Supporting Teachers to Encourage the Pursuit of Undergraduate Physics for Women

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Women’s Representation in STEM

Bachelor's Degrees Earned by Women

Source: IPEDS and APS
When does this difference emerge?

Percentage Participation by Women at Various Levels

(Hodapp & Hazari, 2015)
When does this difference emerge?

Percentage Participation by Women at Various Levels

(Hodapp & Hazari, 2015)
Compared to Other Sciences

Percentage Participation by Women at Various Levels by Field
What about other countries?

Percentage of Undergraduate Physics Degrees Awarded to Women

<table>
<thead>
<tr>
<th>Country</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>20</td>
</tr>
<tr>
<td>India</td>
<td>30</td>
</tr>
<tr>
<td>Iran</td>
<td>40</td>
</tr>
<tr>
<td>USA</td>
<td>60</td>
</tr>
</tbody>
</table>

(IUPAP International Conference on Women in Physics Proceedings, 2005-2013)
What about other countries?

Percentage of Undergraduate Physics Degrees Awarded to Women

(IUPAP International Conference on Women in Physics Proceedings, 2005-2013)
What are some of the cultural issues?

Percentage of PhDs who are Women

Field-specific ability beliefs
(higher numbers indicate greater emphasis on brilliance)

(Leslie et al., 2015)
Why focus on high school?

<table>
<thead>
<tr>
<th>Middle School</th>
<th>Beginning of High School</th>
<th>Beginning of College</th>
<th>In College (Now)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhysicsMS</td>
<td>PhysicsHS</td>
<td>PhysicsCOL</td>
<td>PhysicsNOW</td>
</tr>
<tr>
<td>MultiWithPhysicsMS</td>
<td>7.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MedHealthMS</td>
<td>MedHealthHS</td>
<td>MedHealthCOL</td>
<td>MedHealthNOW</td>
</tr>
<tr>
<td>OtherSTEM_MS</td>
<td>OtherSTEM_HS</td>
<td>OtherSTEM_COL</td>
<td>OtherSTEM_NOW</td>
</tr>
<tr>
<td>NonSciMS</td>
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</tr>
</tbody>
</table>

- 962 women physics majors
- Most were attracted to physics in high school

(Hazari, Brewe, Goertzen, & Hodapp, 2017)
STEP UP 4 Women Project Goal

Bachelor's Degrees Earned by Women

- Physics

Graph shows the percentage of bachelor's degrees earned by women in Physics from 1965 to 2025.
STEP UP 4 Women Project

• More than 1.3 million students taking physics
  • 47% are women (635,000 in 2009)
• ~27,000 high school physics teachers
• Need ~18,000 for equal representation entering as physics majors
  • Already have ~4500 entering now
  • Need ~13,500 additional

If half of the teachers recruit one additional female student to a physics major, the incoming college gap will be closed

(HERI, 2017; Mulvey & Nicholson, 2015; White & Tesfaye, 2011; White & Tyler, 2014)
Framework: Why Identity?

- Physics/science identity has been found to be predictive of:
  - Physics/science achievement
  - Physics/science persistence

Physics Identity – How students see themselves with respect to physics which evolves with their perceptions and navigation of experiences with physics

(Aschbacher et al., 2010; Basu, 2008; Barton & Tan, 2009; Carlone & Johnson, 2007; Gilmartin et al., 2007; Hazari et al., 2010; Olitsky, 2007; Shanahan, 2009)
Framework: Physics Identity

A Student’s Identity

Personal Identity
(Related to characteristics of the individual)

Social Identity
(Related to characteristics as member of a group)

Physics Identity
(related to characteristics as a physics student)

Recognition
(Recognition by others as being a physics person)

Performance
(Performance on required physics tasks)

Competence
(Understanding of physics content)

Interest
(Desire to study/understand physics)

Recognition by others as being a physics person

Performance on required physics tasks

Understanding of physics content

Desire to study/understand physics

(Carlone & Johnson, 2007; Hazari et al., 2010)
Is identity an issue for women?

(Hazari et al., 2014)
What might help?

- Values Affirmation
- Communal Goals

(Diekman et al., 2010; Diekman et al., 2011; Hazari et al., 2010; Miyake et al., 2010)
What might help in high school?

- Importance of Discussion

(Hazari et al., 2013; Lock & Hazari, 2016)
Project Phases

Pilot and Refine

Experiment and Refine

National Campaign

10 Physics Master Teachers

- Refine strategies
- Test strategies
- Pre/post student assessment, video
- Refine strategies
Project Phases

Pilot and Refine
- Refine strategies
- Test strategies
- Pre/post student assessment, video
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Experiment and Refine
- Experiment with control and treatment groups
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National Campaign

10 Physics Master Teachers

28 Randomly-Selected Teachers
**Project Phases**

**Pilot and Refine**
- 10 Physics Master Teachers
  - Refine strategies
  - Test strategies
  - Pre/post student assessment, video
  - Refine strategies

**Experiment and Refine**
- 28 Randomly-Selected Teachers
  - Experiment with control and treatment groups
  - Pre/post student assessment, video
  - Refine strategies

**National Campaign**
- 16,000+ Teachers
  - National Campaign
  - Propagation of strategies
What are the strategies?

• General Classroom Strategies
  • Focus on Explicit Recruitment, Reducing Marginalization, and Promoting Recognition

(Carlone, 2004; Danielsson, 2012; Dar-Nimrod & Heine, 2006; Dasgupta et al., 2015; Diekman, Brown, Johnston, & Clark, 2010; Gonsalves, 2014; Gonsalves, Danielsson, & Pettersson, 2016; Gonsalves, Rahm, & Carvalho, 2013; Haussler & Hoffmann, 2002; Hazari et al., 2013; Lock & Hazari, 2016; Potvin & Hazari, 2013; Stadler, Duit, Benke, 2000)
How will they help?

Physics identity development is impeded because female students:
• Have lower physics self-efficacy, feelings of competency
• Are often marginalized in group work and/or discussions
• Are less recognized in physics classes
• Experience stereotype threat, implicit and explicit bias
• Have communal goals not associated with physics
• Are unaware of gender issues in physics

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• Intervention 1 – Career Exploration Lesson
  • Focuses on Values Affirmation and Communal Goals

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• Intervention 2 – Underrepresentation Lesson
  • Focuses on Discussion of Implicit Bias, Stereotypes, and Countering Myths

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Please Join the Movement!

Mobilize your local high school physics teacher to join

Mobilize other undergraduate students, graduate students, and faculty to reach out to their high school teachers to join

Sign up to be a part of the network:

www.stepup4women.org
Thank You!
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Prior research findings

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- Values Affirmation
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Prior research findings

• Importance of Discussion

(Hazari et al., 2013; Lock & Hazari, 2016)
General Strategies

• Direct recruiting
  • Rationale: Self-efficacy is lower for female students; implicit strategies may not be effective

• Reducing marginalization
  • Rationale: Stereotype threat, unconscious bias, and unsupportive environments experienced by female students

• Recognizing female students
  • Rationale: Recognition is the most important factor for physics identity development; women are less recognized than men

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Career Exploration Lesson

• Goals – Students will
  • Reflect on their own career goals/values
  • Explore a breadth of physics career profiles, focusing on those that match their own goals/values
  • Discuss the skills of physicists that are transferable to many careers (e.g. medicine, climate science, arts, business)
  • Create their own career profile envisioning how a physics degree could help them achieve their goals

(Cohen et al., 2006; Cohen et al., 2009; Diekman et al., 2010; Diekman et al., 2011; Kessels, Rau, & Hannover, 2006; Miyake et al., 2010; Stadler, Duit, Benke, 2000; Walton & Cohen, 2011)
Underrepresentation Lesson

• Goals – Students will
  • Examine the conditions for women in physics through an interactive presentation of statistics and prior research
  • Engage in a discussion about gender issues drawing on their experiences with respect to famous physicists, gendered professions, and personal interactions
  • Propose and assess strategies that could be used to support women in physics

(Danielsson, 2012; Dar-Nimrod & Heine, 2006; Gonsalves, 2014; Gonsalves, Danielsson, & Pettersson, 2016; Gonsalves, Rahm, & Carvalho, 2013; Hazari et al., 2013; Lock & Hazari, 2016; Weisgram & Bigler, 2007)
National Campaign

• Strategies for Propagation
  • “Train the trainer” workshops for regional teacher leaders
  • Teacher workshops and webinars
  • Workshops for undergraduate students to mobilize teachers (through CUWiP and SPS Chapters)
  • Mass communication of campaign and modules through teacher networks and social media

NSF #1720810, 1720869, 1720917, and 1721021
Why High School?

• High school is the most strategic time point:
  • Most women physicists and physics undergraduates become interested in high school
  • Compared to elementary school, teachers have more content knowledge and confidence, more vested in physics
  • Compared to elementary/middle school, students are closer to decision-making time point
  • Compared to college, smaller classes and more time to build relationships

(Eagan et al., 2017; Hazari, Brewe, Goertzen, Hodapp, 2017; Ivie & Guo, 2006; Yilmaz-Tuzun, 2007)