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Ontario Network of Women in Engineering Case Study: Indicators of Success and Reflections on Lessons Learned

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ABSTRACT
The Ontario Network of Women in Engineering (ONWiE) was formed in 2005 and is a partnership of the 16 Schools and Faculties of Engineering and Applied Science in Ontario—a group that accounts for almost half (44%) of undergraduate engineering students in Canada. The mandate of the network is to advance gender diversity in the engineering profession by encouraging the next generation of women to study and pursue careers in engineering. By sharing resources and effective outreach practices among members, the collective impact of ONWiE has been significant. Since its formation, ONWiE programs have influenced young women, their parents, and community leaders, thus far engaging with over 28,000 participants. Both qualitative and quantitative indicators confirm ONWiE's efficacy in dispelling stereotypical ideas regarding who can be an engineer, what engineers do, and the globally important role they play. Since 2005, the number of female students applying for engineering programs in Ontario has tripled. This case study highlights key successes, not only in terms of immediate feedback from participants in ONWiE programs, but also its longer-term impacts on gender diversity within undergraduate engineering programs. We also reflect on the lessons we have learned—not least, the factors that have contributed to the success of the collaboration—and the value of linking outreach programs to social science research.

KEYWORDS
ONWiE; STEM outreach and engagement; collective impact; engineering; physics

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INTRODUCTION

The Ontario Network of Women in Engineering (ONWiE) is a pioneering initiative that began in 2005. Via this case study, we present details of ONWiE's activities, indicators of the network's success, and the lessons learned via the project over the past 14 years.

ONWiE was formed to enable all of the schools and faculties of applied science and engineering throughout Ontario—those that offer accredited engineering programs—to work collectively in order to address the underrepresentation of women. The network connects a myriad of stakeholders and provides opportunities for them to exchange information and relevant resources. ONWiE provides opportunities for participants to interact with inspiring role models (e.g., undergraduate engineering students and recent alumna) and has introduced innovative outreach programs aimed at engaging young girls through team-based, hands-on activities. Via the communication of best practices and a system of peer mentorship, all ONWiE members benefit from a wealth of insights and assessment strategies. Since its inception, the network has been supported by the Council of Ontario Deans of Engineering (CODE) and led by recognized champions for gender diversity in engineering. Valerie Davidson was the founding Chair (2005–2012) and was succeeded by Mary Wells, who served as Chair from 2013 to 2018. Kim Jones has recently assumed leadership of ONWiE for the next five years.[1]

ONWiE is the primary network through which schools and faculties of engineering collectively address the status of women in engineering. This is significant because close to half (44%) of undergraduate engineering students in Canada are enrolled in programs in Ontario (Engineers Canada, 2018). A list of ONWiE members is included in the Appendix (Table 1). ONWiE's success has been recognized nationally, and engineering programs in other Canadian provinces now offer outreach programs based on the ONWiE model (Appendix, Table 2). The ONWiE Chair plays a pivotal role, not only acting as an experienced mentor, but also developing strategic relations with external stakeholders.

ONWiE stands out as an effective model of collective impact that has had a significant effect on the engineering landscape in Ontario and throughout Canada. We made a deliberate choice to present ONWiE as a case study because this provided the most appropriate format via which to disseminate our activities and key findings to a wide range of stakeholders. We have focused on the breadth of ONWiE programs as well as quantitative and qualitative indicators of their impact. We have also included reflections on the lessons that we have learned and hope that others find this information useful in their efforts to increase diversity in engineering.

METHODOLOGY

ONWiE's goals are to inspire the next generation of engineering students and to change public awareness of engineering—particularly with young people, parents, and community leaders. ONWiE members deliver a number of programs that are appropriate across a range of ages and interests.

In October 2005, ONWiE launched its flagship outreach program *Go ENG Girl/GÉNiales, les filles.* This is an annual, one-day event for girls and their parents, which takes place at locations throughout the province. The activities are specifically designed for girls aged between 12 and 16 years (grades 7 to 10). While each institution can customize the day's activities to highlight their particular engineering programs and specializations, through experience and feedback, we have learned that the following components are key to the program's success:

- team-based, hands-on activities with simple materials to demonstrate a broad range of applications (e.g., environmental, biomedical, transportation, materials engineering) and to emphasize the social and human impacts of engineering work;
- the presence of undergraduate engineering students (the majority being women) and recent alumna to supervise the hands-on activities and speak about their experiences, both in engineering classes and at work, to act as effective role models for young girls and their parents;
- open discussion with parents about new areas of engineering, the academic requirements needed to apply for engineering, and student and career experiences.

Feedback from participants (girls and their parents) was obtained at the end of each event, and in 2011 there was a survey of those who participated over the first five years of *Go ENG Girl/GÉNiales, les filles*.

In 2011, ONWiE initiated an outreach program called "Badge Days" for a younger cohort of girls. In this program, Girl Guides (ages eight to 11) and Pathfinders (ages 12 to 14) can fulfill the requirements for engineering, science, or technology badges at a one-day event on an ONWiE campus. Since 2011, the Badge Day program has grown and is now offered by about half of ONWiE's members. Participants who are 11 years or older are also encouraged to attend *Go ENG Girl/GÉNiales, les filles*. This ensures a continuum of activities that reinforces diverse ideas of who engineers are and the type of work they do.

In early 2015, ONWiE introduced *Go CODE Girl*—a program that recognized the need to motivate more girls to study software and computer engineering. Currently, 11 ONWiE members offer this outreach program and more than 1,000 girls (aged from 11 to 16) have participated over the last three years.

While ONWiE provides a common framework for a number of outreach programs, not all participating members are expected to do the same thing. Some members choose to offer Badge Days and *Go CODE Girl*, while others focus solely on *Go ENG Girl/GÉNiales, les filles.*

ONWiE's public website (www.onwie.ca) includes a variety of resources that showcase the various undergraduate engineering programs currently on offer in Ontario. The site also presents a video contrasting the misconceptions girls have about engineers and engineering careers with the stories and experiences of real female engineers.[2] This video received international recognition in the form of a 2016 MarCom platinum award.[3] To inspire young girls as well as undergraduate students, the ONWiE website also provides profiles of current engineering students and professional ambassadors. Finally, ONWiE members can login to a restricted section of the website to share resources and data.

IMPACT

Both quantitative and qualitative assessment tools have been used to evaluate the impact of ONWiE programs since its inception in 2005. Key indicators are tracked annually and included in a report to sponsors and stakeholders within the engineering community.[4] These reports contain a wealth of qualitative information (such as images and comments) that demonstrates the enthusiasm of participants for the hands-on activities as well as revealing changes in their perceptions regarding who can become an engineer.

In 2005, the first *Go ENG Girl/GÉNiales, les filles* program engaged about 700 girls and 500 parents and guardians. Today this program is recognized as a leading outreach model that is effective in educating both girls and their parents about the engineering profession and the range of careers available in engineering fields. Since 2014, it has become a national outreach program that is offered in six provinces outside of Ontario (Appendix, Table 2).

Through the expansion of *Go ENG Girl/GÉNiales, les filles,* as well as the addition of programs such as the STEM Badge Day for Girl Guides and Pathfinders and *Go CODE Girl,* ONWiE now reaches more than 3,000 girls and approximately 850 parents, guardians, and community leaders each year. More than 28,000 participants have engaged in ONWiE programs since 2005.

At the conclusion of each event, ONWiE members request feedback from all participants (including girls, parents, and community leaders). Over the years, these surveys have confirmed that the majority of participants are more interested in considering science, engineering, and mathematics courses after attending an event. Qualitative feedback, such as comments from participants, shows that ONWiE outreach programs dispel stereotypes and change misconceptions, as expressed in the following participant quotes:

> "Before today I thought engineering was just for boys." (Badge Day participant)
>
> "GEG changed my view of engineering from nerdy and boring to fun and interesting." (GEG [*Go ENG Girl/GÉNiales, les filles*] program participant)

> "I like the hands-on activities, because it made me think. I also like the speeches, because the speakers are actual women engineers and they really know what they are talking about." (GEG program participant)

> "J'ai aimé l'implication des bénévoles." [I liked the involvement of the volunteers.] (GEG program participant, translation by the authors)

> "There are many more opportunities than there were 26 years ago when I was an engineering student." (Parent)

In 2011, girls who had participated in the first five years of *Go ENG Girl/GÉNiales, les filles* were asked to provide feedback (anonymously) via an online survey. Responses (240 in total) were received from participants who had moved on to post-secondary education, as well as others who had not yet completed high school. These comments capture some key findings about the influence of *Go ENG Girl/GÉNiales, les filles* on their choices:

> "I am going into engineering next year. Before Go ENG Girl I had no idea what engineering was about."

> "I am still unsure about my path but Go ENG Girl gave me some interest in taking Physics next year."

> "I was also able to experience university campus life and I realized what a great place it was."

> "I am currently studying Mechanical Engineering—I did not choose to study this subject based solely on my experience at Go ENG Girl but it definitely sparked my interest in this field."

ONWiE analyzed data from 2013 provided by the Ontario Ministry of Education.[5] The data recorded the number of high school students in the province, categorized by gender, enrolled in senior science and mathematics courses required for admission to engineering programs. Referring to Figure 1, Grade 10 Academic Science, one of the key foundation courses, is gender balanced (i.e., 50% female). However, there are significant gender discrepancies in advanced physics courses: 38% female at Grade 11; and 32% female in Grade 12. In terms of the total number of students, only 15% of female students reach Grade 12 Physics compared to 30% of male students—a difference that cannot be explained by gender differences in advanced level mathematics. This is a significant barrier to increasing the numbers of women studying engineering and the analysis has been used to develop a white paper (Wells, Williams, Corrigan, & Davidson, 2018) that has been submitted to the Ontario Minister of Education. However, we are encouraged to see that, between 2005 and 2015, there was a 21% increase in the number of females taking Grade 12 Physics across Ontario. We believe that ONWiE's efforts to raise awareness of STEM career pathways, the importance of physics in engineering, and the value of keeping options open, have contributed to this increase.

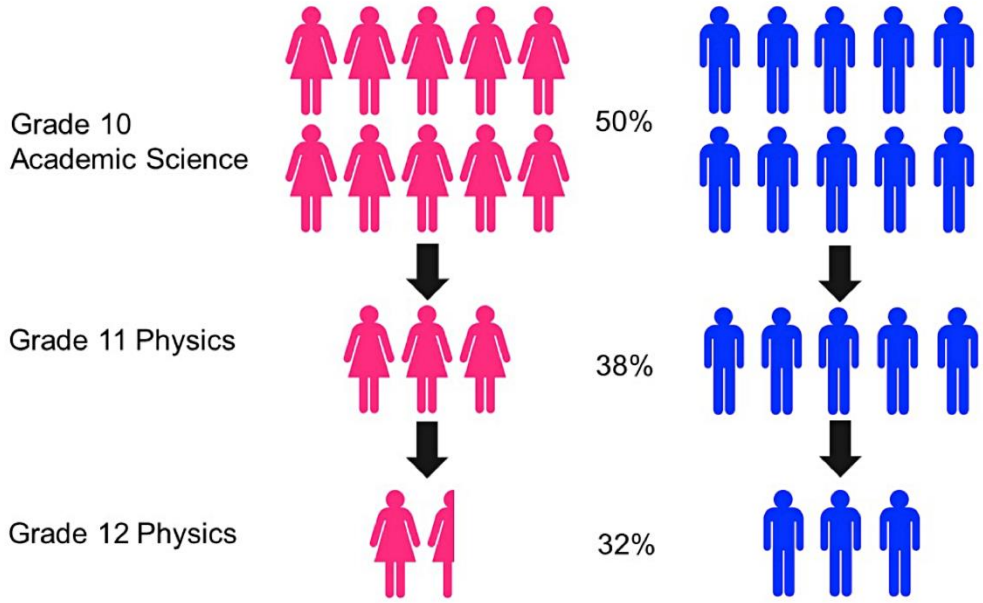

Figure 1. 2013 enrolments in Ontario high schools from Grade 10 Academic Science through to senior level physics courses required for admission to engineering programs. (Percentage indicates proportion of female students enrolled in each course.)

All applications to university programs in Ontario are processed through the Ontario University Applications Centre. ONWiE also tracks these data and it is clear that there has been significant growth in the representation of women in the applicant pool for engineering programs since ONWiE began its outreach programs. Figure 2 shows that since 2005, the number of female applicants has tripled from approximately 2400 to almost 7200—the percentage of female applicants growing from 16% to 25%.

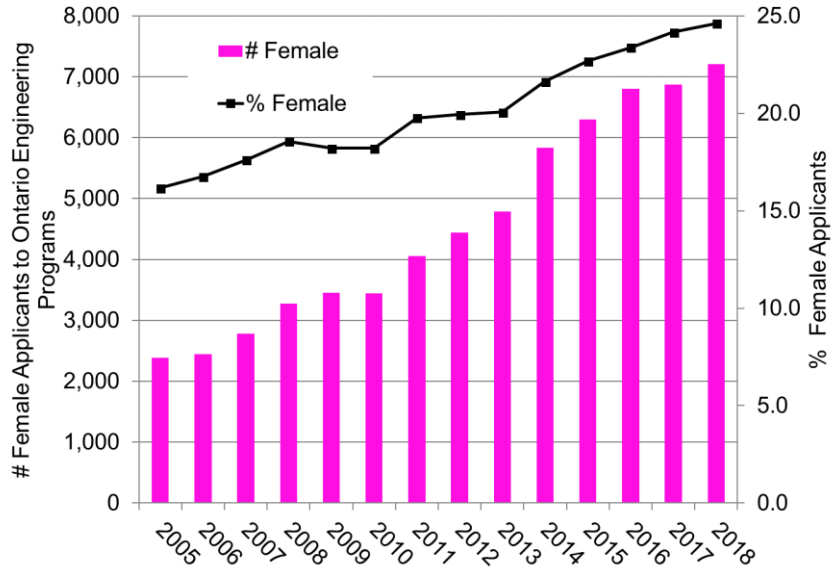

Figure 2. Applications to accredited engineering programs in Ontario from 2005 to 2018 (data from Ontario University Applications Centre).

We know that the pool of female applicants to engineering programs differs from that of the male. Overall, the female applicants are stronger in terms of academic grades and those with the highest academic grades receive multiple offers of admission, including offers for non-engineering programs (i.e., these women may choose to pursue opportunities outside of engineering). There is anecdotal evidence (e.g., from one-on-one discussions with students and entry surveys by individual faculties) that female applicants are attracted to institutions that offer opportunities for undergraduates to participate in research, and research internships may be one way to draw more women to engineering. Furthermore, women are more likely to choose engineering programs that are linked to solving important and meaningful problems in the world.[6] While the social and human impacts of engineering are obvious for some programs (e.g., biomedical or environmental engineering), we suggest that it is important to make these connections more explicit for disciplines such as electrical, mechanical, or computer engineering in order to encourage more young women to consider these options also.

We recognize that ONWiE is not the only organization working to increase the participation of women in engineering, although it is acknowledged as a leader in the Canadian outreach community. Indeed, ONWiE was recently invited to join the Engendering Success in STEM consortium (http://successinstem.ca/). The consortium brings together academic researchers from the social sciences and STEM experts from across Canada. It has received major funding for a period of seven years (2017–2024), which will allow its research partners to design and test the effectiveness of interventions aimed at reducing the impact of implicit gender biases from early education through to professional careers. ONWiE's experience will contribute to the design of these interventions. Furthermore, ONWiE will be able to incorporate the findings of the research in both its outreach programs for young

girls, and its efforts to create more positive environments for female university students.

In November 2016, ONWiE also received formal recognition from the Global Engineering Deans Council (GEDC). Mary Wells, as Chair of ONWiE, was chosen as one of three finalists (out of 40 nominations from around the world) for the GEDC Airbus Award for Diversity Award in Engineering Education.[7] In 2017, the Natural Sciences and Engineering Research Council (NSERC) of Canada recognized ONWiE's impact with its prestigious Science Promotion Award (Group Category). These recent developments demonstrate the contemporary relevance and success of the network.

REFLECTIONS

ONWiE was established in 2005 because there was unanimous agreement among all of the schools and faculties of applied science and engineering that it was critical to work together to increase the participation of women—both as students and professionals—in engineering in Ontario. The 2005 vision for ONWiE was stated in practical terms that emphasized engaging, inspiring, and collaborating with girls to see themselves as future engineers—assessing progress, sharing resources, communicating best practices, and networking. Since members are separated geographically, it has been important to create opportunities for face-to-face meetings. At an ONWiE summit in 2015, members reaffirmed their commitment to the original 2005 vision. There was widespread agreement that the collaborative approach to outreach activities was proving effective and providing leverage as a provincial voice for issues related to diversity in engineering.

In addition to the commitment of its members to a common goal, ONWiE has succeeded because the Ontario Deans understand and appreciate the value it adds to the wider engineering community. At meetings of the Council of Ontario Deans of Engineering (CODE), there is regular discussion of issues and progress with the ONWiE Chair. It also helps to have some strong advocates among the Deans (both male and female), who emphasize the importance of ONWiE programs and collaboration. ONWiE has financial resources through CODE as well as sponsorship from the public and private sectors. The financial support covers the cost of coordination and management of the network as well as developing materials and delivering ONWiE programs. The Chair's responsibilities include supporting ONWiE members so they can deliver core programs and maintaining relationships with key external stakeholders (e.g., CODE, sponsors, the NSERC Chair for Women in Science and Engineering in Ontario, and leaders in the engineering community). In addition, the Chair has release time from teaching and a part-time coordinator to assist her in her duties.

The primary focus of ONWiE has been to increase gender diversity in engineering, but members recognize that there is also a need for diversity in terms of backgrounds, talents, and interests. ONWiE programs are offered at no or minimal cost so that there is no financial barrier to participation. A recent initiative has been to offer *Go ENG Girl/GÉNiales, les filles* in rural communities in order to make it easier for participants who live outside of urban centers to attend. Some ONWiE

members have experimented with co-ed versions of *Go ENG Girl/GÉNiales, les filles,* but recognize that this changes the experience for young girls and this idea needs further evaluation. Males are not excluded from outreach events—indeed, male undergraduate students, staff, and faculty members participate at many *Go ENG Girl/GÉNiales, les filles* events to supervise the hands-on activities, talk about extracurricular clubs, and to answer parents' questions about student life and engineering careers.

Our final reflections come from ONWiE members who participated in a second summit in November 2017. In considering the future of the network and priorities for the next five years, they agreed that ONWiE's strategic strengths continue to be:

- creative, purposeful engineering outreach to girls aged 8 to 16;
- engaging parents as partners in influencing and raising awareness of engineering as a possible career path; and
- changing the narrative around who belongs in engineering and what is needed to succeed.

ONWiE members reaffirmed their commitment to continue working collaboratively in order to reshape ideas and inspire women to pursue careers in engineering.

APPENDIX

Table 1: ONWiE members.

University	**City**	**Province**
Carleton University	Ottawa	Eastern Ontario
Conestoga College	Kitchener	South western Ontario
Lakehead University	Thunder Bay	Northern Ontario
Laurentian University	Sudbury	Northern Ontario
McMaster University	Hamilton	Central Ontario
Queen's University	Kingston	Eastern Ontario
Royal Military College of Canada	Kingston	Eastern Ontario
Ryerson University	Toronto	Central Ontario
University of Guelph	Guelph	South western Ontario
University of Ontario Institute of Technology	Oshawa	Central Ontario
University of Ottawa	Ottawa	Eastern Ontario
University of Toronto	Toronto	Central Ontario
University of Waterloo	Waterloo	South western Ontario
University of Windsor	Windsor	South western Ontario
Western University	London	South western Ontario
York University	Toronto	Central Ontario

Table 2: National collaborators – Go ENG Girl/GÉNiales, les filles.

University	City	Province
Memorial University	St. John's	Newfoundland
Simon Fraser University	Vancouver	British Columbia
University of British Columbia	Vancouver, Kelowna (Okanagan campus)	British Columbia
University of Alberta	Edmonton	Alberta
University of Calgary	Calgary	Alberta
University of Manitoba	Winnipeg	Manitoba
Université de Moncton	Moncton	New Brunswick
University of New Brunswick	Fredericton	New Brunswick
University of Northern British Columbia	Prince George	British Columbia
University of Prince Edward Island	Charlottetown	Prince Edward Island

ENDNOTES

[1] http://www.onwie.ca/about-onwie/history/
[2] The video can be retrieved at www.onwie.ca or at https://www.youtube.com/watch?time_continue=25&v=fhE4cChhkkk
[3] MarCom Awards honor excellence in marketing and communication (https://enter.marcomawards.com/winners/#/platinum/2016).
[4] Annual ONWiE reports from 2005 to 2018 are available at http://www.onwie.ca/about-onwie/reports/
[5] Education is a provincial responsibility in Canada. The Ontario Ministry of Education is responsible for administering the system of publicly funded elementary (Kindergarten to Grade 8) and secondary (Grades 9 to 12) school education in Ontario. Additional information is available at https://www.ontario.ca/page/ministry-education
[6] Chart 2.2 in the 2017 Engineers Canada enrolment report confirms that representation of women is high in biosystems (47.5%) and environmental (41.3%) engineering, compared to mechanical (14.2%) and computer (14.8%) engineering programs. Retrieved from https://engineerscanada.ca/publications/canadian-engineers-for-tomorrow-2017. See also Chopra, Gautreau, Khan, Mirsafian, and Golab (2019). Based on analysis of free text responses contained in applications to an Ontario engineering faculty, the authors found that female applicants demonstrated a greater desire to serve society than male applicants.
[7] Please note Mary Wells appears on page eight in the gallery of finalists 2013–2017. Global Engineering Deans Council (GEDC)—Airbus Award for Diversity Award in Engineering Education. Retrieved from http://company.airbus.com/careers/Partnerships-and-Competitions/GEDC-Airbus-Diversity-Award.html

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