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Student Retention in STEM: Exploration of the Gender Gap

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Abstract for DBER Group Discussion on 2014-01-23

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Title:
Student Retention in STEM: Exploration of the Gender Gap

Abstract:
Prior research indicates that there are small numbers of women in STEM areas and in physics in particular; the latter may suggest that women who have potential to contribute to physics choose other careers. This presentation examines the gender gap in STEM with a focus on physics. We discuss a survey administered to undergraduate science students at one primarily undergraduate college in the United States, the factors that impacted student decisions in physics, and recommendations to increase student retention.
Gender Gap in STEM

Olha Ketsman, Ph.D. University of Nebraska-Lincoln
&
Carolina C. Ilie, Ph.D. State University of New York at Oswego
“The demographic changes to occur in the U.S. over the next half century make it vital that we increase the participation of women and under-represented minorities in physics, as well as all other scientific and technological fields.”

(Artie Bienenstock, Ph.D. APS President & Special Assistant to the President for Federal Research Policy at Stanford University, 2010, February 13)
U.S. Global Competitiveness in STEM

- **China** graduates almost 4 times as many STEM students as U.S.

- **South Korea** graduates as many STEM as U.S. although it has 1/6 the population and 1/20 the GDP.

- **European Union** poised to graduate 4 times as many PhD’s as U.S.

- **India** is pouring money into technology parks to lure back native talent.

- From 1980 to 2001, U.S. share of high-tech exports fell from 31% to 18% (nearly half over 20 years)
What is the value of having more native STEM employees?

- We need STEM students to maintain educational capacity
- Portion of students from abroad is declining
- Higher Ed in Australia, New Zealand, England are growing
- China and India have educational infrastructure now
- We need STEM students because the greatest growth in the future workforce is in STEM fields
- STEM - “big engine” for our economy and GDP
- We won’t compete in a global economy without building workforce
The Trend

- Small number of women in physics and STEM in general – at all levels.

- The trend starts from high school and even elementary school with the math education and the gender oriented job expectations.

- The percentage of women in physics decreases markedly with each step up the educational level and academic rank.
“Giving girls the background in physics greatly enhances their career opportunities across the board. All students should study physics in K-12 and should have multiple exposures.”

Millie Dresselhaus, MIT, Professor of Physics and Electrical Engineering
Even though the number of women in physics has increased over the past years, percentage is still very small and is less than 20%.

Less than one out of four Physics undergraduate and graduate degrees is earned by a woman.
From STEM fields, engineering and physics have the smaller number of female PhD graduates.
Gender Polarization in Academia

“Training search committees to recognize unintended biases and stereotypes is crucial”

Alice Agogino, Professor of Engineering at UC Berkeley

The number of women in physics decreases dramatically with the rank: the number of women full professor is less than 10%.
## Statistics: Jobs in Academia

<table>
<thead>
<tr>
<th>University</th>
<th>Total Number of Faculty</th>
<th>Number of Women Faculty</th>
<th>Percentage (%) of Women Faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUNY Universities and Colleges</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stony Brook</td>
<td>50</td>
<td>6</td>
<td>12.00</td>
</tr>
<tr>
<td>Albany</td>
<td>14</td>
<td>1</td>
<td>7.14</td>
</tr>
<tr>
<td>Binghamton</td>
<td>17</td>
<td>3</td>
<td>17.65</td>
</tr>
<tr>
<td>Buffalo</td>
<td>35</td>
<td>3</td>
<td>8.57</td>
</tr>
<tr>
<td>Brockport</td>
<td>4</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Buffalo State</td>
<td>12</td>
<td>3</td>
<td>25.00</td>
</tr>
<tr>
<td>Cortland</td>
<td>6</td>
<td>2</td>
<td>33.33</td>
</tr>
<tr>
<td>Fredonia</td>
<td>9</td>
<td>2</td>
<td>22.22</td>
</tr>
<tr>
<td>Geneseo</td>
<td>8</td>
<td>1</td>
<td>12.50</td>
</tr>
<tr>
<td>New Paltz</td>
<td>4</td>
<td>2</td>
<td>50.00</td>
</tr>
<tr>
<td>Oneonta</td>
<td>8</td>
<td>1</td>
<td>12.50</td>
</tr>
<tr>
<td>Oswego</td>
<td>6</td>
<td>2</td>
<td>33.33</td>
</tr>
<tr>
<td>Plattsburgh</td>
<td>6</td>
<td>1</td>
<td>16.67</td>
</tr>
<tr>
<td>Potsdam</td>
<td>7</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td><strong>17.92</strong></td>
</tr>
</tbody>
</table>

| University of Nebraska System |                         |                         |                                |
|-------------------------------|-------------------------|-------------------------|                                |
| Lincoln (UNL)                 | 40                      | 2                       | 5.00                           |
| Omaha (UNO)                   | 13                      | 1                       | 7.69                           |
| Kearney (UNK)                 | 6                       | 2                       | 33.33                          |
| **Average**                   |                         |                         | **15.34**                      |

* Data from 2011-2012 academic year.
The “scissors” plot shows the percentage of women at each stage. A huge “leak” between high school and PhD is noticed. The net drop from high school to college is worse for physics as compared to other sciences.

Increase supply of women the pipeline and the scissors will slowly close up.
The problem with underrepresentation of women in STEM creates a situation where many intelligent and talented women, who have potential to significantly contribute to science choose other careers.

- STEM communities and organizations loose opportunities to be improved by greater diversity and perspectives
Purpose & Research Questions

**Purpose**
To determine factors that influence student decisions to study physics at one primarily undergraduate college in the northeastern part of the United States.

**Research Questions**

1) What are student experiences studying physics?
2) What factors have impact on student decisions to study physics?
3) How does student previous experience with physics relate to their future career choices?
• Data was collected from STEM majors (N=46) using survey instrument.
• Survey instrument included 25 open, close and partially close ended questions.
• Descriptive Statistics was used to calculate measures of central tendency.
• Pearson correlation (r) was calculated to determine relationships between different factors that impact student decisions to study physics.
• Independent-samples t-test was conducted to examine difference in opinions and experiences between groups.
• Instrument was piloted and validity was reassured
Results: Demographics

<table>
<thead>
<tr>
<th></th>
<th>Number (N)</th>
<th>Percentage (%)</th>
<th>Non-physics Majors (%)</th>
<th>Physics Majors (%)</th>
<th>Participant Age (M, SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>35</td>
<td>76</td>
<td>37</td>
<td>39</td>
<td>M=20.30</td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
<td>24</td>
<td>15</td>
<td>9</td>
<td>SD=5.66</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>100</td>
<td>52</td>
<td>48</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Non-physics majors include students of all other science majors that participated in the study*

- 48% of survey takers were physics majors
- 24% of survey takers were female
- The average number of physics classes taken by survey takers was 4.7
Encouragement & Discouragement

• Half of all survey takers were encouraged to study physics.

• 11% were actively discouraged from studying physics by parents, friends and public opinion.
Who encouraged you to pursue physics?

High School

Parent

Parent

Known physicists

Advisor

Themselves

Sibling

Friends

College Prof

Coach
Teacher Effect

- “Experience with teachers and their style influenced my choices”

- “My high school teacher made class fun and he taught well. He exposed me to physics in the best way possible”

- “My physics teacher made it fun and exciting and really showed me how I can use it in my everyday life”
Teacher Effect

- Pearson Correlation revealed that students who perceived high school physics teachers “as competent and knowledgeable” were more influenced in their decisions to study physics $r(38)=.352, p<.05$

- An independent-samples t-test indicated no significant difference in the influence of high school physics teacher on decisions to study physics for male ($M=1.87, SD=1.22$) and female students ($M=2.30, SD=1.42$); $t(38)=-932, p=.357$
Family Encouragement

- None of the surveyed female students indicated receiving any encouragement from the family to study physics.

- 42% of surveyed male students indicated that they were encouraged by their families to study physics.
How did your family encourage you to study physics?

• “Motivated me to do my best in math”

• “My Family did not hold any stereotype about the image of a scientist”

• “Bought science books”

• “Attended physics related demonstrations and visited science museums”

• “Performed science related experiments and encouraged to repair things around the house”
Experience with Physics as a Negative Factor

Previous experiences with physics or lack of such experiences influenced student career decisions.

✓ “Physics is irrelevant and not necessary for our future. I don’t see why we should have to take it”

✓ “I don’t think there are many jobs in the field. I am only taking physics because it is required....”

✓ “Physics is a challenging science...the amount of algebra and calculus is very intensive”
Experience with Physics as a Positive Factor

Previous experience and challenge involved in it served as a motivation for students to pursue physics.

✓ “Physics is challenging but I walk out of the class amazed by what I have just learned”

✓ “I like challenge. I want to know how things work. I want to contribute”
Other Factors

- Low physics grades did not influence student decisions to study physics.

- Significant positive correlation was found between math difficulty and lower grades in physics as well as between lack of knowledge about physics and lower grades in physics.

<table>
<thead>
<tr>
<th></th>
<th>Lower grades in physics</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Difficulty</td>
<td>+.566</td>
<td>41</td>
</tr>
<tr>
<td>Lack of knowledge about physics</td>
<td>+.454</td>
<td>40</td>
</tr>
</tbody>
</table>

*Note: Significant at the p<0.05 level, two-tailed.*
Reasons for a Small Number of Physics Majors

• Too challenging and not popular and appealing

• Lack of understanding about the importance of the field

• Stereotypes in society & “nerdy” image of a scientist
“Physics is a Male Dominated Field”

✓ “I think physical sciences attract the male crowd more than females.”

✓ “There are fewer females studying physics because society has assigned the gender role that science is work for men. It can be hard for a woman to be taken seriously, especially around men.”

✓ “Physics is too hard for females”

✓ “Physics requires a strong emphasis on math which may intimidate female students”

✓ “There seems to be more males than females in physics. Physics departments consist of mostly male faculty.....it is not encouraging for females”
Female Physics Majors

Female physics majors revealed a variety of feelings and constructs ranging from “awkward” to “intimidated at first” to “fine” and “normal”

✓ “It is sometimes awkward. Physics tends to be a “boys club” and when you are the only girl or one or two girls, the guys tend to forget there are girls around and act differently”

✓ “I felt a little self conscious at first and intimidated. Now, it doesn’t really make a difference to me, the number of women in my physics classes”
Physics Majors and Future Leaders

Women in physics and leadership: Common features

**Physics**
1. Discouragement
2. “Nerdy image”
3. Weak math background

**Leadership**
1. Few women in the workplace and others are not benefiting from their ideas
2. Do not see opportunities for advancement
3. Negative perceptions of the work climate
4. Hard to achieve work-family balance
1. Reticent about speaking up
2. Intense pressure to conform to gender expectations
Conclusions

• Women in physics are under represented

• Stereotyping plays a large role in the lack of women in physics.

• Teachers and families were main variables that played a role in student motivation to pursue careers in physics.

• Faculty matter a great deal when looking at the low numbers of women in physics.
Recommendations

• Start with elementary education – prepare teachers with solid math background.

• In the middle and high school have physics taught by teachers with Bachelor Degrees in Physics (*only 25 % of physics teachers have Bachelor Degrees in Physics)

• Teacher subject matter knowledge and pedagogical knowledge as necessary factors for effective teaching.

• Teacher education programs need to have high selection criteria and high standards when accepting and graduating future science teachers.

• Outreach opportunities where both K-12 students and families can learn more about sciences and types of careers scientists have.
Recommendations Cont.

- Hire talented and dedicated faculty who will be good role models
- Make the female professors more visible during “open house” events
- Organize mathematical physics courses or recitations
- Present potential careers for Physics Bachelors
- Get the students involved – form the physics community: conferences, women in physics conference, scientific organizations, clubs
- Keep small class sizes for best student recruitment and retention
- Have a gathering place where physics students can work
- The freshmen female students - junior or seniors female mentor
Limitations and Future Research

- One institution study
- Relatively small number of participants

**Future Research**

- Replicate the study with a larger number of participants
- Collect data from multiple institutions across the country
- Study involving graduate female students who decided to continue with physics.
“If you make all your women students and faculty feel more valued by your speech and actions—including speaking up for family friendly practices—and if you publicly chastise those that make demeaning or snide comments, you will find the rewards are great.”

Judy Franz, condensed matter physicist, and the Executive Officer of the American Physical Society
Acknowledgements

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Questions???