Gender Representation in High School Physics

by Joe Muise

When I started teaching, I was surprised at the composition of my senior physics class — only five girls out of a class of twenty-five. I made it a priority to promote physics classes to girls, as I wanted more students taking physics, and a wider range of viewpoints in the conversation. As the number of girls in my classes increased, I noticed differences in the questions I was being asked, and the types of explanations I was giving, which I felt was improving the overall dialogue in the class.

WOMEN IN PHYSICS IN CANADA

In this paper, the terms girls and boys are used to represent gender expression in high school physics students. References to female and male follow the usage of those words in previous studies or data reported from provinces and territories.

Data collected in the 2016 Canadian census showed the current disparity in the representation of women in physics [1]. The report on Major Field of Study shows that just 20 percent of people identifying physics as their field also identify as female. When filtering for individuals with doctorates in physics, this number drops to 15 percent. These numbers are consistent with previous reports on women's enrollment in university physics majors in Canada — 22 percent of physics bachelor's degrees awarded in 2002 were to women [2]. In Ontario, the percentage of female students and male students in advanced math classes are approximately equal, and in grade 12 chemistry, there are more female students than male. The percentage of female students in physics trails the percentage of male students by more than 20 percent [3].

Summary

High school physics enrollment data from across Canada shows that more boys are taking physics courses than girls at both the grade 11 and grade 12 level. The STEP UP series of lessons are designed to change the culture of classrooms and to help female students identify themselves as physicists.

Several gender-dependent factors have been identified as alienating girls from physics: socialization patterns; self-efficacy towards physics; classroom culture; curriculum and assessment strategies; and teachers' beliefs and awareness regarding girls' engagement [4]. Girls are more likely than boys to report that gender negatively affects their experience in physics classes [5].

Changing high school instruction and making the classroom climate more inviting could positively affect girls, including introducing women models and mentors and raising teacher awareness regarding their beliefs about girls' participation in physics [4]. Female students have reported several positive factors influencing their decision to study physics at the upper high school level — their teachers, school science culture, family member attitudes, and peer interactions [6]. Of these, interactions with their physics teacher seems to be particularly significant to many female students who go on to study physics in college [7]. With university physics enrollment at 20% female representation, high school physics classes represent a key opportunity to make a significant impact on the number of women in physics [8].

PROVINCIAL ENROLLMENT

To understand gender representation in Canada with more granularity, all Canadian provincial and territorial ministries of education were contacted. Enrollment data for grade 11 and 12 physics courses was requested, with a breakdown by gender, as collected by the respective provinces. There is a lack of data about students who are non-binary or gender non-conforming, so we cannot know the representation for these students without further data collection. Data from eight provinces and two territories has been compiled in Table 1.

For most provinces, participation of female students is less than male students, with more of a difference in grade 12 than grade 11. Both Advanced Placement and International Baccalaureate physics courses show large gaps between female and male enrollment. With the percentage of female students in grade 12 physics trailing by as much as 30 percent in some provinces, the chances of seeing an improvement in female participation at the post-secondary level are decreased. Previously published data [9] reported the number of female and male students writing provincial examinations in several

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Table 1

The percentage of female students in physics courses at the grade 11 and 12 level for provinces and territories across the country. Jurisdictions with the female percentage less than 40% female at the grade 12 level are highlighted. Ontario's data is taken from previously published data [3]. Advanced Placement (AP) and International Baccalaureate (IB) courses data has been compiled from those provinces that provided information broken down by course (Alberta, British Columbia, Newfoundland, Nova Scotia and Saskatchewan).

Province	% Grade 11 Female	% Grade 12 Female
Alberta	41.5%	36.1%
British Columbia	42.7%	34.8%
New Brunswick	51.0%	49.1%
Newfoundland	40.3%	35.7%
Northwest Territories	46.7%	40.6%
Nova Scotia	43.5%	40.1%
Ontario	40%	34%
Prince Edward Island	45.7%	39.7%
Quebec	52.3%	48.3%
Saskatchewan	52.4%	45.8%
Yukon	47.0%	38.4%
All AP Courses		38.3%
All IB Courses	34%	31.9%

provinces. Some provinces have had modest gains in female participation, but the overall pattern is largely unchanged — there are still fewer female students than male students in high school physics. Addressing this in high school is possible using a proven method to build equitable classrooms, increase female students' physics identity and raise awareness about bias in physics — STEP UP.

STEP UP

STEP UP (Supporting Teachers to Encourage the Pursuit of Undergraduate Physics) represents a powerful movement for high school physics teachers who are motivated to support and inspire girls [10]. The project has developed guidelines for teachers along with two lessons that directly deal with the issue of representation in physics.

The *Everyday Actions Guide* is designed to develop equitable classroom culture, providing teachers with a self-reflection questionnaire to help them consider how they interact with students, and if their work promotes inclusivity in their classroom. Teachers consider whether women are taking active roles in their classes, and whether they share girls' successes and capabilities with the students' families. These reflection prompts are supported with suggestions of how teachers can support students' aspirations through their conversations with them both within and outside of the classroom. The Guide further suggests inclusive practices for facilitating group work, lab activities and whole class discussions.

The *Careers in Physics Lesson* has students explore profiles of individuals with a degree in physics and identify goals that can be accomplished with a physics degree. Students are encouraged to assess their personal values and see how they match with the values of people already working in various careers, learning that physicists are in jobs that help others and the world around them. This is completed with the help of a 2 question survey and "profile matching matrix". Critically, students are tasked with developing a "Personal Career Profile" in which they envision themselves in a future, physics-enabled career.

The *Women in Physics Lesson* examines the conditions for women in physics, drawing on current statistics and research. The goal of the lesson is to help students reflect and think critically about the issues of underrepresentation in order to counteract bias, with a focus on gender. The lesson has students examine the conditions for women in physics, discuss gender issues with respect to famous physicists, and share personal experiences. This lesson relies on teachers facilitating whole class discussions about topics which are often considered uncomfortable, and steering the conversation toward how our culture and society are represented in the field of physics — something that is not regularly discussed in Canadian physics curricula. This lesson provides discussion guidelines to help build inclusive classroom culture and enable vulnerable conversations.

The STEP UP lessons have been examined by researchers in a pilot and quasi-experimental study in the United States and are linked to improvement in students' belief in a future physics career. The STEP UP *Careers in Physics* lesson has been shown to communicate the utility of a physics degree to students [11], with girls showing higher gains in perceived utility of a physics career [12]. Teachers play an important role in getting students to see themselves as a 'physics person' [7], and both STEP UP lessons are designed to help girls develop their physics identity.

The STEP UP lesson sequence addresses the recommendations that education systems "create public awareness of gender imbalance in physics classrooms" [3], with early research into the effectiveness of the lessons showing promising results in the U.S. implementation. The lessons are also well suited to a previously identified need to change teacher attitudes about girls' engagement with physics [4]. There is tremendous potential for these lessons to change the culture of high school physics classrooms with particular benefit to those traditionally underrepresented in the field.

This academic year, my classes have nearly equal representation of girls and boys, and I'm excited to share the new Canadian STEP UP lessons with them. I hope to see more students explore the possibilities that physics can offer them. The STEP UP lessons present a great starting point for Canadian teachers to discuss equity in their classes, and help change the future of physics.

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