Residents Pursuing STEM Doctoral Degrees Lags 1970 Levels
Freshmen with Intention to Major in Science & Engineering

Year

Percent
10.0 15.0 20.0 25.0 30.0 35.0 40.0

Whites
Blacks
White Females
Black Females
Growth of Total Doctorates Relative to 1970
US Citizens and Permanent Residents

Year

Percent Change from Baseline
-100 -50 0

Data from NSF Survey of Earned Doctorates
Major Choices

- **Integral Part of STEM Pipeline**
  - Major Pre-req for STEM
  - If major is not STEM, less than 1-2 percent chance of graduate study in engineering or biological sciences. 3-5 percent chance in math or physical sciences.

- **Limited Information on Major Choice**
  - Admissions Exams Provide Intent
  - Beginning Post-Secondary Survey

- **Key Career Decision**
Data

- Ohio Public Colleges
- 1998-99 Cohort of Incoming Students
- Focus Solely on Students Taking ACT Exam
  - Provides Pre-College Major Intent
  - Allows us to Identify High Ability Students
<table>
<thead>
<tr>
<th>Intended Major</th>
<th>All Students</th>
<th>Students w/ Overall ACT&gt;24</th>
<th>Students w/ Science ACT&gt;24</th>
<th>Students w/ Math ACT&gt;24</th>
<th>Students at 2yr Campus</th>
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<td>Students w/ Overall ACT&gt;24</td>
<td>Students w/ Science ACT&gt;24</td>
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<td>18.4 (0.5)</td>
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<td>19.0 (3.9)</td>
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## Major Defections

<table>
<thead>
<tr>
<th>Sample</th>
<th>Pre-College STEM Major</th>
<th>Non-STEM Major “Defectors”</th>
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<td>STEM Major</td>
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<td>ACT &gt;24</td>
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<td>2yr Students</td>
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### The Converted

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<tr>
<th>Sample</th>
<th>Pre-College Non-STEM Major</th>
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<tr>
<td></td>
<td>STEM Major “Converts”</td>
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<tr>
<td>All Students</td>
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<tr>
<td>ACT&gt;24</td>
<td>7.7</td>
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<tr>
<td>ACT Science &gt;24</td>
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<td>ACT Math &gt;24</td>
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<td>HS Math GPA &gt;=3.5</td>
<td>7.0</td>
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<td>2yr Students</td>
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## Where Do They Go?

<table>
<thead>
<tr>
<th>Major</th>
<th>All Students</th>
<th>ACT&gt;24</th>
<th>ACT Science &gt;24</th>
<th>ACT Math &gt;24</th>
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<td>Social Science</td>
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<tr>
<td>Social Work</td>
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<td>0.6</td>
<td>0.3</td>
<td>3.5</td>
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</table>
Likely Explanations for the Dearth of STEM Degree Holders

1. Few are prepared, at the end of secondary school, to enter STEM fields.
2. Few express initial interest in entering STEM fields.
3. Once a student is off the STEM “wagon”, he cannot get on it.
4. The culture of STEM fields is off-putting once higher education is reached.
5. The returns are insufficiently high to justify greater adherence to STEM fields.

From Hoxby (2008)
Percent of Students Scoring at Top Level
PISA math test for 15-year-olds

From Hoxby (2008)
Number of STEM bachelor's degree recipients per 100 persons of relevant age in the population

From Hoxby (2008)
Rigidity of Major

- STEM Majors Usually Have Rigid Structures
  - Extensive Hour Requirements
  - Sequential Course

- Supporting Evidence:
  - Defections start in 1st Semester
When Do They Leave?
4-yr Campuses
First Semester Schedules

Percentage of Schedule in STEM

STEM Pre-Coll Major Stayers
STEM Pre-Coll Major Defectors
When Do They Leave?

4-yr Campuses
First Semester Schedules (ACT>24)
When Do They Leave?

2-yr Campuses

Percentage of Schedule in STEM

- STEM Pre-Coll Major
- Non-STEM Pre-Coll Major
When Do They Leave?
2-yr Campuses

![Graph showing the percentage of schedule in STEM for STEM Pre-Coll Major Stayers and STEM Pre-Coll Major Defectors.](image-url)
When Do They Leave?

2-yr Campuses – ACT>24

![Graph showing the percentage of schedule in STEM between STEM Pre-Coll Major Stayers and STEM Pre-Coll Major Defectors.](image)
Defectors vs. Converts

First Semester Schedules

Percentage of Schedule in STEM

STEM Major who was Pre-Non-STEM
Non-STEM Major who was Pre-STEM
Rigidity of Major

- STEM Majors Usually Have Rigid Structures
  - Extensive Hour Requirements
  - Sequential Course

- Supporting Evidence:
  - Defections start in 1st Semester

- Dissenting Evidence:
  - Similar Students “Convert” to STEM Fields
  - Destinations Are Often Hours Intensive
  - Among Top Students, Defectors are Just as Less Likely to Pass
Is the culture of STEM fields off-putting once higher education is reached?

- Since students take STEM classes in high school and still express interest in the fields, cultural problems would need to start in college to produce defection.
- The fact that students who show early immersion in STEM classes are more likely to persist could be indicative.
- Women and Minorities?

Adapted From Hoxby (2008)
Women and Minorities

- Largest growth in STEM Majors are among Women, Blacks and Hispanics
- Women are more likely to defect from STEM
  - Even among the top students
- Blacks are less likely to defect from STEM
  - Especially true among top students
Is the culture of STEM fields off-putting once higher education is reached?

- Since students take STEM classes in high school and still express interest in the fields, cultural problems would need to start in college to produce defection.
- The fact that students who show early immersion in STEM classes are more likely to persist could be indicative.
- Women do defect disproportionately: women with high science or math ACT scores are 9 to 14% more likely to leave STEM majors than men.

Adapted From Hoxby (2008)
Earnings in Majors

- **Major Destinations**
  - 4-yr Campuses
    - 50 Percent Move to Business
    - About 20 Percent Move to Education, Social Work, or Humanities
  - 2-yr Campuses
    - 30 Percent to Business
    - 30 Percent to Education, Social Work, or Humanities

- **Movements toward Business and Social Sciences**
  - Women’s earnings in business and economics earn as much or more than any STEM fields.
  - Men’s earnings are similar across STEM, business, and social sciences.
  - Wages growth in these fields greater than STEM fields

- **STEM Earnings would fall if greater supply of STEM workers.**
Earnings Premium (in Percent) of Majors Relative to Education Major

- Education
- Humanities
- Architecture/Art
- Nursing, Social Work
- Natural Sciences
- Social Science
- Communications
- Engineering
- Plan II (honors course)
- Business, soft
- Business, hard

Premium in Percent

0 10 20 30 40 50 60
Changing Values

- 74% say that an important part of college is to be “well off financially”
- Increased focus on vocational offerings (Adelman 1995)
- Especially True in 2-year Campuses
Additional Defections

- 50 percent of engineering majors aim to pursue MBA or law
- Similar defection rates in other STEM fields but more movement toward medicine
- 30-40 percent retention in graduate study plans among engineering, physical and computer science and math
How do we *know* that the number of STEM degree holders is deficient?

- There is no magic number that we need.
- As a rule, we look to earnings as guidance:
  - High average earnings indicate generalized excess demand.
  - Superstar earnings indicate a demand for a big pool to produce a small number of superstars.
  - Computer science, the one field with obvious earnings growth & superstar earnings, has experienced tremendous growth in majors/degrees.

From Hoxby (2008)
Hypotheses that Can Reconcile the Lack of Economic Symptoms with our Sense that STEM Degrees are Insufficient

The supply of foreign people with STEM degrees keeps earnings at a modest level.

- Earnings in certain STEM fields (math, theoretical physics, etc.) are not set by the private market.

- We do not really need numerous STEM majors: we need a small number of people with extraordinary STEM ability.
  - In this case, we should be looking for symptoms that people who should not fall off the wagon do.

From Hoxby (2008)
Implications and Conclusions

- Half of well prepared, top students defect from STEM majors
  - Women are more likely to leave
  - Defections start in 1st semester (rigidity?)
  - Defections are higher in 2yr Campuses
- More Lucrative Majors
  - Students go to business and social science
  - Echoes previous findings on markets with cobwebs