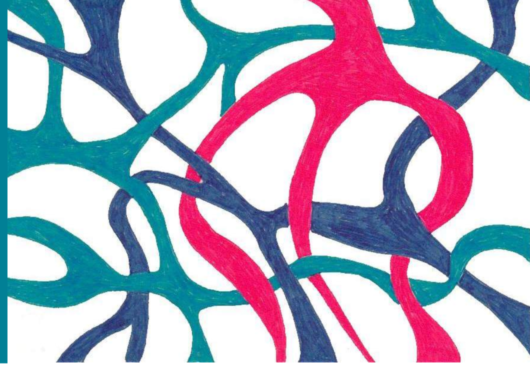
GenHET newsletter



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Inclusive science, education and communication

This issue of the GenHET newsletter brings together perspectives on inclusive science, education and science-communication. It features interviews with researcher in sociology Clémence Perronnet on gender and science education, and with astrophysicist Amelia Bayo on nonlinear career paths and inclusive outreach. We also present updated GenHET statistics on gender diversity in string theory and HEP-th.

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An interview with Clémence Perronnet

Could you introduce yourself, tell us a bit about your academic background, and explain how your interest in gender and science education began?

I am a sociologist who has been working in the field of gender and science education for about ten years, although I came to it rather late. After completing a scientific *baccalauréat* in France, I began studying literature, but soon realized that literary research—working alone with texts—did not suit me. During my studies at the *École Normale Supérieure (ENS) de Lyon* (France), I switched to sociology, where I discovered gender studies and the study of inequalities between women and men.

My entry point was somewhat unexpected: I was intrigued by literature considered low-status, especially the *Twilight* novels, which I loved despite their sexism. That paradox—why so many women enjoy books that are objectively sexist—led me directly to gender questions.

> **What feels personal is often collective.**

I then met Christine Détrez, who became my PhD supervisor. Her work showed how the cultural products we consume shape our relationship to gender norms—an idea that profoundly influenced me. Gender studies also helped me make sense of personal experiences I had not understood, such as why I suddenly began to dislike mathematics after years of enjoying it. Later, I realized this was not just my individual story but part of a broader social pattern—one of sociology's first lessons: what feels personal is often collective.

During an Erasmus year in London, I took a course called *Gender and Science*, which proved decisive for me. It revealed how scientists' social characteristics shape what science studies and discovers. Learning, for example, that the contraceptive pill exists for women but not for men for social rather than biological reasons completely changed my view of science's supposed neutrality.

Back in Lyon, I joined an equality project aimed at encouraging girls and working-class pupils to engage with science. This experience later became the foundation of my PhD, in which I explored children's relationships with science. Since then, my work has focused on how people develop relationships—positive or negative—with science, both through education and through the wider scientific culture that surrounds them.

Nature or Culture?

Could you describe the current state of research on social inequalities in education, particularly in science? Recent studies suggest a broad consensus that there is little evidence for innate differences in early mathematical ability. Does this mean that gender gaps arise mainly from social factors?

Here, we touch on the perennial nature-versus-culture debate. In other words: do we know of any biological factors that naturally make people better at one subject or another? Across both the social and natural sciences-sociology, psychology, biology, and neuroscience—there is a broad consensus that there is no evidence of innate capacities. Put simply, there do not appear to be any biological factors that make particular groups of people naturally better at literature, mathematics, music, or any other domain. Rather, it is seemingly training and exposure which modify our brains and create the differences we observe later. Hence the title of my first book: *La bosse des maths n'existe pas*: there is no such thing as a natural talent for math.

As for girls and boys, studies have repeatedly tried to demonstrate cognitive differences, but the evidence simply is not there. Biological differences between female and male bodies, of course, exist, but they do not translate into differences in cognitive capacities. Even the often-cited female advantage in language or male advantage in spatial reasoning does not hold up—those findings stem from outdated or unreliable studies.

One of my favorite examples is a study that suggested men might be better at geometry because, on average, they are taller—and therefore supposedly have a better "view of the world." It illustrates just how far some researchers have gone to try to prove such differences.

So yes, the consensus is clear: gender gaps in mathematics and science arise from social, not biological, factors.

> **Gender gaps in math and science come from social, not natural, factors.**

How can we make sense of the existence of such hypotheses in light of the consensus you described—that there is no natural talent for mathematics, for example?

This mostly stems from the fact that the scientific world is not as homogeneous or consensual as we might think. In neurobiology, for example, a minority of scientists still defend hypotheses of cognitive differences between women and men and continue trying to provide evidence for them.

As in all disciplines—perhaps even in physics—there are strong debates about how studies are conducted, interpreted, and what can legitimately be extrapolated. Yet I refer to a consensus because several meta-analyses consistently confirm the absence of such differences. What we see instead are isolated studies that periodically resurface, claiming to have found one.

The debate is fierce and extends far beyond academia: the media tend to give disproportionate attention to the few studies suggesting differences, amplifying them in both general and specialist outlets.

Thus, the gender gap in science can be fully explained by the different ways people are socialized depending on their gender, rather than by biological factors. How does intersectionality fit into this picture?

Intersectionality is a concept introduced by Kimberlé Crenshaw in the context of legal studies in the 1970s and it is now well established in sociology, psychology, and history. It encourages us to analyze power relations by considering all factors of discrimination and exclusion together—gender, class, race, ability—without ranking them or treating them separately.

It also reminds us that social positions are not additive: we cannot play the "privilege-points" game, because the intersection of power relations creates distinct situations. The way a black woman is socialized cannot be understood simply as the sum of the experiences of white women and black men—this is the essence of intersectionality. This is especially important when analyzing social inequalities—broadly speaking—in science.

What I find most valuable is its empirical lesson: never overlook any axis of the problem. To understand why people act as they do, we must consider all these dimensions jointly.

You have also studied how mathematics is learned in working-class environments. How does being part of a working-class social context shape students' educational experiences and outcomes in school?

Yes—it was in primary and lower secondary schools. This was crucial, because the study involved three dimensions: gender, social class, and the ethno-racial context, as many pupils in the Lyon suburbs were racialized.

Intersectionality was essential, because gender relations are not the same in working-class and more advantaged contexts. In working-class milieus, girls often carry the hopes for academic success. They are generally more aligned with school expectations and tend to perform better.

We rarely observed the pattern of boys being seen as the "brilliant scientists" while girls were considered less capable. The boys I studied—sons of manual workers or mechanics—were not regarded as geniuses. Even when they demonstrated scientific ability, it was quickly dismissed as merely "technical skills." Social class reshapes gender relations entirely.

The ethno-racial dimension also proved crucial. The value mothers placed on science depended heavily on migration history. In families with little or no schooling background, teachers' authority was absolute—"they know better than I do"—which often worked in favor of science, since teachers tended to prioritize mathematics and science.

Conversely, mothers educated in the French system often carried linguistic trauma, having been criticized for their accent or spelling. For them, the key to success was mastering language. They told their daughters, "You must know how to speak". In these cases, ambitions shifted toward law or the arts rather than science.

In both cases, we are speaking of mothers and daughters from working-class families; hence we see that the family's migration history plays a crucial role in explaining why their relationship to science is shaped so differently.

The notion of *stereotype threat* seems central to explaining differences in performance and engagement. Is it also a useful concept for understanding how students develop their relationship with science?

Stereotype threat is a concept from social psychology, a discipline closely related to sociology. It is a robust finding, confirmed by numerous studies since the 1990s, both in France and the United States—most notably by Huguet and Régner in the French context.

The classic experiment involves equivalent groups of pupils placed in different contexts for the same task. Specifically, children are asked to reproduce a geometric drawing known as the *Rey–Osterrieth figure*. One group is told the task measures drawing ability; the other, that it measures geometrical ability. When it is presented as a "drawing" task, girls outperform boys; when it is described as a "geometrical" task, boys outperform girls.

This is precisely where the concept of stereotype threat comes from: when a person is aware of a stereotype about their group—such as "girls are worse at math"—that awareness takes up enough mental space to hinder performance in the moment.

Similar experiments have been conducted on gender, social class, and ethnicity. A well-known example comes from MIT, where students were given a math test and some were told that Asian students usually perform better. The white students in that group immediately underperformed—the effect appeared instantly.

So yes, stereotype threat does play a role in understanding individuals' relationships with science. Interestingly, we also know that it can be encountered in specific situations: simply stating before a task that "there is no difference in performance between girls and boys," or between groups, helps to neutralize part of the effect. It is a simple yet effective strategy—and it works.

The Myth of Self-Censorship

In your book *Matheuses*, co-authored with Claire Marc and Olga Paris-Romaskevich, you describe how girls are systematically discouraged in mathematics. How does this process unfold over time? Does it appear from a very early age, and does it intensify as girls and women progress in mathematics?

The dominant explanation for why there are fewer women than men in STEM fields often points to self-censorship: girls are said to lack confidence and tell themselves, "this isn't for me". I have always found this explanation unsatisfactory, as it implies the existence of some kind of "low self-confidence gene."

> **When thirty-five out of forty say, "It's me," the issue is clearly structural, not individual.**

For *Matheuses*, we studied forty-five 16-year-old girls who were passionate about mathematics—bright, high-achieving students attending a maths camp. Even they said they lacked confidence and "self-censored." We found that the cause was not abstract stereotypes, but lived experience: sexist and sometimes sexual violence, jokes, and remarks constantly reminding them that they did not belong.

We therefore reversed the notion: it is not self-censorship but social censorship—external, pervasive, and structural. And it intensifies with success. Privileged women may be shielded for longer, sometimes until they become professors, but the backlash eventually comes: progress slows, and comments about femininity or motherhood begin to appear. The higher women rise, the greater the pressure and the more visible this systematic social censorship becomes.

How do students experience such remarks? Some say that women who reach lecturing or professorial positions must have "thick skin." Can this be measured?

It is anecdotal for no one. The effect is always self-doubt-questioning one's abilities and mental strength. These are not easily "measured"; in this context, qualitative research is far more revealing.

What we observed was a double violence: girls face constant, small aggressions while being told that everything is fine—that society is egalitarian and that women in science are celebrated. Many knew they lacked confidence but could not explain why—they had internalized the problem. When thirty-five out of forty say "it's me", the issue is clearly structural, not individual.

The term *impostor syndrome* is misleading, much like self-censorship: it pathologizes a social reaction. Similarly, "resilience" is less about inner strength than about available resources—family, culture, money, therapy. Those who succeed often start in more favorable conditions, yet we mistake privilege for strength, reinforcing elitism in science.

Are there notable differences between disciplines? For instance, between physics and mathematics?

These dynamics affect all sciences. Women make up about 36% of researchers overall, and even in fields where they are a majority, sexism persists.

Mathematics is a particularly revealing case: it is among the least feminized and most elitist disciplines, with recruitment heavily skewed towards the socially advantaged. It is also useful analytically because, unlike laboratory sciences, it has fewer material constraints—no equipment or experiment schedules—which makes mechanisms of exclusion more visible.

Physics shows similar patterns, especially in its theoretical branches, while in applied or experimental areas, another form of masculinity emerges. To caricature: the more abstract a science, the more elitist it tends to be; the more applied, the more working-class backgrounds appear.

Sexism also changes form. In applied physics, "old-school" behaviors persist—crude jokes, inappropriate remarks. In mathematics, it is often more invisible: denial, ignorance, silence. The issues are the same, only expressed differently.

Beyond a binary perspective on gender, are there studies on gender minorities and LGBTQIA+ individuals in science?

Research on this topic remains very limited. A few studies exist, mostly in the United States; in France, there are almost none.

One key finding challenges the notion of science as a "safe haven" for gender minorities. From the outside, science is often perceived as neutral—"scientists don't care about that"—but in reality, it is no more welcoming than other fields.

Both statistical and qualitative data remain scarce. Colleagues in mathematics report that, alongside sexism, homophobia is still common. Questions about inclusion for LGBTQIA+ individuals are emerging within the community, but they have not yet been widely addressed in the research literature.

Discipline and Elitism

Over the past decade, have you observed positive changes in how issues of gender and science education are addressed? To what extent do institutional measures—such as equality charters or dedicated committees—make a difference in practice?

Yes—there has been real change since the early 2000s, above all in our ability to talk about these issues. We've moved from protests against so-called "gender theory" to a point where the word gender is now widely accepted. When I began my PhD in 2014, some headteachers still banned it; today, it's part of everyday vocabulary.

Progress is also visible in discourse and visibility: exhibitions on forgotten scientists, training on gender biases for recruitment committees, equality officers in universities, and a growing recognition of gender-based violence—one of the major impacts of the #MeToo movement. We now have data that objectively demonstratestrate its scale.

Yet the proportion of women in science is stagnating, and in some areas even declining. Many fear a new backlash—a familiar feminist cycle of progress and retreat. Given the current political climate, especially in the United States, the pushback against diversity is strong—a worrying sign, but also evidence of how much has been achieved.

> **Traits coded as "feminine," such as being friendly or sociable, clash with the ideal of geniuses.**

Theoretical physics and mathematics are often regarded as "pure" and abstract fields, supposedly insulated from social influences. How does this perception shape the recognition—or denial—of gender and other inequalities within these disciplines?

It is directly connected. Portraying these fields as pure and detached makes it harder to recognize inequalities—of gender, class, or minority status. In a study that I am currently conducting with Manon Réguer-Petit in Swiss and French mathematics and physics laboratories, we examine how the profession defines who is considered "good."

When asked what makes someone good, people often reply: "intuition," "a spark," "that little something". Yet that "something" is usually social—"a colleague recommended them", "I saw them at a colloquium." Access to such spaces is far from equal. For young women, conferences can even be unsafe environments, which directly undermines the supposed meritocracy.

The enduring myth of the mathematical genius, imagined as antisocial and detached, is particularly revealing. It is, in itself, highly exclusionary of women, since certain traits associated with the current feminine norm—such as friendliness or sociability—clash with that ideal and effectively prevent women from being recognized as geniuses.

Qualitative observation has been particularly illuminating here. We interviewed many researchers who said things like "we're not normal people", "we have zero social skills", even at conferences where everyone was perfectly charming and dinner conversations were lively and sociable. This gap between the imagined purity of the discipline and its very real social dynamics helps explain much of its persistent exclusion of certain profiles.

Teaching Practices and Assessment

You have studied both pupils' experiences and teachers' perceptions. For those of us teaching undergraduates, which everyday practices are most effective in fostering non-gendered learning environments?

There is a lot teachers can do. The key question is: when a student behaves a certain way, do I interpret it the same way regardless of who they are? Studies show that for identical results, teachers often assume a girl worked harder and has reached her limit, while a boy achieved the same result effortlessly and still has potential. Simply asking oneself that question already makes a difference.

Another helpful habit is to challenge what feels obvious. Why do I see a particular student as "strong"? Do I value those who speak up—but only in a certain manner? Is correcting a teacher's mistake a sign of ability, or simply a product of confidence and prior social training? Becoming aware of such biases is already meaningful progress. There is, unfortunately, no manual for an "equal classroom," but these reflections definitely matter.

Beyond addressing personal biases, what other practices or strategies help make classrooms more inclusive?

One crucial step is to take problematic interactions seriously. Students continue to report sexist behavior, and sometimes even harassment, yet complaint procedures often fail, leaving the burden on a few women.

Many male colleagues respond "I didn't know"—maybe they don't want to. Awareness alone is not enough; genuine engagement is required. It is insufficient to assume that "someone else will handle it".

The same applies in professional life: conferences where everyone is aware that certain behaviors occur, yet no one intervenes. There is still a great deal of progress to be made in fostering collective responsibility.

Class participation and assessment are highly gendered. Direct intervention can feel risky, yet doing nothing is equally problematic. What strategies or approaches help in these situations?

Single-gender activities can be highly effective. Although they challenge our egalitarian ideal, women-only initiatives—such as study groups—often prove very beneficial.

Managing turn—taking in discussions is another helpful strategy: alternating between male and female questions, for example, as is done at some conferences. However, when women are a tiny minority, this can actually increase pressure, so the approach always needs to be adapted to the context.

> **A large part of inequality comes from the implicit—hidden rules of learning and assessment. Making them explicit benefits everyone.**

Regarding assessment, we often treat exams as pure measures of competence, forgetting that performance is shaped by social context. From this perspective, are there effective practices or strategies that help create a fairer evaluation environment?

Indeed! Studies on entrance exams—for example, for the *grandes écoles* in France—show that male students often score higher, not because of greater competence, but because they tend to start many exercises without finishing them. In mathematics, that strategy earns more points than focusing on a single problem, which is often the approach many girls take.

This raises important questions: are we rewarding risk-taking over persistence, and how does this relate to gender or social background? The solution is not to rewrite every exam, but to make expectations explicit. Simply explaining, "You gain more by attempting all the problems," can significantly influence outcomes.

A large part of educational inequality stems from the implicit-hidden rules of learning and assessment. Making these rules explicit benefits all students.

Why do female students tend to concentrate on completing a single exercise, while male students often "point-grab" across several?

It stems from gendered expectations. Girls are encouraged to value precision and consistency—to finish tasks properly—while boys are allowed to be more erratic. That is also why women often have neater handwriting in general: it is not innate, but the result of social scripts.

Studies show that when two students produce equally poor work, girls are criticized more harshly. Over time, such feedback shapes behavior: perseverance and attention to detail become coded as feminine, while risk-taking and switching between tasks are tolerated in boys.

These patterns emerge early and persist, depending on the context and the structure of assessment.

> **The most helpful models are ordinary and diverse—women and men, from varied backgrounds.**

Given that exam design is central to assessment in physics and mathematics, should examinations be made more attainable—for example, by introducing bonuses for fully completed exercises?

It reminds me of a debate I once had with high school teachers. I said that today, intelligence is often judged through mathematics, whereas in the past it was measured through Latin. One colleague replied: — "Mathematics is better at assessing intelligence because it's harder." — "Really? Why?" — "Because fewer students get good marks." — "Okay, but why is that?" — "Because in Latin, students are assessed through oral presentations." Alright, then problem solved—let's do oral presentations in maths too!

We build hierarchies around disciplines. Mathematics is demanding, but so are Latin, history, or musicology. Questioning what we label as "difficult" reveals how arbitrary our measures of intelligence can be.

Representation and Role Models

Female role models are often seen as crucial for reducing inequalities, yet they can also be a source of ambiguity. How do you view this tension?

Representation matters—the absence of female scientists limits how girls and women imagine themselves in science. But presenting role models as the solution is risky: it shifts the responsibility onto women to solve structural problems like sexism or unequal working conditions.

Celebrating only exceptional figures, such as Marie Curie, can also be counterproductive. It reinforces the idea that women must be extraordinary, discouraging those who think "if I have to be that brilliant, it's not for me". Similarly, when role models claim they "never had problems", it erases the social factors at play and perpetuates the myth that only the "strongest" women succeed.

The most helpful models are ordinary and diverse—women and men from varied backgrounds—demonstrating that science is collective work rather than a contest of geniuses.

Has the rapid development of scientific outreach on YouTube over the past 10 to 15 years influenced how students today perceive science?

A few years ago, I studied science education on YouTube, asking whether it had made science communication more inclusive. Unfortunately, the answer was largely no. The novelty lies in the format rather than in who produces or consumes it. Most creators are still highly educated men, and the audience remains predominantly male.

We also observed a resurgence of "objective" and "neutral" science discourse, echoing older, masculine ideals of positivism and detachment from the social world. In some cases, rational-skeptic communities reinforced this vision, pushing back against decades of research showing how science is socially constructed. Far from a revolution, YouTube largely reproduces existing patterns.

> **Science should be shown as collective work rather than a contest of geniuses.**

To conclude, could you recommend resources for scientists—particularly those without a background in sociology—who want to learn about the sociology of gender in science education?

Isabelle Collet's books on computer science and digital education are both rigorous and accessible. In social psychology, Isabelle Régner at Aix–Marseille is essential, particularly for her research on stereotype threat and recruitment biasesbias.

Internationally, Sara Hottinger's work on mathematics, gender, and race is excellent, and Cathy O'Neil's *Weapons of Math Destructio*n remains a brilliant entry point.

Regarding my own research, *La bosse des maths n'existe pas* explores how children form—or lose—an interest in science, while *Matheuses* focuses more on gendered experience, elitism, and racism. Both are grounded in empirical studies with young people.

GenHET statistics 2024

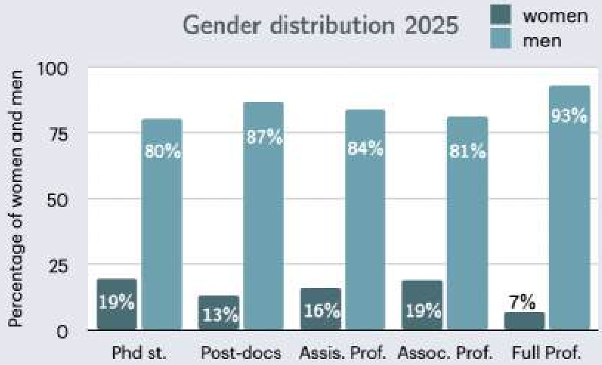
The data presented here were designed and collected by Alex Belin, Agnese Bissi, Yolanda Lozano, and Silvia Penati. Following the first survey of the high-energy theory community in 2017, this update summarizes the 2024–2025 data and provides a snapshot of current gender distributions across career stages in string theory.

Survey scope and focus

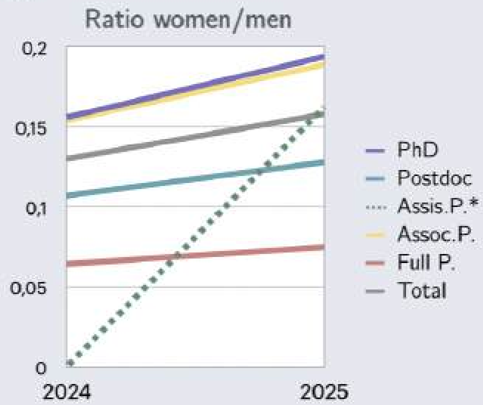
- Focus: string theorists at European institutions
- Data collected via reference contacts in each country
- Categories:
  PhD student, Postdoc, Assistant Prof.,
  Associate Prof., Full Prof.
- Based primarily on self-identification as string theorist

Data collection done voluntarily by the GenHET team.

Gender distribution across career stages (2024–2025)



Total sample: 1062 (2024), 1600 (2025)

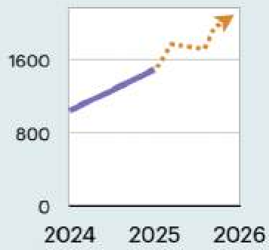


**the category of "Assis.P." was newly introduced for the '25-data collection*

What's next?

- Expand data collection within and beyond Europe
- Include additional factors (nationality, intersectional data)
- Develop a standardised framework for both quantitative and qualitative data
- Maintain yearly monitoring

The number of responses has already grown from 1062 (2024) to 1600 (2025). Your participation can help this trend continue and make the data more representative of the global community.



Want to contribute?

If your country is not represented, help us expand the data set!
Contact GenHET → genhet.web.cern.ch

An interview with Amelia Bayo

You have followed an unusual path in academia. Could you walk us through your personal timeline?

My career has been nonlinear, and I am happy with that. I studied mathematics – absolutely theoretical: algebra, geometry, and topology. That is where my brain used to work. I loved the idea of relying on first principles and not learning things by heart. I enjoyed my studies and saw myself doing research in math.

During my degree (it was a five-year degree back then in Spain), I wanted to do research, but mathematicians were not keen on summer students. They said that mathematical problems are too hard; I would not be able to solve anything within a summer. It was frustrating.

Then, I saw an announcement for astrophysics: physics students could do summer research at the European Space Agency (ESA) in Madrid. It sounded so cool. I had never thought about astronomy – I'm from Málaga, you don't see anything in the sky from there. Nonetheless, I applied. My parents always encouraged me to try: "If you don't try, the answer is definitely no."

> **Chile has extraordinary natural and human resources, but they weren't contributing much to instrumentation – I wanted to help change that.**

Arriving at ESA felt like being a villager in a futuristic place, I was impressed by the antennas. There, I found my first mentor: Pedro García Lario, who works on planetary nebulae, the future of our Sun. These are among the most beautiful objects in astronomy, yet what he showed me was not images but an ASCII table, a numerical catalog of hundreds of objects. He knew all those complicated IRAS-type names and could describe each object from the numbers alone. His passion was infectious. After the interview, I wasn't sure he would take me, as I knew nothing about what he had said. But I did know I also wanted to be so passionate about something one day. He did take me and I switched to astrophysics.

From abstract math to the night sky

After this first contact, you switched fully to astrophysics?

Yes, I have ultimately moved into instrumentation and operations. Initially, I went observing in the southern hemisphere. My first time observing was at La Silla, in Chile. My supervisor at the time told me, on my first night there: "Go outside, lie on the ground, and look at the sky." I did, and it was extraordinary. As your eyes adapt, you see more and more stars. You understand why many southern cultures orient themselves by the voids in the Milky Way, the dark dusty regions. At one point I saw two "clouds" and thought: "Great night overall, but I hope these clouds won't be there tomorrow." Silly me, as they were the Magellanic Clouds. Seeing other galaxies with the naked eye was just too cool. As days went by, watching the telescopes move, seeing how many people collaborate to make an instrument work... I fell in love. Later, I was a postdoc fellow in Chile, working at the telescopes. Afterwards, I did more research, but I have never enjoyed doing only research; I need other things.

Can you give us an example of beyond-research scientific activities that you have been involved in?

From my instrumentation experience I thought: "Chile has extraordinary natural and human resources, but these are not contributing much to the basics of telescope instrumentation". I wanted to change that. So I returned to Chile, to a public university, and started an instrumentation project. We worked on ultralight primary mirrors made of carbon fiber instead of glass – much lighter but with properties similar to those of glass regarding stability against drastic changes in temperature (very common in the desert where most telescopes are located). I led the group for more than six years.

Founding and leading a group must have been very challenging.

It was! But it also provided exceptionally satisfying moments. Eventually however, I could not continue, as it had taken a toll on my physical and mental health. I had to leave.

Then, an opportunity came to join the European Southern Observatory (ESO) in Germany, as a project scientist. I now work on instruments developed in Europe, with parts also coming from Australia. In a very close collaboration with the consortia that leads the development, we integrate and characterise them, ship them to Chile, make them work at the observatory, and then transfer ownership. My role is all-encompassing, as it covers definition, development, and integration – ensuring that the instrument arrives in good shape (regarding its scientific requirements) and works as intended.

> **All my education was funded by public grants, by taxes. Who am I not to give back?**

Overall, how was the transition from a theoretical training to experimental work?

Very hard, but a good learning opportunity. This will sound arrogant, but in math things came naturally to me and I had a high opinion of my intellect. Switching to astrophysics, I couldn't tell if I was the stupidest person in the room or simply untrained in a new way of thinking. Factually, I think I was somewhere in-between. For many things I am very stupid, but I also had to retrain my brain.

When moving from the theoretical to the experimental realm, you have to give up on first principles and instead assume things. For that, you need intuition about what to trust. You will never advance otherwise! The first two years were particularly hard. But it was good to accept that I wasn't top-notch anymore and hence I could either be miserable or I could learn from everyone around me. After wrestling with my ego, I chose to learn. Developing a good intuition took time, but I am glad I did it.

> **During my PhD in Spain, there was an unspoken rule that if you did outreach it was because you weren't good enough in science.**

Making science accessible

Beyond instrumentation, you have also made multiple contributions to outreach. Could you walk us from your human-resources appreciating science to your work in making science more accessible, thus always putting people first?

Sure. I am a people-oriented person, although I am also an introvert. On the whole, I like to learn from and exchange with people.

During my PhD in Spain, there was the unspoken rule that if you did outreach it was because you weren't good enough in science. And yet another "rule": when asked a question, answer technically and complicatedly, so that people think you are "good". I never understood those rules. Explaining something simply is harder: to this aim, you need to understand that something in great depth. You have to avoid jargon, find relatable explanations, and be careful, because analogies don't always follow the same physics. You have to succeed in making the person gain the right intuition.

Complementarily, I feel strongly about the fact that all my education has been funded by public grants – by taxes. Who am I not to give back? We get paid to do science; why should we not explain what we do to the people paying for it? This is not a populist claim; this is a deep truth for me.

Accordingly, I have been active in outreach throughout my career. During my PhD, I worked at the Centre for Astrobiology, where many people did outreach, so it was easy to participate. At ESO Chile, I received excellent communication training and, as a Spanish speaker, I had many outreach opportunities.

How did you start working on outreach for visually impaired people?

Around 2014, a friend mentioned tactile astronomy. The mere idea broke my brain. It was fantastic, and I was ashamed I had never thought about it. I use my hands constantly when explaining things; I am a very visual-oriented person. I had never realised that my way of communicating was excluding people by design. I was able to identify the exclusion when it follows from technical language, but I had failed to notice it when it follows from visuals. That was a blind spot for me.

> **Explaining something simply is harder; you need to understand it better.**

Arrogantly, I thought: "I am going to make material for visually impaired people". With the deaf community, I approached things differently: I learned sign language, talked to people, and understood their interests. But for the blind community, I assumed tactile meant I understood what to do. It turned out I didn't.

We created material with two students, announced an outreach event on Facebook with a poster – which was an image – and invited the blind community. Of course no one came. One blind archaeologist came, Francisco Fernández, and tried the material, and gently asked me: "Did you talk to the community?" I had not. "Did they test anything?" They had not. "Was the promotion accessible to the audience?" It was not. "Well," he said, "now you know what you did wrong."

We started over. We worked with inclusion departments, associations, and blind students. Francisco was involved too. I learned that even within the visually impaired community there is diversity – for some, Braille is part of their identity; for others, it is too slow. I hired a product designer, because we knew nothing about such product design. I hired a differential educator, because teachers needed support to make our material truly useful. We focused on planet formation – our research area and funding source – and teachers confirmed that concepts like gravity are hard to teach, especially to visually impaired students. So we built a team and worked for a long time. I am proud of what we did.

Can you tell us more about the resources you created at this time?

We created a 3D-printable kit and a small booklet on basic astrophysical concepts, designed with inclusive principles: high contrast, audio description, and inclusive narrative. We also produced it in Braille. We created a larger book, covering inclusive communication, the difference between inclusivity and equity, different kinds of disabilities, and tips from educators and the community on how to best interact with such children. Some needs differ by group, but there are also overlaps. We wanted to give teachers as many tools as possible so that they would feel comfortable and prepared for all cases.

Our goal is to explain how planet formation works. The booklet guides a multi-step activity to this aim, and there are supporting materials along with it. You start with a full disk – that people can explore with their hands – and that includes two spatial scales, one for the planet and stellar sizes and one for the extent of the disk (the distances within the system). We tested different ratios and chose the ones that people could interiorise best. For example, the planet (depicting Jupiter in its infancy) measures barely a millimeter, and the whole disk, if it were at the same scale, would extend 500 meters (around five average city blocks), instead of 50 centimeters. That immediately helps people understand. The activity goes on with akin materials, until the planet formation has been thoroughly accounted for.

> **I had never realised that my way of communicating was excluding people by design. This was a blind spot for me.**

In the book, we highlighted the curricular concepts teachers must cover for different age ranges – gravity, sublimation, and so on – and where these are relevant in the booklet activity. The "baby" that came out took a very long time to create and involved several people. Of course, it can always be improved, but considering how wrongly we started, we eventually did well.

How to outreach

Often, researchers have the intention to do outreach but not the means. Who funds projects like the one you just described?

When this project started, I was a Principal Investigator (PI) in Chile, at a public university. I applied for Chilean research funds that are similar to the European Research Council (ERC) ones: high-risk, high-reward, and very competitive, with about 5% success rate. I was lucky to get one. The planet formation project I have just described was funded through this grant.

> **Outreach should be treated as a research line.**

From the start, I told all my co-PIs that outreach is extremely important to me, and that I wanted to hire someone fully dedicated to it as part of the grant. Outreach should be treated as a research line. In our case, instrumentation needed most of the money – we had to buy an autoclave, for example –, but I wanted outreach to be part of the structure, not an afterthought. Everyone agreed.

We were very lucky with the hire: Carol Rojas was fundamental to the success of this endeavor. She had a master's in astrophysics and a master's in written press communication. When she applied, it felt like finding a unicorn. She coordinated everything and helped enormously.

Long story short, the funding came from research money. I had to negotiate the amount we would spend on outreach, but since it was part of the plan from the beginning, it was never doubted that we had to invest in it. Producing the tactile planetary disk was not very expensive; it took an absurd amount of time and coordination, but not a huge budget. Counting everyone's payment and production, maybe around 4,500 euros. I call that well-invested money. It helped a lot that we built a network that reduced costs: for example, by printing Braille through public institutions rather than through private companies. Overall, it wasn't expensive.

Beyond contributing to outreach, you also place value on feedback and success assessment. How do you measure impact, distinguish effective outreach from well-intentioned but unsuccessful efforts, and identify what is simply a bad idea?

We have had different types of impact measurements, depending on the activity. In punctual classroom activities showcasing our planet formation materials, we used simple questionnaires: what students knew beforehand, how fearful they were of certain concepts, and how comfortable they felt confronting them. Typically, there would only be a few visually impaired students in the group. So we would add blindfolds – only if students were comfortable – to generate empathy. This is harder to measure, but important. It is good to have a pre-activity questionnaire and a post-activity one, where students explain things in their own words. It is often the case that the students end up understanding planet formation, feeling more engaged and less intimidated. At big events, something simpler is needed. We have used forms asking which parts of the explanation were unclear, so we could improve on them.

However, most of the learning has come from the design phase. We prototyped endlessly with different test groups: with and without an astronomer explaining, with long and short material, with university-educated people and people without that background, with Braille users and non-users, etc. At the design level, we realized that there is no magic bullet. One design cannot cover every need. So we identified where we would be most impactful: teachers. Sonification is important in the blind community, and some asked why we had not included it. But it wasn't the most useful tool for teachers, and some kinds of sonification would impair students on the autism spectrum, who are often in the same classroom. We tested many ideas and returned to our core principle: focus on what helps teachers create inclusive classrooms. For that, we had to make compromises.

Confronting blind spots in access

You work very transversally: visually impaired students, deaf students, and autistic students. Do you plan to work with other social groups?

I moved to Germany a while ago, but my German is still not great. I recently managed to explain in German the planet formation material, during the open house of ESO, but I need to improve. I want to reach a point where I can do in Germany what I was doing in Chile, and that clearly requires German.

We recently had interns at ESO through a short-term program. I did several activities with them, and they were wonderful, extremely engaged. In an ulterior faculty meeting, when we reflected on the program, a colleague made a point that surprised me: almost all the students were from an international school. How can we reach public schools? I hadn't thought of that at all. It was yet another blind spot for me.

I am involved, but not leading, ongoing efforts to diversify ESO's intern program. Language matters a lot here: we cannot assume all students speak English!

A colleague of mine, Claudio Cumani, works with refugees. He has informed me that if I want to join, I need to improve my German. Teaching such a child maths in English isn't really helping. All teaching should be in German, which aids in their integration and everyday life.

What is the target age for your interns?

Around 13–14. The call is open, but it's posted on the ESO website in English. Families or teachers need to already be "in the loop" to see it. It's like open science not really being open: the data is there, but without instructions. This is similar.

Early confidence, hard lessons

Could you tell us about the start of your scientific journey, from a female point of view?

I am lucky by birth. Both my mum and dad have higher education, so the question of whether a woman could study was never on the table – it was a given. They have a balanced relationship in most gender aspects. Some stereotypes were there – women are made to grow up with the fear of being raped world-wide –, but intellectually zero difference was assumed with respect to, for instance, my older brother. At home, capability had nothing to do with sex or gender.

I went to a school where, funnily enough, the "elite" were the girls who played basketball. In Spain, this elite is typically conformed by the boys who play football, but not in my school. If you were a girl who liked sport, that was good – another huge lottery I won by mere chance. Later on, in Chile, I saw something very different: girls around 10 years old who stop playing because it is not "ladylike".

> **You can seek help and still keep playing. You can be vulnerable and strong at the same time.**

When I was 12, my favorite game was pushing and being pushed by other children around. Within limits, I think that is really healthy. If other girls wanted to talk about clothes, that was fine, but there was nothing wrong with being physical and competitive. Since basketball is a team sport, you also learn cooperation. On the whole the message was: "if you are a girl you likes being physical and playing in a team, that is okay". Bad things happened too, but those principles helped build self-confidence: "I can be like this, there is nothing wrong with it, and nobody can tell me this is not my place." I did not have to question whether I belonged.

One of my math teachers, María Ángeles, had a huge impact on me. She taught us that we shouldn't memorise. Instead, we should solve problems in different ways, and show our personality in so doing. It mattered that she was a woman; very strict, androgynous, and respected. Meanwhile, my mum was strict, but more traditionally feminine. Seeing different models was helpful.

Overall, I have been very fortunate. This doesn't remove self-doubt – we all have it –, but it planted a seed that helped later, when I wasn't allowed to speak or people were betting against me, even as a PI.

You have done mentoring, outreach, and programs for girls and women. Could you share some specific initiatives that shaped your critical view of the "equality lie" and helped others move beyond the status quo?

Two very different activities come to mind. The first started as a generic outreach idea and ended up having a gender dimension. One of the engineers in my group in Chile came to me one day and said: "We have a problem. I have promised to do some outreach with a primary school, a huge number of students, and I have no idea what to do". I had been reading about how girls stop doing physical activities around a certain age, so I replied: "Perfect, let's design something".

We created a game around planet formation. Each of the kids – six year old, about 200 of them, split into groups of 60 – represented a particle in a molecular cloud. They moved around chaotically to music. In each group, one child (always a girl) had a "secret power", symbolised by a little globe with a sprout. When we clapped, the secret power activated: she was allowed to "capture" other particles, and they had to move together from then on. Thus they were growing a planet.

At first, it was just a way to manage chaos. But then we worked together with the teachers to select girls who were shy or had already stopped playing so much. They would be the ones leading, grabbing others, building the planet. We did this activity once in Chile and later in South Africa, in three schools.

In both places, we had several instances where girls came to us – to the women in the activity – complaining that someone had pushed them or been rough. Of course you don't always react perfectly, but we tried to take time to transmit the message: "You don't have to accept abuse, and it is good you came to us. But also, you can stand your ground". I'd tell them stories about playing basketball, of times when I stood my ground, to show them that you can seek help and still keep playing. It is a small thing, but from my own experience, having one person show you that you can be vulnerable and strong at the same time can be very impactful.

> **We often fall into "success story" narratives, but especially for women we also need to be very real about the difficulties.**

What was the second initiative?

The second example is very different: a talk I gave for female students at the Ludwig-Maximilians-Universität in Germany. It was about learning from "non-success" – I don't want to call it failure – and about recognising hardship and choosing which battles to fight. It was about accepting that "a woman should be able to do whatever she wants" is a true statement in principle, but it is not sufficient. You will face things.

For me, the key moment was in Chile, when I realized: "I cannot deal with this anymore. I have to put myself first". I felt terrible, I was physically ill: I became diabetic from the huge stress. My early experiences helped me identify and react to the situation: "I have to get out. This is not about me being incapable; this is about me not having to endure such extreme situations". I felt very guilty about not finishing the technical parts of the project, and about not being able to shield the students, postdocs and engineers from what was happening. I had been shielding them, but I could not do so anymore. I had to think of myself and I had to leave.

I think it is necessary to talk about stories that don't go well, and about the fact that if you can find a way out, you may have to take it. I don't think of it as failure, but it is not a success story either. We need those narratives too. We often fall into "success story" narratives. I am not blaming anyone who focuses on the positive, it is motivating. But especially for women, we also need to be honest about the difficulties. What is the point of telling young women that everything is fine, that they won't face discrimination, if that just sets them up to crash when reality hits? That is not fair. We shouldn't be overly pessimistic either. There are many opportunities, and we can do great things. But there will be costs, and it is important to talk about that.

When you are invited to work on initiatives for women in physics, do you experience a moral dilemma? What advice would you give to those participating in such initiatives?

My advice is to get people – sometimes friends, sometimes colleagues – who can tell you things you don't want to hear.

A colleague once told me: "You are banging your head against something you cannot change". One person alone cannot change systemic dynamics. She continued: "Either you learn their game and play it and maybe then you can change something, or you focus on your own project and do what you want within it, or you leave." At first I thought those are not the only three options. When you are right, you fight and you fix the problem. However, this is naive – there is no single "right", and systems are complex. But her comment was an act of friendship. She didn't just validate me. She agreed with me in substance, but understood that reality was different. It is not easy to tell someone, "maybe the answer is that you have to leave." It mattered. It was helpful. It can look like a woman against another woman, but it was in fact a woman helping another.

Tools for inclusive science

Could you recommend some resources for an inclusive science?

For visually impaired audiences, I would recommend two concrete resources. First, Chris Harrison in the UK, who works on sonification. He has a very science-oriented approach and systematically tests different sonifications with pre- and post-assessments, and publishes the results openly. It is very worth looking up his materials.

> **Sometimes the only thing stopping you is fear. If fear is the only thing, and you can afford it, then go for it.**

Second, the project with Enrique Pérez Montero, the blind Spanish astronomer I mentioned, at the Instituto de Astrofísica de Andalucía (IAA) in Spain. They have developed a series of sonifications and also organised discussions where astrophysical processes are described in a way that is carefully audio-described, not just relying on visual cues. It is like a talk show, but with a deliberate focus on description.

More generally, there are excellent resources from the Space Telescope Science Institute (STScI) – that is, the Hubble Space Telescope's operations centre – on writing Python notebooks in an inclusive way. For visually impaired people who are internet-literate, coding is incredibly inclusive. You describe what you are doing; the syntax is textual. Mathematics and coding are very accessible. And if they want to explore graphs, there are libraries that let you "scan" a plot with the mouse and get different sounds depending on whether the curve is there or not. The STScI webpage has many good materials on this.

For a closure, would you like to share some take-home messages?

This comes from a place of privilege, because I was lucky and had ways out: I think we must not blindly follow the "normal" path. If what you want to do is not what is usually considered "successful" in your field, but you truly feel it is what you want, do it. During my PhD, talking about outreach was seen as a waste of time, even by my supervisor. Anyway, I did it because it was important to me. This is easier said than done, but sometimes the only thing stopping you is fear. If fear is the only thing, and you can afford it, then go for it.

Inclusive Astronomy

Since 2015, Amelia Bayo has led or contributed to multi-sensory outreach projects grounded in Universal Design Principles.

In 2020, as director of the NPF and with support from the Millennium Scientific Initiative, she coordinated a team of engineers, educators, astronomers, designers, and inclusion specialists to create an interactive, multi-sensory kit for experiencing star and planet formation.

The material is freely available online, originally in Spanish and now translated into several languages thanks to volunteers.

Sensorial, 3D-printed models

This freely available 3D-printed model, offered either as single pieces or in segmented form depending on printer size, lets users interactively explore the main stages of planet formation.

At each step, lifting an outer layer advances the "cosmic clock" by millions of years, revealing the next phase described in the text and in the accompanying materials.

Two books, many voices

The 3D models are accompanied by two books.

The first is a booklet introducing key astrophysical concepts needed to follow the activity.

The second is a longer volume that goes deeper into the physics of planet formation.

Both books are fully audio-described, with each page narrated by a different member of Amelia Bayo's team, ensuring a rich variety of voices and accents and making the material as inclusive and accessible as possible.

All files are free to download at
https://ameliabayo.wixsite.com/astronomer/outreach

Rubrique

Screening of "All That Matters" Commemorating Rohini M. Godbole

The documentary "All That Matters", commemorating the life and achievements of Rohini M. Godbole, and directed by award-winning filmmaker Mamta Singh, was premiered on 22 November at the Inter-University Centre for Astronomy and Astrophysics (IUCAA) auditorium, located in Rohini's hometown Pune, in India. Further screenings have taken place since and continue to be scheduled throughout the country.

The documentary traces Rohini M. Godbole's scientific contributions to particle physics, including the Drees-Godbole effect, which influenced the design of a new generation of particle colliders. At the same time, it portrays her as a mentor, advocate and tireless champion of gender justice in science.

More information about the film: here.

Call for lecturers African Institute for Mathematical Sciences

The African Institute for Mathematical Sciences (AIMS) is a pan-African network of centers offering a one-year Master's program in the mathematical sciences to talented students from across the continent, with strong links to mathematical physics, applied mathematics, and interdisciplinary research.

AIMS is continuously looking for international lecturers to teach intensive three-week modules in one of its five centers, located in Cameroon, Ghana, Rwanda, Senegal and South Africa. Lecturers deliver a self-contained course, set and assess coursework, and engage closely with students.

More information and the application platform are available via the Next Einstein Initiative: here.

ICTP Associate Programmes

The Abdus Salam International Centre for Theoretical Physics (ICTP, Trieste) offers several programmes supporting researchers from developing countries at different career stages. These include the ICTP–IAEA Sandwich Training and Education Programme, as well as the Junior, Regular, and Senior Associate schemes. Together, they provide long-term research affiliation, training opportunities, and sustained access to ICTP's scientific environment.

Further details and application information are available via the ICTP website: here.

SNSF Career and Gender Equality Grants

The Swiss National Science Foundation (SNSF) invites applications for its Starting Grants, supporting early-career researchers in establishing independent research programmes, as well as for the Gender Equality Grant, a supplementary measure aimed at promoting equal opportunities in academic careers. Proposals are funded in order of priority based on their ranking and available funding, with an additional budget specifically earmarked to support additional excellent female applicants.

Further details and application information are available via the SNSF website: here.

Maryam Mirzakhani Scholarship

The Maryam Mirzakhani Scholarship, offered by the Fondation Mathématiques Jacques Hadamard, commemorates the life and legacy of Maryam Mirzakhani, the first woman to win the Fields Medal. The program aims to address the underrepresentation of women in mathematics by providing funding that can cover both the master's and doctoral phases (with a master's excellence scholarship and a three-year PhD commitment), helping recipients transition seamlessly to research within the Ecole Doctorale Mathématique Hadamard.

Further details and application information are available: here.

EDI at IFT
Intersectionality Training

The Institute for Theoretical Physics (IFT UAM-CSIC, Madrid) has begun a new series of Equity, Diversity and Inclusion (EDI) training sessions. The first, held on 25 November to coincide with the International Day for the Elimination of Violence Against Women, was a workshop titled "Intersectionality: Reflections on Identity, Privilege, and Positioning in Academia", led by Shannah Khan of Intersect Madrid. The session featured participatory exercises on identity and privilege in academia, followed by informal discussions over coffee.

Further details about the session and IFT's broader EDI activities: here.

The Newsletter Team

This issue of the GenHET Newsletter has been produced and edited by Saskia Demulder, Camille Eloy, Verónica Errasti Díez, Alessandra Gnecchi and Valdo Tatitscheff. We took over after the amazing work of Alejandra Castro and Elli Pomoni, who curated the first issues in 2020. We aim at publishing three issues per year.

We welcome suggestions for articles, interviews or announcements at genhet.newsletter@gmail.com. Don't hesitate to get in touch if you would like to become an editor.