The Gender Gap in Physics:
A Study of Educator Perspectives
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EDUCATOR PERSPECTIVES ON REDUCING THE GENDER GAP IN PHYSICS

Abstract

The gender gap in science and mathematics remains an issue in Canada today, with far-reaching socioeconomic implications (Dionne-Simart et al., 2016). The gender gap is wider in physics than in most other science disciplines (Xu et al., 2015). In this qualitative study, I examine educator perspectives on the low retention rate of young women in physics. The experience and perceptions of female students and educators in physics can inform best practices for physics education in order to retain women in physics. I interviewed two female physics educators: a high school physics teacher, and a graduate physics Teaching Assistant. From these interviews, four themes emerge. The first is that participants believe that the gender gap is caused by differing interests, which may be shaped by societal norms and stereotypes. The second is that participants feel that having strong STEM programming and positive female role models in schools would do the most to reduce the gap. The third theme is that group-based learning should be used to promote inclusivity of young women in physics classrooms. Finally, both participants feel that institutional initiatives geared specifically towards young women sometimes reinforce gender stereotypes, and that promotional initiatives should be designed to foster gender inclusivity, rather than emphasize gender differences.
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Introduction

Women remain underrepresented in STEM (science, technology, engineering, and math) occupations in Canada. The 2011 National Household Survey (NHS) found that women accounted for only 33% of STEM university graduates (Dionne-Simard et al., 2016). Furthermore, not all of these women then choose to stay in STEM post-graduation. Despite an increase in women with STEM degrees in Canada, the percentage of women working in the field has remained around 20% for the past 30 years (Shendruk, 2015).

Certain STEM fields have a larger gender gap than others. For example, mathematics and biology have a smaller gender gap than physics, computer science, and engineering (Hango, 2013). Looking at physics specifically, there is not only a gap in the number of young women who choose to pursue physics in postsecondary in Canada, but this gap widens further along in a physics career. In 2010, 12.4% of physics faculty members were female (Xu et al., 2015). There is a thus need for improving recruitment and retention of women in physics in Canada.

There are currently initiatives across Canada geared towards increasing the representation of women in STEM, outlined in Xu et al. (2015). For example, the University of Waterloo has a Girls Club with the mandate of inspiring girls to pursue science. Another example is the National Science and Engineering Research Council (NSERC) allowing the deferral of NSERC grants during maternity or parental leaves. These types of initiatives do make a difference, however, the underrepresentation of women in STEM is still a pressing issue in Canada (Gaviola, 2017).

Systemic change can only take place if the majority of persons of influence actively participate in working towards change. As an educator of physics at the secondary level, I am in a position to influence the decisions of young people about their future careers. Thus, I am interested in learning more about the gender gap in STEM, and what educators can do to support young women interested in physics specifically. I therefore undertook a research project whereby I sought out and interviewed people who could speak to their experience as women in physics, both as students and educators. This paper outlines the findings of this research.

Research Purpose

Greater understanding is needed about how physics students and educators perceive the gender gap in physics, their relationship with the gender gap, and their ability to affect change. The purpose of this research is thus to gain a deep understanding from women currently working as educators in physics about their relationship with the gender gap in physics. As physics
educators and women, they have experienced the gender gap throughout their careers, and therefore have a unique perspective that is key to understanding how to reduce the gender gap in physics. This research will disseminate knowledge and experience of people currently working toward addressing the issue of the lack of women choosing physics as careers.

**Research Questions**

There were five questions that guided this research study, which are as follows: 1. What are physics educators experiences with the gender gap in physics? 2. What are their perspectives on why the gender gap in physics persists? 3. What are physics educators perspectives on how gender stereotypes surrounding STEM can be reduced? 4. How are educators supporting young women in their classrooms as a means to addressing the gender gap in physics? 5. What are physics educators experiences with institutional initiatives geared towards reducing the gender gap in STEM?

**Positioning Myself**

The data collected through interviews are necessarily affected by the personal identity of the researcher. Research has shown that people respond differently in interviews depending on how they perceive the person asking the question (Denscombe, 2010). My identity also affects the particular lens through which the data is analyzed. Therefore, my relationship to the research is an important consideration in the research process.

I am a teacher candidate at OISE, with teachable subjects in physics and mathematics, and also developing as a teacher researcher. I found over the course of my Bachelor’s degree in science that I was one of only a handful of women in my physics classes. Thus, starting in my research journey, I wanted to know if the gender gap that I passively noticed in my classes was a prevailing trend across Canada – I found that it was. My interest in this topic thus stems from a need to understand my own experience with physics and how larger, societal-level and psychological factors may have influenced my own decisions. I am also interested in how and why others’ experiences may have differed from my own.

**Literature Review**

Increasing female participation in STEM means increasing diversity, adding perspectives, and therefore enriching STEM fields. Having more women in STEM would ensure that a more
diverse set of voices is included in scientific research and industry. In addition, reducing the gender gap in STEM may mean also reducing the wage gap, since on average, STEM occupations pay higher than other fields (Dionne-Simard et al., 2016). Arguably the most significant reason for reducing the gender gap, however, is simply to ensure that the most capable people go into science and math disciplines. STEM careers are economy and innovation drivers, and it is a human resource loss to these disciplines when capable women choose to not pursue STEM fields (Broadley, 2015; Gaviola, 2017).

A person’s gender identity has no affect on aptitude for science and math (Beekman et al., 2015; Edgerton et al., 2008; Fryer et al., 2010; Guiso et al., 2008; Hango, 2013). Furthermore, aptitude for science and math does not necessarily indicate whether or not an adolescent will choose to go on in the field (Hango, 2013). Thus, there is a subset of young women who are fully capable of pursuing careers in STEM, but choose otherwise (Hango, 2013). So, the question remains: why do women disproportionately choose not to go into STEM?

Research has found that both women and men’s choices to pursue and stay in STEM fields are affected by many interacting social, psychological, and cultural factors (Blickenstaff, 2005; Cheryan et al., 2016). Cheryan et al. (2016) conducted an extensive analysis on the factors that affect the gender gap and how they differ across STEM disciplines in order to determine which factors were more likely to play a larger role in gender disparities. They found that the most significant factors included stereotypes about the people in the field, negative stereotypes about women’s abilities, lack of female role models, and gender gaps in self-efficacy. They found that some factors influenced gender disparity in all fields, but did not correspond to variability across fields; these included: formal discrimination, perceived gender bias and discrimination, stereotypes about the type of work, and work-family conflict.

Adolescent attitudes toward math and science are important predictors of whether or not students pursue STEM careers (Bench et al., 2015; Correll, 2001; Simon et al., 2015; Rice et al., 2013). Women experience higher anxiety and lower motivation and self-efficacy towards math and science than men (Desy, Peterson, & Brockman, 2011). In addition, Nosek and Smyth (2011) found that women showed “stronger implicit negativity toward math than men did and equally strong implicit gender stereotypes” (p. 1125). Studies done by Bench et al. (2015), Correll (2001), and Simon et al. (2015) provide evidence that men overestimating their ability may actually be a contributing factor to the STEM gender gap more so than women
underestimating their ability. It is important to remember that the gender gap is not only created by women choosing not to go into STEM, but by men choosing STEM as opposed to other fields (Cheryan et al., 2016).

Differences in attitudes towards STEM could be a result of overarching stereotypes about gender and STEM that disproportionately deter women and draw men into STEM fields (Leaper, Farkas, & Brown, 2012). These stereotypes associate STEM as lacking a caring and nurturing aspect, and thus being more masculine. Stereotypes about women and STEM could lead to what is known as “stereotype threat” (Cheryan, 2011), as well as “imposter syndrome” (Ivie and Ephraim, 2011). Stereotype threat refers to “anything that reminds women or minorities of their stigmatized identity” that can “reduce their performance on a stereotype-relevant task” (Johns et al., 2005, p. 178). Imposter syndrome is the belief that you do not really belong in your chosen field or occupation, and has been shown to disproportionately affect women in STEM, particularly in physics (Ivie and Ephraim, 2011). Even if the culture of STEM fields is not overtly hostile to women, women will be less likely to enter or persist if they feel they do not belong (Cheryan, 2011). In general, research shows that stereotypes surrounding women, STEM, and physics still exist in the high school classroom (Cheryan, 2011; Dentith, 2008; Makarova et al., 2015).

Looking specifically to physics, where the gender gap is wider than most other science disciplines (Xu et al., 2015), more can be done to reduce stereotypes associated with both gender and the field itself in secondary school. Furthermore, secondary physics is a pre-requisite to many other STEM programs, so fostering a positive attitude about physics may reduce the gender gap in other technical fields. Based on the results from the research described above, in order to reduce the gender gap in physics, efforts should be focused on changing stereotypes about people in the field, women’s physics abilities, improving women’s self-efficacy and introducing more female role models in the physics classroom. In addition, the literature recommends that schools work towards de-emphasizing gender difference, gender relevance, and gender homogeneity so that students’ career choice is based solely on their interests as opposed to related to their gender identity (Legewie & DiPrete, 2014). Having girls-only classrooms, more interactive pedagogy, group-based problem solving, and more encounters with role models outside of the classroom has all lead to positive results in terms of female engagement, achievement, and perseverance in physics and math classes (Lorenzo et al., 2006; Riegle-Crumb
et al., 2012; Shapka et al., 2003; Weber, 2011). Of interest in this study, however, are the perspectives and opinions of physics educators on the gender gap in physics, and specific actions they have taken to reduce gender and STEM stereotypes and support young women in their classes.

Methodology

Data Collection

This qualitative research study was conducted through two semi-structured, one-to-one, in-person interviews with women physics educators. Brinkman and Kvale (2015) explain that interviews are an effective method of data collection when the research involves the human experience. My research is focused on the experience and perceptions of the participants as women in physics, as both students and educators; therefore interviews were an effective means of gathering these insights. I used semi-structured interviews because they allow for flexibility in terms of the order in which topics were considered (Denscombe, 2010). Since I was focused on obtaining in-depth information about their experiences, I wanted to allow room for the participants to elaborate on certain issues and develop ideas in areas that pertained most to them.

Participant Selection

Participants were recruited using convenience sampling, via a network of colleagues, as well as purposeful sampling. Two were selected using the following criteria:

Criteria #1: Participants must be active educators of physics at either the secondary or postsecondary level. I focused on physics educators because educators of physics play a key role in influencing the gender gap in both physics specifically, and STEM as a whole. Secondary physics educators influence students’ decision as to whether or not to pursue physics at the postsecondary level. Postsecondary educators are in a position to influence the retention of women in physics in postsecondary and beyond.

Criteria #2: Participants must identify as being a woman. I wanted to learn from their experience as women in physics and the decisions that lead them to pursue physics. This is important because their experiences as women in physics can give insight into the major influences on women’s decisions to choose physics.
Criteria #3: Participants must have demonstrated a commitment and/or leadership in the area of promoting women in physics. I wanted to learn from participants who were committed to reducing the gender gap in physics and have experience in addressing this issue so that I could learn about what they felt has been successful. This is valuable information as it can inform the practices of other teachers.

Participant Profiles

Hannah: Hannah was a graduate student in the physics department at a university in Southwestern Ontario. She was in her first year of graduate studies, and was a teaching assistant for two first year physics courses.

Meghan: Meghan was a math and physics teacher at a high school in Southwestern Ontario. She was on maternity leave at the time of the interview, but had been teaching Grade 11 University physics for four years at that school.

Data Analysis

The interviews were audio-recorded, and then transcribed. Pseudonyms were given to each participant, listed above. Data was collected from the transcribed interview by searching the document for key ideas, which were then analyzed through the lens of how they relate to factors in women choosing to pursue physics. Key ideas were grouped into themes, each of which addressing one of the research questions.

Research Findings

From a detailed analysis of the interview transcripts, four themes were identified. The first responds to Research Questions 1 and 2: participants’ experiences with the gender gap as physics students and educators informed their beliefs that the gender gap in physics persisted due to societal stereotypes, resulting from the institutional legacy of physics being a man’s endeavour. In addition to their experiences with the gender gap, their perception that their gender did not affect their success in physics is discussed, as well as their experiences with stereotype threat, and their experiences regarding societal perceptions of gender and STEM. The second theme responds to Research Question 3 regarding how educators are combatting gender stereotypes. Participants felt strongly that a strong science education in elementary school and the presence of positive role models made a significant impact on a young woman’s decision to
pursue physics. The third theme responds to Question 4 about how educators are supporting young women in physics classes. It speaks to participants’ experiences with inclusive pedagogy and professional mentorship in their schooling, and how they provide these positive influences to their students. Finally, the fourth theme responds to Research Question 5 in that participants found institutional initiatives surrounding the gender gap in physics to be largely ineffective.

**Theme 1: Participants’ own experiences with the gender gap as physics students and educators informed their beliefs that the gap was a result of institutional legacies as well as stereotypes surrounding gender and STEM**

Physics educators perceived the gender gap in physics as unchanging: they felt it was strongly evident going through their physics training and today they perceive the gap as still apparent in the current cohort of students. However, they do not perceive the gender gap as negatively impacting women that do choose to pursue physics – although one participant did find evidence of stereotype threat in her own practice and in her students. Although the participants felt that decisions to pursue physics were based on interest, they felt these interests were influenced by societal norms and stereotypes. They saw stereotypes about physics and gender as a legacy of historical institutional practices that barred women from entering physics. With less women exemplars in the field, they believed the gender gap persisted due to a lack of strong female role models in physics.

**Participants experienced the gender gap as students and continue to observe it as educators.** Both participants in the study had observed the gender gap going through their schooling in physics, and observe it today in their physics classes. Hannah explained that the gender gap in physics in University was a widely-accepted phenomenon; explaining that in the physics building the “male bathrooms are gigantic compared to the female bathrooms,” because “everybody knows” that more people use the male bathrooms. Hannah found that her classes in University were about 15% female or less, and as a grad student she explained, “there’s only two girls in our [research] group.”

Meghan had a similar experience. She explained that she noticed a bit of a gender gap in her math classes in University, but said, “It didn’t stand out to me the way that it did in physics.” Even in her Bachelor of Education physics course, she found the gender gap persisted: men outnumbered women by a four to one ratio. In her experience teaching secondary school physics, she has found that the ratio of young women to men would be at most one third.
That both participants witnessed the gender gap as both students and teachers is not surprising, given the vast amount of statistical data supporting the prevalence of the gap in STEM in Canada (Fryer & Levitt, 2010; Hango, 2013), and in physics specifically (Xu et al., 2015).

**Participants did not perceive that their gender had a significant impact on their decision to pursue physics or their experience in physics.** Both Hannah and Meghan enjoyed physics in high school, which was why they decided to pursue it in University. Hannah explained that she “liked the challenge,” and that she never felt that high school, physics was a “male thing.” In addition, Meghan explained that she did not notice the gender gap early on because she had a female physics teacher. Both thus had a positive attitude towards physics, did not perceive physics as a man’s profession, and felt that their gender did not hinder their success. Hannah said, “I have noticed it [the gender gap] but I have never felt like I was discriminated against.” Furthermore, Hannah explained that every since she was in high school, she felt that working in a power plant was the “coolest job.”

Both participants’ long-standing interest in physics stemmed from their experience in elementary and secondary school, highlighting the importance of these formative years in school on a person’s career choice. Both had an image of physics that was positive and not necessarily gendered, which lead to their decision to pursue physics. That neither participants experienced discrimination themselves supports the research done by Cheryan et al. (2016), which found that active discrimination was not the cause of the gender gap in physics. Furthermore, Cheryan et al. (2016) argues that it is more so attitudes towards physics that determine whether or not someone will choose physics as a career

Hannah, now one of the few women pursuing graduate studies in physics in Canada, was evidently not negatively impacted by stereotypes about women in physics – mainly because she did not perceive their existence going through school. Thus Hannah was not affected by the engrained stereotypes that lead women to not think of physics as a career. Meghan also did not hold stereotypes about women in physics, because she had a positive experience in her physics classroom in high school, which was headed by a female teacher. This highlights the importance of positive role models in countering stereotypes about women in STEM, to be discussed in Theme 2. Furthermore, both participants felt a sense of camaraderie with their peers in their physics degree. Both Meghan and Hannah explained that they had a few friends in each class
that they would attempt problems with. The importance of fostering a community is discussed further in Theme 3.

One participant experienced stereotype threat and observed its impact on female students. As discussed, Meghan’s experience with the gender gap in physics was more pronounced after high school and beyond. This may have lead to her becoming affected by stereotype threat later in life. Meghan explained that she is cognisant of herself as an important role model figure for the students, and that she feels pressure to perform well as a woman in physics: “I don’t want to look like I don’t know what I’m doing,” she said, “because sometimes I do feel a little bit of pressure, almost like I need to prove myself, although it’s not quite like that. I don’t know, put it this way, I don’t really feel that way in math.”

Meghan’s experience is an example of the well-studied phenomena of stereotype threat and imposter syndrome, which have been found to be still prevalent amongst women in STEM in the high school classroom and beyond (Cheryan, 2011; Ivie & Ephraim, 2011). That she feels more of this pressure to perform in physics than in math is a reflection of her experience with the gender gaps in both disciplines. While she is well aware of the gender gap in physics, she has noticed, “there are quite a few female math teachers.” Stereotype threat occurs when minorities are reminded of their stigmatized identity (Johns et al., 2005); thus, Meghan feeling that she is less of minority in math than in physics may explain her more pronounced feelings of stereotype threat in physics.

Meghan also noted that, “girls seem to work a lot harder [than boys] and are more focused, especially the girls that I seem to get in physics.” She also explained that in physics “girls if anything would be kind of in the top end of the class.” These observations indicate that the following two phenomena are happening, or a combination thereof. The first is that only the young women who are strongest in physics choose to study physics. This is in keeping with the findings of Hango (2013) that men with lower marks in high school are more likely to choose STEM than young women with higher marks. The second is that young women feel they need to compete for the top spot in their class in order to prove their relevance in a predominantly male field. This situation is analogous to that observed by Dentith (2008), where girls felt the need to compete with each other for what they viewed as a finite number of spots for women in higher level STEM courses.
Meghan’s experiences as a physics teacher lend evidence to stereotype threat occurring in disciplines with a wider gender gap, such as physics. Stereotype threat has been shown to lead to a decreased sense of self-efficacy and thus a pressure to work harder (Dentith, 2008), as is the case with Meghan and her students. Furthermore, it could also lead to young women simply not choosing physics, thus perpetuating the gender gap (Dentith, 2008).

**Participants believed that the gender gap in physics persists as a result of institutional legacies as well societal norms and stereotypes surrounding gender and STEM.** Both participants viewed the gender gap in physics as the relic of historic systemic barriers to women in Canada, but that “in general, things are more accessible to women now than they used to be.” Meghan added that, “I think some of it [reducing the gender gap] might just take time.” That is, both Meghan and Hannah did not view systemic barriers in physics as the main issue causing the gender gap. More so, they thought that children in Canada were free to choose what they wanted to study based on their interests, but that these interests were shaped by their upbringing, and influenced by societal norms and stereotypes about gender and STEM. This was supported by their observations that many girls in their classes seemed to “naturally prefer” activities that were less technical. This opinion is different from what is explored in the literature on the topic, where gender stereotypes are seen as a form of oppression, because they limit children’s ability to choose based on interest alone and unhindered by societal norms (Legewie & DiPrete, 2014).

Hannah had a unique perspective growing up in Korean culture, where young men are more highly valued. She understood that views about gender get passed down from generation to generation. She also explained that, being the only child in her family, her father actively fought against gender bias in their family. This explains why Hannah felt the freedom to choose physics as a career and was less affected by gender stereotypes. Thus, although Hannah thought children generally had the freedom to choose, she was also aware of gender discrimination happening within families, and stated: “I think the only way to stop gender discrimination is teaching kids that gender has nothing to do with success, and those kids will grow up and teach that value to their children. That’s how we can close the gender gap.”

Both Hannah and Meghan thought that the lack of role models in physics, due to the institutional legacy of physics being primarily a man’s endeavour, is likely a factor that influences young women’s opinions of physics. In addition, they both thought that children’s
interests might not align with what their *perception* of physics was. Meghan said, “I don’t know that they always know what they are getting into when they take physics,” and that physics is often viewed “as being a lot of math, which it can be, or something that leads to engineering.” These findings support those of Cheryan (2011), which was that stereotypes about science and math may also deter young women from continuing in STEM, and that schools should work to change the image of science to better reflect the people and type of work involved. This can be done through both incorporating positive role models as well as bolstering science programs, as discussed in the next section.

**Theme 2: Participants advocated for stronger science programs and the presence of positive role models in schools in order to reduce the gender gap in physics**

The main two ideas that both Meghan and Hannah had for reducing the gender gap in physics was to ensure all students experience a good science program early on, with plenty of opportunity to understand how modern science works, and that students have the opportunity to interact with positive role models. These recommendations were inspired by their own positive experiences with science schooling, as well as their observations as science educators.

Participants believed that the strength of elementary science programs influenced young women’s perspectives. Meghan believed students’ opinions about science were shaped by their experiences in elementary school, noting that she could always tell which students were from which elementary school based on their excitement about science: “I know that they have a teacher in Grade 7 and 8 who’s really excited about math and science…I think that it makes a difference.” Hannah also noted that it was especially important for students in junior high school to see science in a positive light, when they are in the middle of “making up their minds” about science. She advocated for including more modern science in both elementary and secondary curriculum, which would give teachers the opportunity to talk about the diversity of people in science research groups. Creating a positive and diverse image of physics for students would draw more young women into physics.

These suggestions are supported by research done by DiPrete (2014), which found that the gender gap in STEM was decreased in schools with a stronger science curriculum. It might be that having a better science program in general ensures that science is more accurately portrayed for what it is today, thus countering stereotypes about STEM and gender. Illustrating
the diversity of scientists to students would help to counter societal stereotypes that associate mathematical fields with masculinity (Cheryan, 2011).

**Participants advocated for having positive role models in schools in order to reduce the gender gap in physics.** Both Meghan and Hannah believed that having positive role models was key in their decisions to pursue physics, and believed the presence of positive role models influenced their students. They also believed that as more women choose to pursue physics, there are more opportunities for students to see positive female role models. Meghan explained, “you do get more women choosing physics, so I think you do get some of those positive role models coming through.” She believed that having “quite a few female math and science teachers” made a difference for students at her school. Thus, both Meghan and Hannah had the perception that the gender gap was improving due to positive female role models.

Both Hannah and Meghan believed that having role models in physics was important due to their own experiences with role models as students. Meghan had a female physics teacher in high school, and a good experience with high school physics. Hannah explained that in high school, scientists came into her class to talk about their jobs. She explained that this was important for making science more relatable and illustrating and creating the awareness that physics was welcoming to all genders.

The importance of positive female role models in young women’s career decisions has been emphasized in the literature. Hannah and Meghan’s anecdotes are in keeping with a study done by Riegle-Crumb and Moore (2014), which found that the gender gap in physics enrolment in high school was smaller in communities where women were employed in STEM professions. Legewie and DiPrete (2014) also recommend the use of role models in schools, as well as flooding the schools with a diversity of STEM images. Thus, that Meghan and Hannah model female physics educators would have a positive impact on their students; in this way, they both passively counter gender and STEM stereotypes.

**Theme 3: Educators support young women in physics through mentorship and inclusive pedagogy**

Both Meghan and Hannah had positive experiences with physics, which lead them to ultimately choose to pursue physics in University. This theme explores the type of support and teaching they received that created these positive experiences, and how their experiences informed their teaching. Both Meghan and Hannah had professional mentors as well as peer
support going through their physics schooling. They emulate these experiences in their practice by mentoring their students, providing extra support and guidance to young women, and ensuring that all students feel included in their physics classes.

The ways that educators are supporting female physics students is informed by their own experiences working with faculty and staff who prioritized relationship-building and professional mentorship. Having positive relationships with professionals was an important factor in Hannah deciding to pursue physics as a career. Hannah relayed one story in particular that emphasized the integral part that her physics advisor played in her succeeding in physics:

“I remember there was one course that I wanted to drop, because my ex boyfriend was in the course, and his friends who are my friends. I felt bullied. Because we were all friends and then we broke up, and they stayed with him. You know, and then I was the only one sitting in class by myself, and I felt left out…I went to my advisor and asked, ‘What should I do?’ He said, ‘if you’re doing great, stay in the course. So I got support from that. And then I sat by myself, and I did great. I got a 99 on the final exam. I think just having an advisor like that, who will just sit down and talk to you and be very kind is really important…maybe we had four meetings in total in four years. But just knowing that I can email somebody who will help me has helped me throughout in making decisions.”

Hannah’s story conveys the loneliness she felt when her male peers chose her ex-boyfriend over herself, illustrating the type of tensions that can happen between young men and women and how these feelings can be more pronounced by young women experiencing a gender gap. Meghan did not have an experience like this, but said, “in physics, all the girls sat together, because we were just so outnumbered.” The participants’ stories illustrate how a gender gap can act to emphasize the differences between men and women, thus widening the gap – a phenomenon explored by DiPrete (2014).

Thus, having a professional mentor becomes really important to ensure the retention of young women in a field dominated by men. Hannah would not have pursued grad school if it were not for a professor who reached out and said, “are you sure you don’t want to be a grad student?” She also had professors who told her to go to conferences as a student to hear about participants’ research. One professor gave her pamphlets on mental illness when she found herself overwhelmed and upset in his office. Hannah explains that throughout her degree: “I felt supported as a woman in physics, but I felt supported being a student in physics, in general.”

As a graduate student and Teaching Assistant (TA), Hannah ensures that she supports her students in a similar way. Hannah has taken on a mentorship role, which is beyond the scope of
her TA duties. She reaches out to her students, asking them how their courses and graduate applications are going, and lets them know that she is there to help if needed. She also tries to connect with her students by writing notes on their tests and giving them stickers, and noted that a couple of students had approached her to tell her that they “loved it.”

Meghan has also taken on a mentorship role for her students, beyond her duties as a physics teacher. She supports students in deciding what careers to pursue after high school, always telling them to keep their options open. She encourages her students to participate in physics-related extracurricular activities, and reaches out specifically to young women in her classes that she think would be interested. “I’m the teacher who runs robots,” she said, “we’ve been, or I’ve been at least, pretty careful about trying to get some girls on the team, especially girls who are in my physics classes already, or if I think they are going to go on in a related field, then I’ll try to get them to join.” She is also intentional about signing up for and bringing students to initiatives outside of school. In this way, students have a more diverse and accurate picture of what science has to offer. Providing these diverse experiences to students is recommended by Blickenstaff (2005) and Cheryan (2011) as a way to counter gender and STEM stereotypes and thus shrink the gender gap in STEM.

Participants recommended the use of inclusive pedagogy, such as intentional grouping, as well as blind marking. Both interview participants emphasized the importance of the camaraderie they experienced in University physics. Meghan explained that she did a lot of group work in her math and physics classes: “I had a few friends in each class and we’d always attempt the problems on our own first and then meet up like two days before the assignment was due and try to figure it out together.” Meghan thus tries to ensure that her students get peer support in her physics class, saying that she also “tries to mingle the young women and men in her classes.”

Hannah also had a positive experience with her peers in her graduate study group: “there are times when all go out to grab a beer on a Friday afternoon, there’s eleven of us and I was the only female; but they made sure that everybody was invited.” She thus emphasized the importance of feeling included: “if they are men or women, or don’t identify as men or women, or identify as both; just everyone should feel included no matter what.” In addition, to reduce marker bias, Hannah would ensure she graded assignments “from the back to front” so that she could not see the names.
Both Meghan and Hannah were cognisant of wanting to counter the idea that gender effects outcome in physics. They de-emphasized gender differences by trying to create student groups that included all genders. Even just including general group work in physics teaching practice, whatever the group make-up, has been shown to attract more young women to science (Dare & Roehrig, 2016).

Thus, Meghan and Hannah’s efforts to support young women in physics through relationship-building, mentoring, and utilizing inclusive pedagogy that enforces team-building and de-emphasizes gender is well-supported in the literature as recommended ways to reduce the gender gap in STEM (Blickenstaff, 2005; DiPrete, 2014; Dare & Roehrig, 2016; Lorenzo, 2006).

**Theme 4: Participants found that institutional initiatives surrounding the gender gap in physics have been largely ineffective, and in some cases, reinforce gender stereotypes**

Two interesting findings came out of the interviews regarding institutional initiatives that Meghan and Hannah had experienced. The first was that Hannah had noticed some tension building amongst her male peers in University with regard to affirmative action initiatives geared towards involving more women in physics. The second was that Meghan found that some women-specific outreach activities run by institutions external to the school included activities that emphasized gender stereotypes. Both of these findings suggest that initiatives that reinforce gender differences are not an effective way to address the gender gap in STEM.

**Affirmative action can create tensions between genders that emphasize gender differences.** Hannah found that some young men in her physics program were resentful of women-only scholarships. Tensions built in a FemPhys meeting that Hannah attended, which was open to all genders. A young man at the meeting expressed his opinion that women should not receive special treatment in the application process, and Hannah agreed. Hannah stated, “the woman who was the exec member of FemPhys looked at me, and she was very upset… They’re like how can you say that, when you’re a woman in physics?” It should be noted that at no point did the literature suggest offering monetary incentives to women as a means of reducing the gender gap in physics. Rather, the literature suggests that women should and are generally given the opportunity to choose their careers based on interest, but that this choice could be made from a more equitable standpoint by changing societal perceptions of gender and STEM (Cheryan, 2011; Nosek & Smith, 2011). This leads to the question of whether initiatives geared towards
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women specifically, as opposed to disbanding stereotypes, emphasize the gender gap in physics and thus emphasize gender differences.

**Outreach activities geared toward young women can reinforce gender stereotypes.** Meghan was disappointed with the institutional initiatives that she had attended with her female students: “I’m always pretty quick to check out what those are, or sign up the girls on the team for that, and I’ve often been pretty disappointed when we do go,” she said. There were two events that stood out to Meghan as a “missed opportunity,” both related to women in robotics. At one, the event organizers had young women making bracelets; another event was called a “cupcake social” – both emphasized gender stereotypes about feminine activities. Meghan explained, “It seems like somewhere, someone is concerned about that issue [the gender gap in STEM]. They are creating these events, but they’re not doing a good job.” The opportunity to combat gender stereotypes is thus lost at these events, as femininity is emphasized as opposed to a woman’s ability to do science.

Research has shown that reinforcing gender segregation and gender differences directly impacts young women’s decisions to major in STEM (DiPrete, 2014). Therefore, Meghan was rightfully disappointed in initiatives geared towards women that reinforce gender stereotypes. Both Meghan and Hannah’s experiences and opinions are validated by literature showing that having gender-segregated activities that reinforce stereotypes is detrimental to the gender gap in STEM (Desy et al., 2011; DiPrete, 2014; Cheryan, 2011). Arguably a better approach would be to encourage women to attend “science for all” activities.

Further questions arise from this theme: are certain institutional initiatives actually widening the gender gap in certain fields due to their emphasis on gender differences? As opposed to fostering a sense of community, do women-only initiatives alienate men, thus widening the gender gap? One successful initiative was discussed in Weber (2011), whereby middle school students attended a “Girls’ Night Out” day that taught them about engineering. Weber (2011) theorized that changes in girls’ perceptions about engineering may have been more so as a result of them gaining a better understanding of their options, rather than the girls-only aspect of the event. While it is important that women feel solidarity with each other as part of a marginalized group in physics, it is also important that initiatives and activities normalize women in physics, as opposed to emphasizing the gender gap.
Conclusion

This research study was conducted in order to gain the perspective of physics educators in Ontario on the gender gap in physics. Two women were interviewed: Meghan, a high school physics teacher, and Hannah, a graduate student who assisted in teaching first year courses. The study was therefore limited by only two perspectives, rather than a range of diverse perspectives. These two people, however, had valuable perspectives in that they were women who chose to study physics at a higher level, and succeeded in undergraduate degrees in physics. The participants could therefore draw from personal experience when making decisions on how to best support women in physics, and also had valuable insights for how institutions and society as a whole can address the gender gap in physics.

Four main themes came from the interviews. The first was that participants believed, due to their personal experiences, that the present gender gap in physics was caused by young women having different interests than young men, and that these interests were shaped by societal norms and stereotypes. These perspectives were largely supported by the literature (Broadley, 2015); illustrating the degree of insight that comes simply from having first hand experience with an issue.

The second theme spoke to how institutions can help to reduce the gender gap. Participants advocated for a strong elementary and secondary science school program, as well as ensuring that young women come into contact with positive role models. Both of these suggestions have already been recommended throughout the literature (Broadley, 2015); however, Meghan and Hannah’s first-hand experiences persevering through physics gave more in-depth insight into the degree to which these initiatives make a difference.

The third theme spoke to how educators can support young women in physics through mentorship and inclusive pedagogy. Again, Meghan and Hannah’s suggestions stem from their experiences receiving support from mentors, as well as their peers, again illustrating the importance of these factors in young women’s perseverance in physics. This study therefore supported the recommendations by Dare and Roehrig (2016) to reduce the gender gap in STEM by ensuring students have mentors and through group-based pedagogy.

Finally, both Meghan and Hannah were wary of the effect certain institutional initiatives had on the gender gap in physics. Hannah thought that having women-only scholarships in physics fostered a gender divide between young men and women studying physics, especially
due to the highly competitive aspect of scholarships in physics. Meghan had had a negative experience whereby an event targeted at young women actually reinforced gender stereotypes. Thus, institutions should ensure initiatives are designed to foster gender inclusivity, rather than emphasize gender differences – a finding that is supported by Legewie and DiPrete (2014).

The main finding of this study was that women are more likely to pursue physics if they are given opportunities to learn more about the field, either in the classroom or outside of school, and are given sufficient support and encouragement by professional mentors and peers. In general, it is important to bring the external world into the physics classroom to make physics less abstract for students, especially given that physics by definition is the study of the physical world. However, there is also a social component to the study of physics, since science happens through teamwork and collaboration. Emphasizing this social aspect and encouraging support and collaboration in the classroom would bring more women to physics (Dare & Roehrig, 2016).

The findings of this study have implications for teachers, administration, the Ministry of Education, teacher education programs, and school partners. Teachers have a key role to play in reducing the gender gap in physics, in that they are in a position of trust with students and can therefore influence young women’s career decisions. Suggestions for teachers include: taking on mentor roles, providing resources and opportunities for students, utilising and encouraging group learning, and encouraging young women to partake in extracurricular activities that would broaden their knowledge of science careers – including perhaps taking students to a real lab. Teachers should strive to create a positive and diverse image of physics. They can do this by connecting the curriculum with current research projects, and illustrating that the type of people that work in research groups are diverse. Administrators can facilitate peer support and mentorship by potentially pairing young students with older students that are strong in physics, or by bringing in a diversity of University students to the school to speak with students. They can also work towards ensuring that schools have strong science programs. The Ministry of Education should ensure that the physics curriculum includes current physics research and implications for society, with the aim of creating a positive and diverse image of physics. Teacher education programs should emphasize the importance of physics teacher staying up to date with current physics, while also promoting inclusive pedagogy. Finally, while some initiatives geared towards women in STEM have emphasized gender differences, school partners
should ensure that initiatives promote the idea that physics is for everyone, de-emphasizing gender associations with physics.

This research gave insight into women physics educators’ perspectives on the gender gap in physics, and what teachers, schools, and society can do to reduce the gender gap. Participants agreed that it was important to give students role models, mentors, camaraderie, and promote the idea that gender has nothing to do with success in physics. However, new questions and areas of inquiry came out of the interviews. For example, due to the large gender gap in Grade 11 physics classes, it is apparent that students make up their mind about physics before high school. One research project could look specifically at what factors go into tenth grade students’ decision to take physics in Grade 11. Another question is how institutional initiatives can be more successful in reducing gender stereotypes. Are there initiatives that have worked in Ontario, and how can high school teachers become better connected with initiatives that have been successful?

It is important for society to address the gender gap in physics, because the field of physics will make greater strides if everyone who is capable and interested feels free to choose physics, unhindered by societal norms and stereotypes. This study was a small contribution to the greater goal of addressing stereotypes about gender and physics in order to reduce the gender gap in physics.
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