communications physics

Comment

https://doi.org/10.1038/s42005-024-01574-0

Empowering educators: the key to achieving gender parity in STEM fields

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Addressing the persistent challenge of gender disparity in science, technology, engineering, and mathematics (STEM) using an intersectional approach, this article showcases Parité sciences' game-changing strategy to fostering inclusivity and diversity in STEM fields by empowering educators, illuminating a path towards a more equitable scientific future.

Occasionally, an opinion letter can have a significant and lasting impact. In 2015, Theodore Hodapp and Zahra Hazari delivered a groundbreaking overview on the underrepresentation of women in physics drawing on research from the fields of STEM education[1]. They argued that high school teachers play a crucial role in influencing girls and women students by supporting the development of their "physics identity," or more broadly, their "science identity"—a notion that describes the extent to which students envision themselves as future scientists[2,3]. To make a significant impact, teachers can adopt strategies that include recognizing the abilities of women students and discussing the contributions of science in society. This sparked the creation of Parité sciences, a Canadian initiative dedicated to achieving gender parity across all STEM fields.

Urgent need for action and a novel solution

During the final decades of the 20th century, the proportion of women in physics saw a steady increase. However, since the beginning of the 21st century, this proportion has remained stagnant at around 20-25%. This stagnation underscores the urgent need for action. Without targeted interventions, the persistent underrepresentation of women in physics will not only have detrimental effects on the future of society but also risks becoming more pronounced with the advent of artificial intelligence—a field notably dominated by men, including many physicists[4]. One way of addressing the underrepresentation of women consists of increasing their enrollment in university programs that train future high-tech professionals, in fields such as physics, computer science, engineering and mathematics. The question then becomes: What is the solution to reaching gender parity in these fields, given the undeniable competence of women in these areas?

Educational research identifies "science identity" as a pivotal solution, as it creates opportunities for girls and young women to envision themselves as physicists, engineers, or computer scientists and enabling them to be actively engaged in such fields[2,3]. Societal biases are perpetuated through culture and media, as well as through gendered socialization patterns (whether conscious or not) from birth[5]. While the task may seem monumental, fortunately science identity is malleable. Beyond the influence of friends and family, teachers play a crucial role in shaping the science identities of young people[2]. Notably, certain attitudes or pedagogical strategies employed by teachers in the classroom have been shown to significantly increase the scientific identity of young women. These strategies encompass addressing the underrepresentation of women in science, exploring job opportunities in computer science, mathematics, physics, and engineering that directly benefit society (such as in environmental, health and social sectors), and actively recruiting young women with aptitudes and interest to pursue advanced courses or bachelor's degrees in these fields. This is crucial, as young women often have less confidence in their abilities in STEM, or self-efficacy, than young men[6]. Minimizing marginalization in the classroom by evenly distributing attention, engaging all students with laboratory materials, and recognizing the abilities of young women through encouragement and affirmation of their potential for success, are also important. By collaborating with teachers, but also all actors in education such as pedagogical consultants and guidance counsellors, Parité sciences took on the initiative to make these strategies easy to integrate into the classroom.

Parité sciences: a game changing initiative

Since its launch in 2021, the Parité sciences project has actively addressed the issue of underrepresentation in the sciences. It achieves this by providing training to Cégep—publicly funded junior colleges—and high-school teachers throughout Québec in the fields of science, mathematics, physics, and computer science, extending also to pedagogical consultants, guidance counsellors, and other professionals in STEM education. This training presents 10 simple strategies that teachers can adopt in the classroom and that have been shown to significantly increase science identity. Originating from the Physics Department at the Université de Montréal, Parité sciences brings together a diverse team of scientists, teachers, students, project coordinators, and specialists in equity, diversity, and inclusion. We, coauthors, are the co-founders of the project and were inspired by the American project StepUp to increase university enrollment in STEM fields. Backed by the most recent research in education, we are convinced that widespread adoption of these strategies by Québec's science, computer science, and mathematics teachers could markedly address the issue of women's underrepresentation in STEM, thereby ensuring a more gender-balanced future for Québec's society. Moreover, when a teacher or a STEM educator chooses to integrate these strategies, it can profoundly impact all students' scientific identity within the current classroom. Crucially, this influence extends well beyond the confines of the current classroom setting, as educators can continue to apply these strategies year after year, benefiting future generations of students (Fig. 1).

Our initial goal was to engage Cégeps in the province of Québec in Canada. Due to the pandemic, we delivered our workshops remotely, enhancing accessibility for Cégeps in more remote areas. This included institutions such as Cégep de la Gaspésie et des Îles, situated over 900 km east of Université de Montréal, and Cégep de l'Abitibi-Témiscamingue, located over 600 km to the northwest. Our campaign was so well-received that we reached 86% (60 out of 70) of Cégeps offering science programs

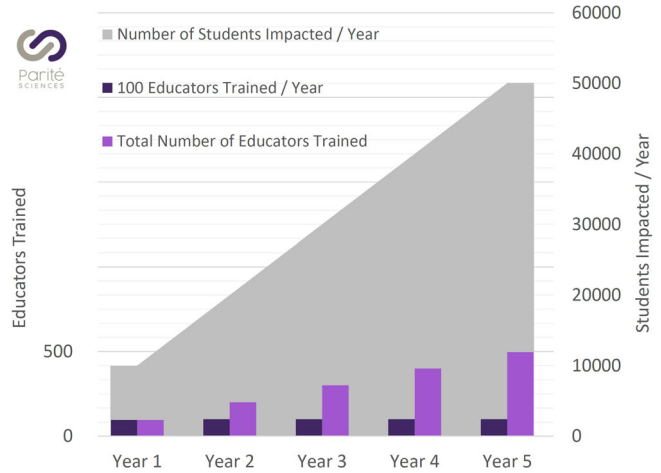

Fig. 1 | Depiction of the exponential effect of reaching out to educators. Here, 100 educators are trained per year. With an estimation of 100 students per teacher, after 5 years, we evaluate that 50 000 students will be impacted every year.

Fig. 2 | Example of representation of scientists with diverse backgrounds. Picture produced by the artist Kay Nau. Permission to publish granted by Kay Nau. All Rights Reserved.

across the province within the first year. We then tackled the more challenging task of reaching high schools across Québec. With ten times more high schools than Cégeps institutes, we approached this challenge with a different strategy. While continuing to offer in-person and remote workshops to various schools, we capitalized on the requirement for high-school teachers to complete 30 hours of in-service training every two years. With funding from the government of Québec, we created a free, 3-hour self-guided workshop accessible through the CADRE21 portal. Not only can teachers follow this workshop at their own pace, but when completed, they receive a badge and personalized feedback that counts towards their in-service training.

How do we measure success? As our goal is to achieve gender parity in STEM fields in the coming years, our primary indicator is the admission rate of women students for STEM programs across Québec, a metric that has remained stagnant over the last few decades and that we can monitor regularly. However, this metric comes with limitations, as it is challenging to attribute any increase to Parité sciences, other initiatives, or broader societal changes. To collect more measurable feedback, we invite teachers, pedagogical consultants, guidance counsellors, and students in STEM to provide us with testimonials, such as the following.

> *"I am a graduate student in physics studying exoplanets and was a pharmacist for nine years. Through my life experiences, I have seen why an initiative like Parité sciences is important. I was influenced by gender stereotypes when choosing my career in pharmacy as a teenager. I was convinced that men performed better in STEM and women in health sciences. After a few years of practising as a pharmacist in a teaching hospital, I realized it wasn't for me, and needed to follow my passion for astrophysics."*
> -Marylou Fournier-Tondreau, doctoral student in Atmospheric, Oceanic and Planetary Physics at the University of Oxford

Going further: using intersectional analysis

As Parité sciences continue to expand, broadening its scope from physics to various STEM fields and from Cégeps to high schools, we wish to look beyond statistics of women in physics to address how factors other than gender can impact life trajectories. This entails considering other forms of exclusion based on sexual orientation, racial/ethnic background, class, and disability, among other factors, and acknowledging that these biases are interconnected[7,8]. To this end, Mirjam Fines-Neuschild, cofounder of Parité sciences and an emerging researcher in equity, diversity, and inclusion in STEM, employed intersectional analysis tools developed by Tanja Tajmel and Emily Dawson in STEM education and science communication[9,10]—note that a popularized zine of Dawson's work can be found here. These tools were utilized to evaluate Parité sciences' documentation and educational materials (including a copy of the website, career presentations, social media communications, funding applications, and training). The intersectional analysis was conducted in March and April 2023, and findings were presented at two research colloquia in Québec, generating significant interest from a multidisciplinary audience.

Results suggest several means of improvement that will transform the focus of Parité sciences from women in STEM to all marginalized groups: (1) be mindful of the vocabulary used to refer to women students so that they are acknowledged as experts in their own lives and paths (avoiding deficit approaches[7,11]); (2) enhance diversity in visual representations and inspirational profiles across all materials and communications. For example, refer to Fig. 2, which portrays individuals with different disability status, racial/ethnic backgrounds, and gender identities; (3) promotes the hiring of individuals marginalized due to their racial/ethnic background; (4) acknowledge that experiences of racism, homophobia and ableism in STEM and their intersections, differ from experiences of sexism within the field; (5) create educational tools in French addressing discrimination related to racial/ethnic backgrounds, class, disability status, sexual orientation and beyond, and involve people from targeted groups to participate in all steps of their design. With this action blueprint, Parité sciences aims to be

recognized within the next 3 years as a benchmark for equity, diversity, and inclusion in STEM education, communication, and learning activities, especially for all marginalized groups Canada-wide.

As members of the physics community, we witness firsthand the effects of the underrepresentation of women in physics and across STEM fields in our daily lives. Working towards a more equitable, diverse, and inclusive environment within physics and the broader STEM community is deeply rewarding for us. We eagerly invite you to share your experiences and motivations in advocating for women in STEM, sparking a collective drive for change.

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Received: 15 February 2024; Accepted: 23 February 2024;
Published online: 04 March 2024

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Acknowledgements

Parité sciences would like to thank their funders : Gouvernement du Québec through Ministère de l'économie et de l'innovation – programme Novasciences and Secrétariat à la condition féminine, Government of Canada through Conseil de recherches en sciences naturelles et en génie du Canada (CRSNG), Université de Montréal, Ubisoft, IVADO (Institut de valorisation des données) and CRAQ (Centre de recherche en astrophysique du Québec). M.F.N., J.H.L. and J.F.A. would like to thank Marylou Fournier-Tondreau for sharing her testimony, Lorna Heaton and Jean-François Carrier who edited and commented on this paper.

Author contributions

J.F.A. and J.H.L. provided parts of the text and commented on every version. M.F.N. led the writing, assembled the text, edited to match the formatting and acts as the corresponding author.

Competing interests

The authors declare no competing interests.

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