SN Operations Research Forum (2021) 2:2
https://doi.org/10.1007/s43069-020-00039-8

ORIGINAL RESEARCH

Women Just Wanna Have OR: Young Researchers Interview Expert Researchers

Lavinia Amorosi[1] · Rossana Cavagnini[2] · Veronica Dal Sasso[3] · Martina Fischetti[4] · Valentina Morandi[5] · Alice Raffaele[6]

Received: 18 June 2020 / Accepted: 9 November 2020 / Published online: 06 January 2021

Abstract

Is the gender gap still a topic in the academic world and in particular in Science, Technology, Engineering, and Mathematics (STEM)? What difficulties did women who pursue a career in academia have to overcome? What are the differences among countries and what has changed compared to the past? As women and members of a community of young researchers in Operations Research (OR), we have tried to find answers to these questions by interviewing a group of prominent female professors

✉ Veronica Dal Sasso
veronica.dalsasso@optrail.com

Lavinia Amorosi
lavinia.amorosi@uniroma1.it

Rossana Cavagnini
cavagnini@dpo.rwth-aachen.de

Martina Fischetti
martina.fischetti@vattenfall.com

Valentina Morandi
valentina.morandi@unibz.it

Alice Raffaele
alice.raffaele@unitn.it

1 Department of Statistical Sciences, Sapienza University of Rome, Rome, Italy

2 Deutsche Post Chair – Optimization of Distribution Networks, RWTH Aachen University, Aachen, Germany

3 Optrail s.r.l., Rome, Italy

4 Vattenfall BA Wind, Kobenhavn, Denmark

5 Faculty of Science and Technology, Free University of Bozen-Bolzano, Bolzano, Italy

6 Department of Mathematics, University of Trento, Trento, Italy

and affirmed researchers in STEM belonging to different generations, with dissimilar careers and experiences. We have discussed with them about awareness, leaky pipelines, mobility, mentoring, society, role of education, and more. Their motivating stories and opinions contained in this article have allowed us to extrapolate a portrait of what barriers women encountered in STEM in the past, but also what challenges and stereotypes are still to be overcome, striving to close the gap.

Keywords Women in OR · STEM · Gender gap · Education

1 Introduction

AIROYoung [1] is the Young Researchers Chapter of the Italian Operational Research Society (AIRO) [2]. AIROYoung is a community "from young to young": it is designed for young researchers and it is managed and run by the volunteering work of young researchers. Currently, the AIROYoung board (i.e., two coordinators, one treasurer, and two social media managers) is all female and also most of our workshop organizers were female (e.g., the organizing committee of the 4th AIROYoung Workshop was composed by women only). Yet the percentage of women in our community is around 29% [1]. Regarding the participation to the AIROYoung workshops, the percentage of women has risen up to 40% in the last event. As women and researchers, we deeply care about *gender equality*. The gender gap at work is a highly discussed topic nowadays, which spans across a wide range of occupations. Since we are starting our careers in *Science, Technology, Engineering, and Mathematics* (STEM) disciplines, both in the academic and industry environments, we asked ourselves if (and to what extent) this is an issue still present also in our field. Therefore, we decided to interview six women coming from different countries, steps ahead from us in their professional life, asking them about their experience so far.

Margarida Carvalho

"Don't worry! One day you will feel super confident and badass giving public presentations!"

Margarida Carvalho [3], the youngest of the interviewees, is an assistant professor at the University of Montréal, in the Department of Computer Science and Operations

Research. Passionate about mathematics since a young age, she got a Master in Mathematical Engineering at the University of Porto, where she was introduced to *decision science*. She felt that OR was a good balance between math, programming, and applications. After a PhD in Computer Science and a postdoc at the Center for Industrial Engineering and Management at INESC TEC, both in Porto, she moved to Canada in 2017. During her studies, she has always found a good number of female colleagues. In fact, her bachelor degree is the title required to become a math teacher. In Portugal, women teachers represent over 90% of the total at lower levels of teaching [4], and similar percentages can be found in other countries as well [5, 6]. At her current position, she believes this gender balance to lack also in Canada. Independently from the place, this may depend on the fact that women can get lost along their path while pursuing an academic career.

Anna Nagurney

"You actually can have it all and if you do it in an unusual sequence, more power to you!"

Anna Nagurney [7], one of the historic figures of OR, is John F. Smith Memorial Professor of Operations Management at the Isenberg School of Management at the University of Massachusetts Amherst. Born in Canada but educated in the USA, she fell in love with OR during her major in Applied Mathematics at the Brown University. She got two undergraduate degrees (in Applied Mathematics and in Russian Language and Literature) and discovered research while studying for a Master's degree and working in the defense sector in Newport. A college roommate introduced her to Stella Dafermos, her future PhD advisor and, at that time, the only female professor in Applied Mathematics and in Engineering at the Brown University. Nowadays, she says, in the USA, there are more female presidents of top universities or deans of Engineering and Business schools, but very few female CEOs of top corporations [8]. Anyway, this does not discourage young females and males to do the best they can.

Dolores Romero Morales

"Do not forget to enjoy what you do! Be happy with every small achievement on the way to your dream, and share your happiness."

Dolores Romero Morales [9] is a professor of Operations Research at Copenhagen Business School. She studied Mathematics at the University of Seville. For the last two years, she had to choose her specialization: she took Statistics and Operations Research. Afterwards, she moved to The Netherlands, to pursue her PhD at Erasmus University Rotterdam, where she felt privileged to attend courses given by top researchers such as Jan Karel Lenstra. She has been an assistant professor at Maastricht University and then full professor at the University of Oxford, which she left for Denmark in 2014. Thus, she has lived in several countries, learning a lot from all of them but, although there are different working conditions and working hours, she feels the glass ceiling of gender gap is the common denominator.

Ivana Ljubić

"Follow your passion for research."

Ivana Ljubić [10] is a professor of Operations Research at the ESSEC Business School of Paris. She discovered her passion in Combinatorial Optimization during the last year of Mathematics at the University of Belgrade. She joined the PhD program at the TU Vienna, having Petra Mutzel as PhD advisor and role model, as one of the very few female professors at the Faculty of Computer Science at the time. She then benefited of the support of the *Hertha-Firnberg* program, an excellent scholarship for female postdoc researchers funded by the Austrian Research Agency (i.e., FWF). She affirms this helped her boosting her career and improving her chances before applying for a tenure-track position. Currently, she works in France, where

she observes that the percentage of female researchers in STEM is much higher than in some other EU countries. She believes this may be related to the lack of pressure by French universities on researchers' mobility.

Martine Labbé

"Follow your dreams! Your life will be fantastic! And do not hesitate to embark in fantastic adventures such as OR. Yes, you can! Dare to try!"

Martine Labbé [11] is a professor of Operations Research at the Department of Computer Science at the Free University of Brussels, and the first woman to receive the EURO Gold Medal (2019). She got her degree in Mathematics in 1978, when the main careers offered to young mathematicians were either high school teacher or actuarian. She went for the latter, not being thrilled by becoming a teacher. She first got a job at an insurance company but she also took an additional degree in actuarial sciences, which she loved. She got the "virus of OR" (as she likes calling it) and decided to embark for a PhD program. She has never regretted this choice. She lives and works in Belgium, where the situation for women is good. The problem, she believes, lies in the fact that girls are not pushed enough to choose and go for STEM careers.

Grazia Speranza

"Believe in yourself and don't be shy. Do not accept any sort of discrimination."

Last but not least, **Grazia Speranza** [12] is full professor of Operations Research at the Faculty of Economics and Business at the University of Brescia, where she currently serves also as Vice Rector. After several exams in basic and advanced calculus, algebra, and geometry, she discovered OR as the discipline that bridges

mathematics and applications, through computer science: it was love at first sight. She got a Master's degree and an Advanced Diploma both in Applied Mathematics at the University of Milan, in 1980 and 1983 respectively, working then at the University of Udine before moving to Brescia. According to her experience, even though percentages of female and male PhD students in Italy are comparable, the percentage of women decreases when moving up in the academic career. For instance, she reports that at Politecnico di Milano about 22% of full professors and 8% of department chairs are women [13].

2 Gaining Awareness Through Difficulties

Women can perceive several challenges when pursuing a career in STEM. We asked our interviewees about their experience and whether they encountered any difficulties in their career. "When I started my career, I believed that men and women had the same rights and opportunities in life. I believed that, especially in academia, there could be no prejudice, because in academia people are intelligent, intellectually honest and open," says Grazia Speranza. "Over time, I realized that reality is much more complicated, in particular in a field where the percentage of men is much greater than that of women."

"I believe that in many past occasions I may have experienced discrimination without even realizing it. For sure, gender inequalities demand us to always prove ourselves and to never make mistakes," adds Margarida Carvalho. Some of our interviewees felt fewer challenges than others: "I could not say I have never encountered any difficulties. But, on the overall, I do not think being a woman has made things much harder for me," says Dolores Romero Morales on a positive note. "Luckily (and surprisingly) I never had any problem concerning my career. Nevertheless, all along my career I have known female colleagues who faced many challenges," adds Martine Labbé.

> "The women that made it to STEM have to frequently serve as diversity educators and diversity elements in their work context." *Margarida Carvalho*

Women in STEM can face several kinds of difficulties. The first challenge is to even just show interest in STEM during education. STEM subjects are indeed generally associated to male gender. In [14] is reported that even women who had selected math-intensive majors had difficulties in associating math with themselves because they did it with the male gender. Also, studies that analyzed the gender stereotype of physics found that, among high school students, being interested in physics was associated with the male gender [15, 16] and that, among girls, being interested in physics endangered their self-identification with the female gender [16]. As a result,

an educational choice, which seems natural for boys, may be an act of courage for females: "Girls are not encouraged or supported to try STEM. It is perceived as non-feminine, and this deeply dictates their future choices and confidence. This completely compromises the diversity of ideas that STEM can attain and thus, its progress," agrees Margarida Carvalho.

> "I consider myself to be like a spring, and the more they push me down, the higher I go up" *Anna Nagurney*

Even if girls may have higher grades in STEM subjects than boys, this still prevents them to pursue them as a career. One of the reasons for this might lie in stereotypes that attribute girls' achievements to diligence instead of talent [17]. Another reason is that the STEM career environment is a male dominated one. "When I started, women in STEM were considered nice exceptions, pleasant to have around. There were very few role models for a young woman," comments Grazia Speranza. "The women that made it to STEM have to frequently serve as diversity educators and diversity elements in their work context. These things take time! How are we supposed to be innovative in our jobs if we need to be involved in such duties?," continues Margarida Carvalho. Being the different ones also exposes girls in STEM to continuously fighting against stereotypes: "At the beginning of the career, a first major challenge has been to be considered a good researcher rather than a nice young lady. Also, to build my self-confidence. In general, I have observed that men tend to consider a man as their first choice for a research project," notices Grazia Speranza. "The prejudice that men are better than women in the professional environments, in STEM and not only, is still alive."

"When I started, it was well seen for girls to become high school teachers because this would allow to reconcile family and work, and I still know parents encouraging this," confesses Martine Labbé. Family, work-life balance, and expectations from society are a challenge for many women in STEM, as well as for women in other fields. "For me, raising kids while working on the PhD was a major challenge," says Ivana Ljubić. "Pursuing academic career allows for more flexible working times, but, by the nature of our work, we do not leave our research questions at the office." Another challenge in work-life balance is definitely the high mobility which is expected by many European universities, in particular at the beginning of the academic career, during the tenure-track or postdoc phases. "For female researchers with kids/family, this requires a huge commitment and support from the partner and the children as well (e.g., readiness to live/work/study abroad for a limited period of time)," remarks Ivana Ljubić. "I personally did not feel this challenge: my son was born when I was 38 years old (so my career was on the track) and my husband has always been super supportive," comments instead Martine Labbé. "Of course, for all of us balancing family and work is a non-trivial exercise. But my family understands the passion I have for what I do, and they support me," agrees Dolores Romero Morales. Work-life balance is important not only in the everyday life but also looking

at our life overall. Anna Nagurney invites young women to embrace the idea that life goals can be achieved at different times, without compromising the final success. "I did everything in reverse," she says. "First, I became a full professor (the first female to achieve this rank at the Isenberg School), quite quickly after my promotion to associate professor with tenure. Then I had a child and subsequently, I got my driver's license!"

The awareness of women's role in society is now growing and the challenges in having a career in STEM for women start to occupy space on the media. "I believe that this acknowledgement gives power to everyone," comments Margarida Carvalho. But equality is clearly still not there and it is therefore important, for women in particular, to fight for it and to be role models for other girls in STEM. "It is a battle that makes me feel angry (as it makes me realize that there are still inequalities) but at the same time makes me feel peaceful, as we know that we are likely 'doing things right' fighting for a more equal society," she adds.

"I was told by a very famous applied math professor, when I was graduating, that 'the higher you rise, the more they will try to take aim at you'," tells us Anna Nagurney. "I consider myself to be like a spring, and the more they push me down, the higher I go up. I have felt that I also was doing this for my female students and those who followed me. One has to be resilient, because the rewards will come, and not to give up. Always do the best work that you possibly can. Also, support others and be positive and celebrate their successes."

3 Women in STEM: Past, Present, and Future

Women participation in STEM has been a pressing issue through the years. In fact, according to the data provided by UNESCO and the World Economic Forum (data provided in [18, 19] and [20]), the percentage of women in STEM suffers from a phenomenon called the "leaky pipelines" represented in Fig. 1. The data show that

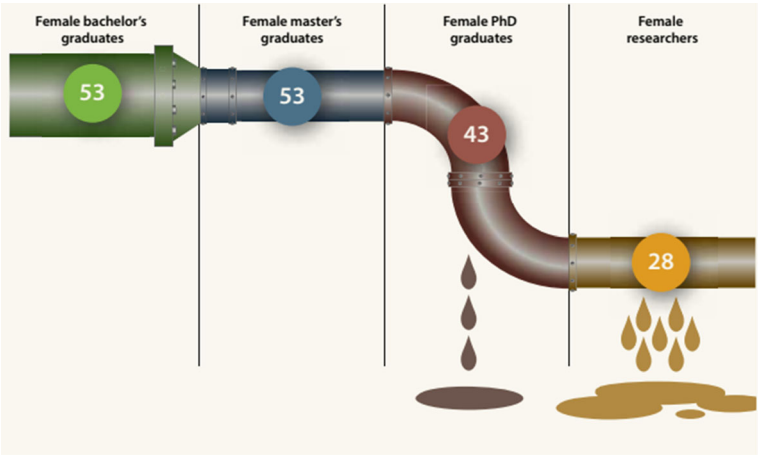

Fig. 1 Leaky pipelines: the higher the academic career level, the lower the women share (Source: UNESCO Institute for Statistics estimates based on data from its database, July 2015)

the percentage of women in STEM at bachelor and master levels is on average higher than 50%. Then, the percentage of women among people choosing to pursue a PhD in STEM worldwide is strongly reduced (43%).

According to the European Union report [6], in UE, the proportion of women among people achieving a PhD in natural science, mathematics, and statistic is quite fair (around 46%) while the situation seems to be very unfair in the information technology and engineering field where the percentage is lower than 30%. Moreover, the major leak is in the passage between having obtained a PhD and in being a researcher in STEM, where the percentage of women drops to 28%.

> "When I started, women in STEM were considered nice exceptions, pleasant to have around. There were very few role models for a young woman." *Grazia Speranza*

However, the situation is steadily improving, albeit at different rates at different countries, as assessed by the UNESCO SAGA program for Stem And Gender Advancement [21]. In order to understand the evolution of the participation of women in STEM fields, we asked our interviewees to provide an insight of how much the behavior of women involved in STEM research has changed during the years and what they are able to observe now in their universities.

At first, the interviewees have been asked whether and how OR women researchers have changed, with a special focus on their goals, attitude, beliefs, and self-confidence. All interviewees agree that the situation improved significantly over the years, which was characterized by conference pictures in black and white with almost no women at all (see, for example, Fig. 2).

These changes have affected both women's personal attitude and their relationship with the scientific community. Concerning women's attitude, Grazia Speranza says: "I see more good and determined young women. I see more self-confidence." Ivana Ljubić adds that women are also more ambitious than they were in the past.

> "Women in OR are growing stronger and mentoring and networking is less sporadic. It is on a larger scale now." *Ivana Ljubić*

Today, women seem also to participate more in scientific activities. Anna Nagurney states that it is more and more common to see women as organizers or keynote

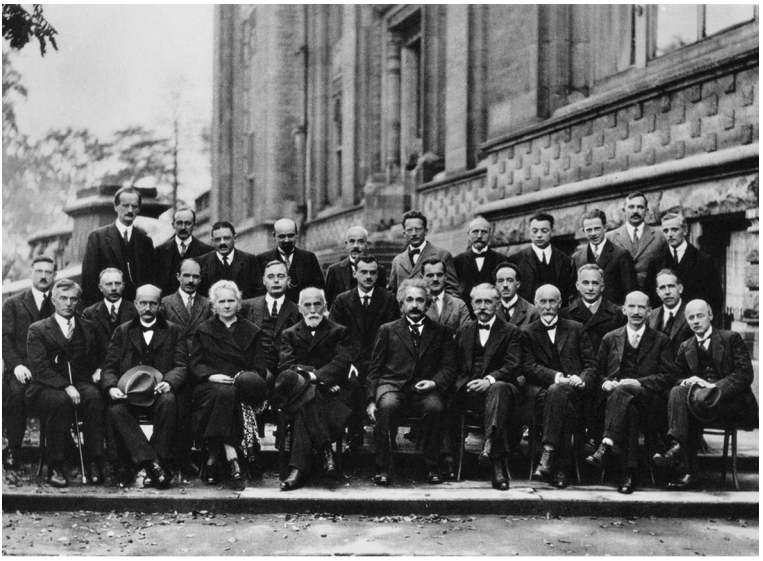

Fig. 2 Participants to the V Solvay Conference, 29/10/1927

speakers at OR conferences and on editorial boards. One feature of women's behavior, which may be a cause for the gender gap, could be found in the words by Martine Labbé, who says that women are "more assertive" than men and "I see many young female OR researchers who give up research after the PhD because they feel it is too difficult to get an academic position."

A shared point of view among the interviewees is the increased awareness of women's condition. Today, women are more open to freely talk about the difficulties they encounter due to the fact that they are female, according to Margarida Carvalho. This increased awareness has contributed to the development of special forums dedicated to female researchers. Anna Nagurney cites as examples *Women in Operations Research and the Management Sciences* (WORMS [22]) by INFORMS, and *Women in OR and Analytics Network* (WORAN [23]) by The OR Society, recently started in the UK; we also report *Women In Society: Doing Operational Research And Management Science* (WISDOM [24]) by EURO. The situation has changed also concerning networking. Women tend to collaborate more towards solutions and to support each other, according to Margarida Carvalho. Ivana Ljubić states that networking opportunities have become more frequent and informal, and Anna Nagurney suggests e-lists as effective tools for exchanging information about opportunities, such as job openings, conferences, journal special issues, and awards. A remarkable aspect is that support is coming also from male colleagues, as witnessed by Ivana Ljubić: "These efforts are also supported by many of our male colleagues, who help spread the message that diversity and inclusion will help our discipline to thrive and grow." However, a great deal of work has still to be done, starting from the lower levels of the education, as mentioned by Dolores Romero Morales; Anna Nagurney adds that even if the

situation is getting better, "many of the top journals have never had a female editor in chief."

> "Lot of work has still to be done, starting from the lower levels of education" *Dolores Romero Morales*

The interviewees have been asked to portrait the current situation at their universities with an eye to the trend in terms of percentage, differences between male and female students and if a balance has been reached in their countries. Ivana Ljubić teaches in a master program of data science and business analytics and she reports the following positive trend: "We have around 40% of female students, a significant portion of them coming from Asian countries. Contrary to common beliefs, these female students are very self-confident, do not feel inferior compared to their male counterpart." Anna Nagurney reports a positive trend too by telling us "not that long ago I had a class with all males, which struck me. The percentage of females in certain undergraduate programs in STEM has increased." Unfortunately, also bad news is reported. Martine Labbé declares that at her university "regretfully, the percentage of female students has lowered! I see fewer female students than in the past." Margarida Carvalho reports "there continues to be a huge gap on the female students' confidence" and Anna Nagurney refers to the leaky pipelines phenomena by saying "once one moves up the educational and professional hierarchy, we see attrition." Anna Nagurney specifies that it "differs from country to country and there are still even countries in Europe, as you might be aware, where there are very few female professors in STEM fields." In fact, the percentage of woman achieving the position of full professor in UE was, in the 2016, around 16% gaining 2% with respect to the 2013 as assessed in [6]. On the other hand, all interviewees agree in saying that they do not notice any major changes in terms of performance of women with respect to the past, which may be the signal that a change in the way of thinking is the main path to gender equality and the gender gap relies only on this, instead of a lack of performances from the women's side.

After having depicted the situation experienced by the interviewees through the years and the current situation, we asked them how we can be proactive and what we can do, as a community, in order to solve the issue. Dolores Romero Morales opens up a big debate about how we can face the issue by suggesting to "put the seeds at primary schools" and, hence, to fight against gender gap by educating children. The same suggestion is given by Martine Labbé, who states that the education to gender equality "must start when they are teenagers. The society in general, and parents and school teachers in particular must work hard on that." Another action could be to enhance the women participation. Grazia Speranza asserts that gender equality in STEM can be reached by "keeping the level of attention high towards the goal of gender balance. In committees, in juries, in round tables, among keynote and plenary speakers there should always be women." Margarida Carvalho shares the same opinion and proposes to "giving minorities space to participate, e.g., by carefully deciding

invitees for seminars, by challenging them to participate in research projects, and by building a comfortable and safe environment for them to be confident."

"Mentoring plays an important role," states also Ivana Ljubić in accordance with Anna Nagurney, who tells us her nice school experience: "My 7th grade teacher, Mrs. Fuller, said to me, 'Anna, one day you will be a Calculus professor'."

> "Be ready to take risks. Pursue academia!"
> *Martine Labbé*

Positive comments from a role model or educator can sustain a student on her/his journey. Female and male students need to see female professors, "who love what they do." Last but not least comes a comment by Ivana Ljubić on the behavior of institutions. She affirms "policy makers need to rethink the whole process of the academic recruitment and the imposed conditions for tenure, no matter the gender. The process is nowadays becoming extremely metric-oriented and less human in many dimensions. In the long term, this might lead to a dead-end with unintended consequences (among others, leading to even less diversity compared to what we have today)." This is an important warning in order not to cancel what has been done in the past and to improve the situation for a fairer future.

4 Find your Own Fuel

Finally, after listening to their stories, we asked our interviewees one last question:

What motivates you today? Some of them experienced the gender gap more than the others, but one thing we can see from all their answers is that the passion that pushed them to pursue a career in OR has not diminished. We report here their exact words, hoping that these will serve as inspiration and fuel for other young researchers, helping them overcoming the difficulties on their paths.

Martine Labbé: "Research! Solving interesting and challenging problems. Collaborate with nice and motivated people. This is really fun!"

Dolores Romero Morales: "I am very passionate in what I do, so that helps. But one of the things I find amazingly rewarding is the transformation I see in students."

Anna Nagurney: "When I was an assistant professor, I would go up to famous professors at conferences, including one of the founders of OR, professor George Dantzig, and ask for advice. A professor told me: 'Anna, you need to build your network, and do it through your students'. Having my PhD students succeed, and my undergrads, who work for innovative companies, makes this Academic Mom proud."

Grazia Speranza: "Curiosity and new scientific challenges. Also, to be a role model."

Margarida Carvalho: "The enrichment of working with diverse people, the belief that genes do not dictate our competence and the freedom for doing what we love!"

Ivana Ljubić: "Supporting young, brilliant and motivated students, sharing my knowledge and the experience with them. Collaborating with many gifted researchers

around the world, brainstorming and learning from each other. Pushing the boundaries in research and discovering new areas."

5 Conclusions

The idea behind this paper was to provide an insight on how the gender gap is perceived by women in STEM, in particular inside the Operations Research community. For this goal, we interviewed six professors working in different countries and with different backgrounds. This paper collects all their opinions on what the situation of female researchers and professors was and is, together with a glimpse on their career path and the difficulties, more or less gender-related, they found on their way. Although we perceive that the situation has been improving, there is still a disparity between the number of males and females working at top roles. This testifies that more effort is still needed to promote gender equality, starting from school education.

Acknowledgments We would like to thank Margarida Carvalho, Martine Labbé, Ivana Ljubić, Anna Nagurney, Dolores Romero Morales, and Grazia Speranza for the time they dedicated to answer our questions. Without their contribution, we could not have given such a complete insight on the current state of women in the OR community.

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