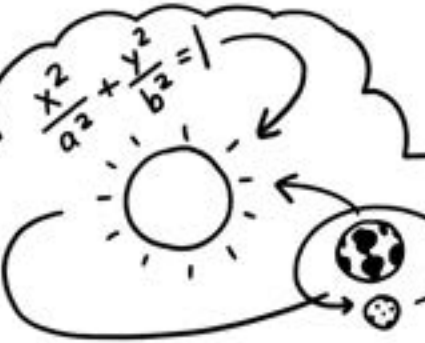
A PERILOUS PATH THROUGH PHYSICS

OBSTACLES, SUPPORTS, AND STRATEGIES OF WOMEN OF COLOR IN PHYSICS

Zine by Sophie Wang

Based on the book *The Double Bind in Physics Education: Intersectionality, Equity, and Belonging for Women of Color* by Dr. Maria Ong

Getting to think outside of the box and be creative…



…being able to generate powerful information from simple equations…

…having fun understanding motion and making sense of the world…

…wondering at the stars and the sky and curiosity about the elemental principles of the universe…

…wanting to be useful to someone through assistive technology…

…living out a mother's mathematics hopes…

…hoping for a vehicle to a better life…

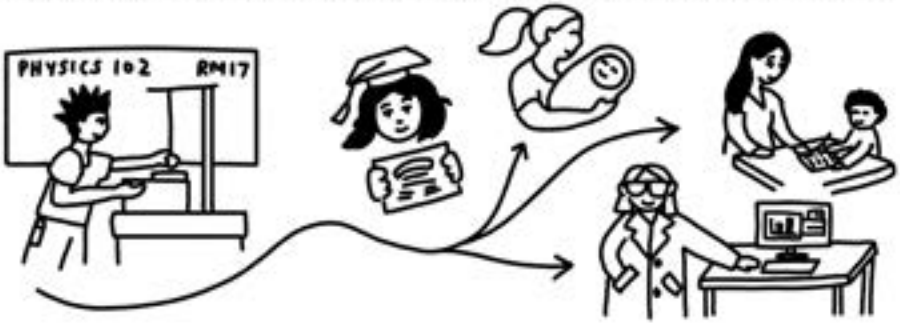
These are all reasons that led the 10 women of color featured in Dr. Maria (Mia) Ong's book, *The Double Bind of Physics Education*, to their academic pursuit of physics.

They entered with hope, excitement, and confidence — and brought with them incredible potential for new knowledge, innovation, and possibilities for our world.

But as we will see, their experiences within physics did not always encourage them to stay or provide them with the support to realize that potential.

The book follows Dr. Ong's 25-year longitudinal study of these 10 women, starting from their time as physics undergraduate students in the mid-1990s to early 2000s, all of whom graduated with bachelor's degrees in physics or related fields like engineering physics.

Over 25 years, additional interviews and observations were collected as the participants graduated, took on jobs, changed careers, started families, and lived life within and beyond physics. The analysis of these data led to the themes covered in Dr. Ong's book and this zine.



So what did physics look like then, and now?

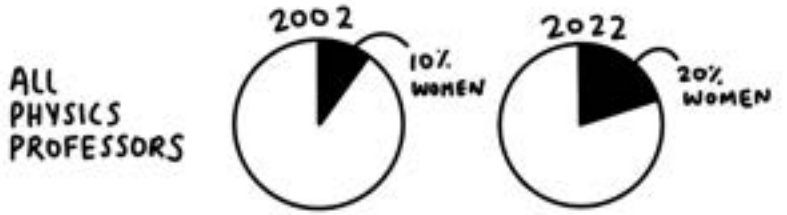
Between 1973 to 2012, 28,959 Americans earned physics doctorates. Only 11 percent of those (3291 total) were awarded to women, and only 2.7 percent (803) were awarded to women of color (Kohli, 2015).

AMERICANS WHO EARNED PHYSICS DOCTORATES IN THE US FROM 1973-2012

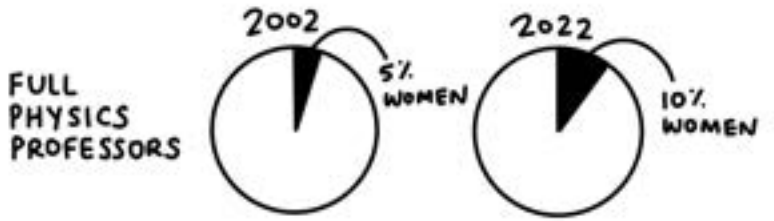
	WOMEN	MEN
WHITE	2,488	22,172
ASIAN	625	2,480
HISPANIC	106	615
BLACK	66	354
NATIVE AMERICAN	6	47

And a snapshot of the difference in representation of women in physics faculty between 2002 and 2022 shows how little things changed over 20 years.

In 2002, women made up 10% of all physics faculty, which increased to 20% in 2022.



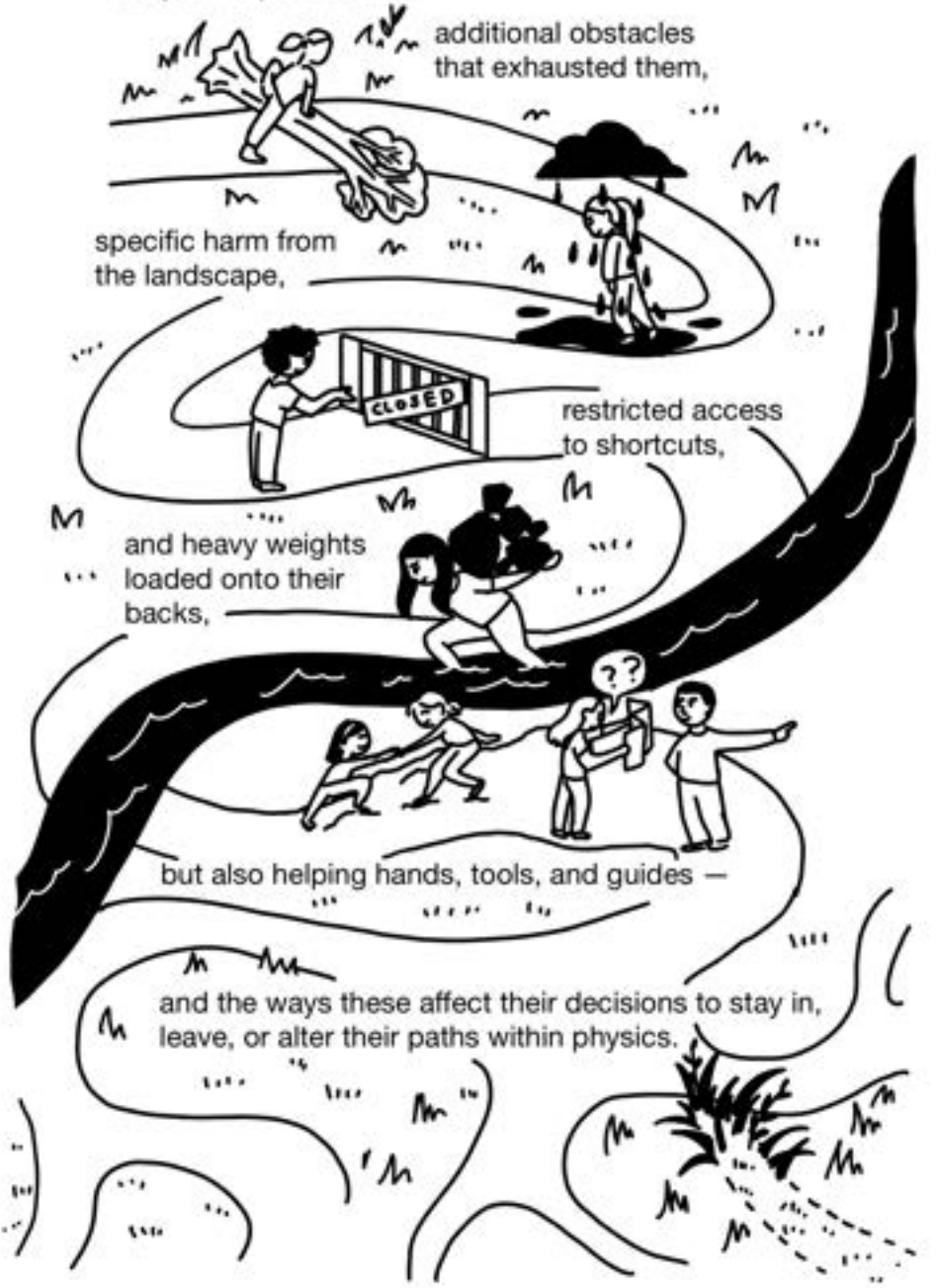
And these numbers were even lower for full physics professors — 5% in 2012 and 10% in 2022 (AIP, 2023).



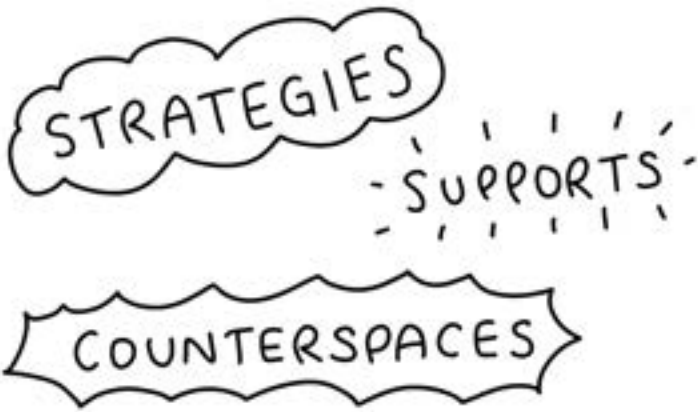
How do we change this? Current undergraduate retention efforts are disproportionately rooted in deficit models that seek to "fix" students rather than address the systemic inequitable practices and culture of STEM institutions — they try to increase interest in physics, provide tutoring, or teach "self-confidence." But the women of color physicists in the study already entered physics with enthusiasm, eagerness, and assumption of belonging. This was often followed by early experiences of discouragement, dismissal, isolation, or harassment that sent a signal of not-belonging. It was not something internal with the women of color that needed fixing, it was how the structures and people around them functioned that needed to change.

Of course, the path towards a "successful" physics career itself is not easy for anyone to traverse — continuing forward in any field requires working hard, and that's what moving along the path represents. We can see that the landscape has its own ups and downs that every aspiring physicist must navigate.

The particular focus of this zine, and the research that it is based on, is how the women of color on this path experienced



You'll also see how participants developed their own strategies for navigating their paths, and how they utilized or created counterspaces — academic and social safe spaces that allow students who are underrepresented in higher education to promote their learning, have their knowledge validated and viewed as valuable, vent frustrations, share stories of discrimination, and counteract many of the negative effects of exclusion perpetrated by majority peers and faculty (Solórzano et al., 2000).



Counterspaces are components of community cultural wealth — the strengths and assets that should be recognized and that contrast with the cultural capital typically valued in majority white, dominant culture institutions (Yosso, 2005). These and other forms of community cultural wealth will show up many times throughout this zine!

The zine is divided into sections based on themes from Dr. Ong's research that stood out to me when I read through her book. When Dr. Ong reached out to me to create a zine based on the book, I was struck by how familiar many of the experiences of the women of color participants were to me, as a former lab and field scientist. Just as pressingly, however, I was reminded of my experience teaching workshops around systems of oppression and the sociology of science to working science professionals — and how those workshops were the first time that many of the men and the white participants had ever considered the harassment, additional emotional and physical labor, and invisiblization that marginalized people in the sciences experience. I hope that this zine can be a useful, engaging, and accessible introduction to some of those experiences in hopes of educating readers on what needs to change and what meaningful forms of intervention have proven to be, and is of course organized through my own lens on the research.

Each section of the zine will name a theme, provide a brief description of the theme, and then include subcategories that will each contain a related anecdote from a study participant. These will be visualized as obstacles in the path, weights a participant is forced to carry, or other physical manifestations that create difficulty. Some sections will also include strategies or structural supports that helped participants continue towards their goals. These will be visualized as useful tools, ropes and railings, or other physical manifestations that create ease or support.

Page numbers in the zine that are not accompanied by a specific reference are all from *The Double Bind in Physics Education.*

Here's a quick table of contents for your navigation:

Harassment: Pp. 30-36

Exclusionary Cultural Norms: Pp. 36-43

Making Their Own Paths: Pp. 44-47

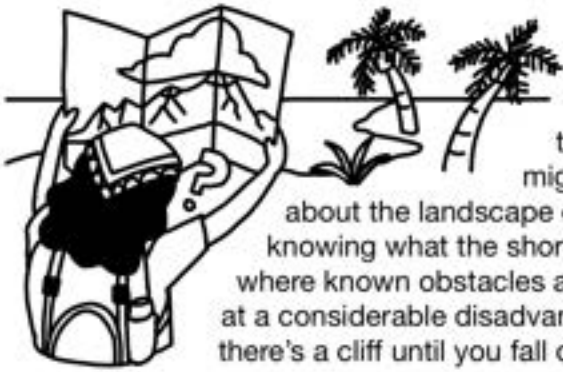
Conclusion: Pp. 48-51

Author's note: This zine is meant as an introduction to some of the powerful themes that came up in Dr. Ong's study. If some of the themes here pique your interest or if you would like a more thorough exploration of anything introduced in this zine, we recommend following up by reading the book itself!

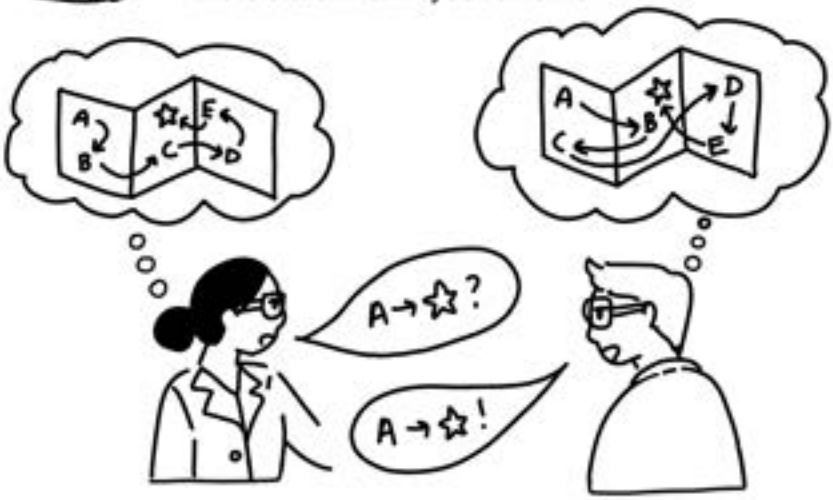
THEME 1

LACK OF SUPPORT AND LOW EXPECTATIONS

MISMATCH OF CULTURAL OR STRUCTURAL NORMS



It's hard to start a journey with a map that shows a completely different place than the one you're at. You might have lots of knowledge about the landscape of this other place, but not knowing what the shortest path here to take is or where known obstacles are on this path places you at a considerable disadvantage. You might not know there's a cliff until you fall off of it!

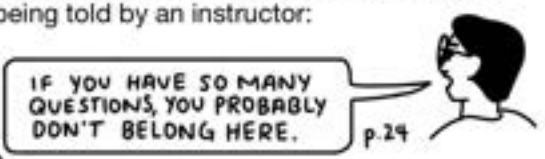


In the same way, upon beginning their physics education, participants were confronted with cultural norms and expectations for behavior that were not explicitly stated or communicated, and which they often were unaware of until they experienced repercussions for not following these unspoken rules.

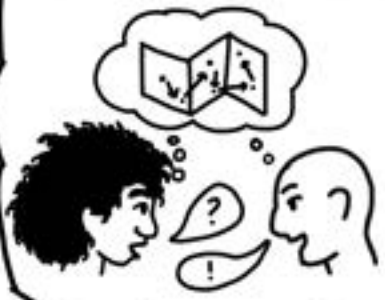
EXAMPLES

One example of this is in asking questions — when participants did not ask the right number or right kind of questions, they experienced harmful consequences.

Gabriela frequently and vocally asked for help during class, which combined with her identity as an Indigena and Chicana woman from a low socioeconomic background led to her being told by an instructor:



On the other hand, Irene, a Filipina American woman, intentionally did not ask professors for help out of fear that this would be seen as incompetence, which instead led to isolation and lack of meaningful professional relationships (p. 52).



Sometimes, participants' approach to asking questions did line up with the norms of their departments. Kendra's questions about professors' current research were welcomed, as they demonstrated understanding and interest about broad possibilities of the field (p. 24).

So what is key here is not whether women of color in physics were *able* to act according to the norms of physics, but how those norms were *not communicated* and any forms of behavior outside of those uncommunicated norms had *negative repercussions*.

Participants also experienced a lack of structural support through uncommunicative advising as well as uncommunicated bureaucratic and departmental procedures that were necessary for graduating on time and with the desired degree.

For students who came in with the "right map" from parents or community members who could advise them based on their own experience, this difficulty navigating academic bureaucracy would have been an easily avoided obstacle.

COMPETITION BETWEEN STUDENTS

Most physics courses were graded on a curve, meaning that students' grades were given relative to each other. This structure led to a competitive, isolating, and individualistic classroom environment, with some students even deliberately giving each other wrong answers. Many women of color also experienced exclusion from study groups or having contributions ignored in study groups.

SUPPORT FROM PEERS

On the other hand, participants also found sources of support, such as from peers majoring in related fields, who were able to support instead of compete as they were not in the same classes. They were "finding support and creating support on the edges of physics" (p. 30).

LOW EXPECTATIONS

Participants consistently experienced low expectations from professors and peers about their abilities in physics, finding themselves to be "presumed incompetent" (Niemann et al., 2020). As Tory put it, "They expect less of me than I can give" (p. 159).

EXAMPLE

Julie's experience with one of her TAs exemplified this — he would answer her questions very differently than other students' questions, starting from the beginning every time and with a much slower explanation — treating her like she wasn't capable.

These low expectations send signals to women of color that they do not belong in physics and that there is a limit to what they can achieve — leading to worse performance. Michelle Camacho and Susan Lord (2013) reported on research by Miyake et al. (2010) that showed that when women and men are given the expectation that they will perform at equal levels and told that they possess equal skills, the gender gap in achievement is erased.

SUPPORT: STUDENT SUPPORT PROGRAMS

Many participants also found a respite from the low expectations and stereotyping of peers and instructors in student support programs — an important form of counterspace. In these student support programs, participants didn't have to worry about peers' or instructors' negative assumptions about them. As Tory said, "I knew if I didn't know how to do a problem, someone wouldn't look down on me, that it was more of a mutual helping environment instead of a competitive environment" (p. 160).

They also often communicated high expectations to their participants — one program told participants that, as a group, they were expected to perform above the average in their courses. This framed exam performance as a communal goal rather than as a personal achievement, and the structure that the high expectations provided led to high achievement from participants.

THEME 2

TEST ANXIETY AND STEREOTYPE THREAT

Women of color, especially in STEM, deal with presumptions of inferiority and low expectations from professors and peers on a regular basis, often rooted in belief systems (such as white superiority, ethnocentrism, patriarchy, heteronormativity, and classism) about their intellectual inferiority.

Out of these belief systems come cultural stereotypes, which are communicated and reinforced through everyday forms of bias and discrimination. Stereotype threat is feeling at risk for confirming a negative stereotype about a group to which they belong (for example, that women are not good at math). This can cause stress to personally prove these stereotypes wrong and debilitate performance in ways that do not affect members of nonstereotyped groups.

EXAMPLE

Kendra demonstrated extreme competence in discussing high-level physics concepts with professors and competently assisting in research labs, but struggled during exams because of test anxiety likely resulting from stereotype threat and seeing her own abilities through a distorted lens.

STRATEGIES

Some participants also developed personal strategies to combat low expectations and stereotypes:

"LETTING IT SLIDE"

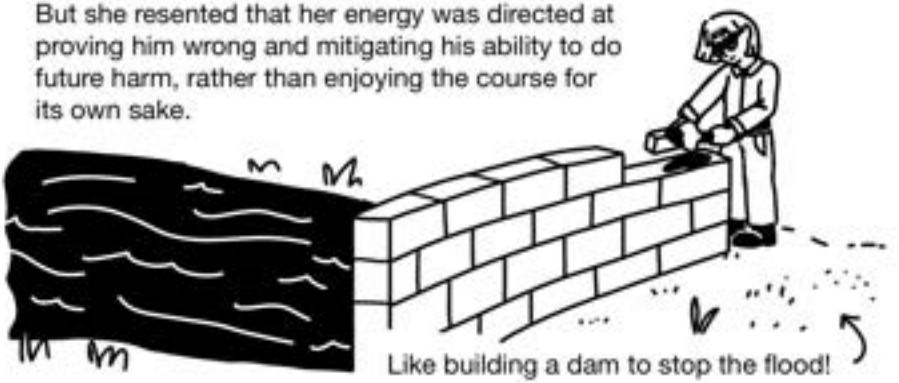
Elena's strategy was "letting it slide" (p. 141) - taking a compassionate stance that instructors were unaware of harm they were causing, and reserving time and energy for studies and personal life. This strategy had a positive impact on Elena's experience, but did not lead to change in behaviors or actions of the instructors that were causing the harm.

Like pulling on a pair of waders to cross a flood!

GETTING ANGRY AND TAKING ACTION

Tory's strategy was getting angry and taking action — she reported her instructor who made derogatory comments about women's intellect to departmental officers, which led to him being reprimanded and thereafter refraining from making further comments.

But she resented that her energy was directed at proving him wrong and mitigating his ability to do future harm, rather than enjoying the course for its own sake.



Like building a dam to stop the flood!

Participants didn't just employ personal strategies — counterspaces provided support as well.

One form of counterspace where participants could study, socialize, and just "be" without worrying about being stereotyped or marginalized for their identities were informal peer groups, which often developed from the more formal student support groups that participants were a part of.

EXAMPLES

After Tory "aged out" of a formal program for students underrepresented in physics, she and the friends she had made in the program continued to hang out, study together, and support each other in their endeavors.

Tory and her peers could be their full selves with each other — something they missed not only in physics classes as often the only women or students of color, but also in their diverse friend groups outside of physics where no one else would get physics references.

In *The Double Bind of Physics Education*, Dr. Ong recounts a time she was standing with Tory and Amy in a parking lot. They pointed to jet contrails in the sky, commenting that they looked like "sine waves" (p. 162).

Tory said of being around these peers:

Sofia also found comfort in working on physics with students who were also women or students of color, saying "It's important for me to not feel like I'm dealing or battling or getting angry. Wondering…if this person thinks that I'm a slacker because of what I am" (p. 163).

THEME 3

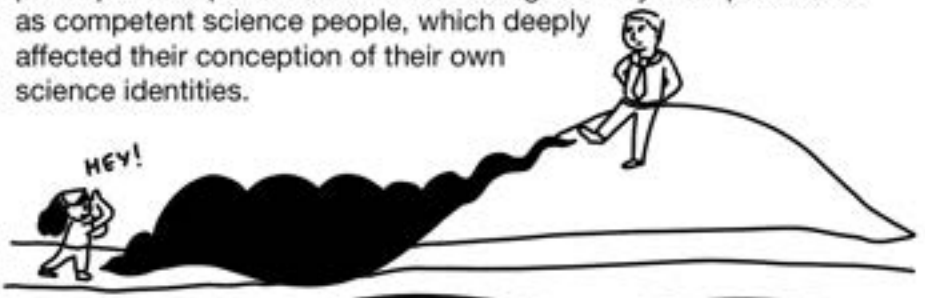
INVISIBLIZATION

Imagine getting a big cloud of dust kicked in your face. Whether it was done intentionally or unintentionally by someone way in front of you, someone right next to you, or a gust of wind, it would make your lungs hurt, your journey ahead harder to navigate, and make you harder for others to see.

This was participants' experience with being not recognized as people who could be competent physicists by their professors, classmates, others, and even the physical infrastructure of their campuses. Other people's actions and artifacts rendered participants' presence, accomplishments, and identities invisible, making their physics journeys more difficult.

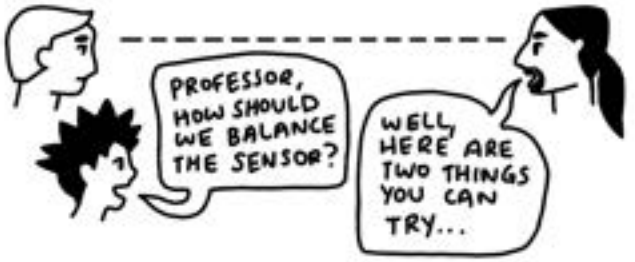
INVISIBLIZATION BY PROFESSORS

Heidi Carlone and Angela Johnson's research has shown that recognition by meaningful scientific others was a predictor of identity development as a scientist – even more than performing well or having a sense of competence. Unfortunately, multiple participants experienced a lack of recognition by their professors as competent science people, which deeply affected their conception of their own science identities.



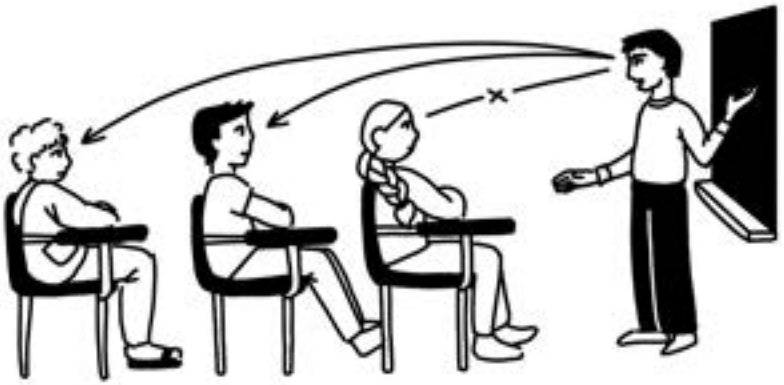
EXAMPLES

During an experimental laboratory course, Irene and her lab partner Kyle (a white man) went up to their professor (a white man) to ask a question. Even though Irene was the one who asked the question, the professor only looked at Kyle while answering. This experience stuck deeply with Irene through the rest of her physics education.

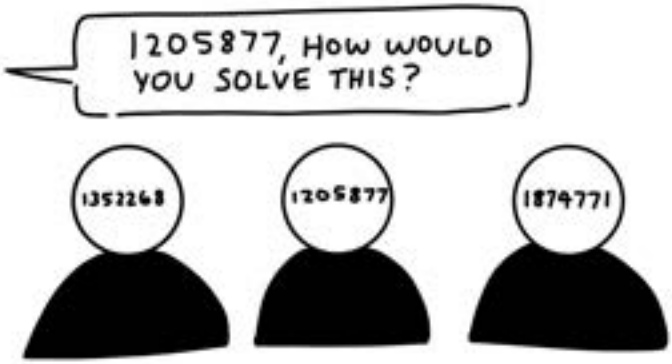


While Irene described the professor as a "great guy…I wouldn't think he has anything against women. I'm sure he had no idea he was doing it" (p. 47), what stayed with her was the signal, sent by a meaningful scientific person, that she did not belong at the center of a physics conversation.

Laura noticed that professors seemed to avoid looking at and speaking with her, which she attributed to her being both Latina and a woman. "It affected me a lot in the beginning…when I started to look at professors and notice that they wouldn't even look my way…I sit in the front. It's hard to miss me." (p. 48)

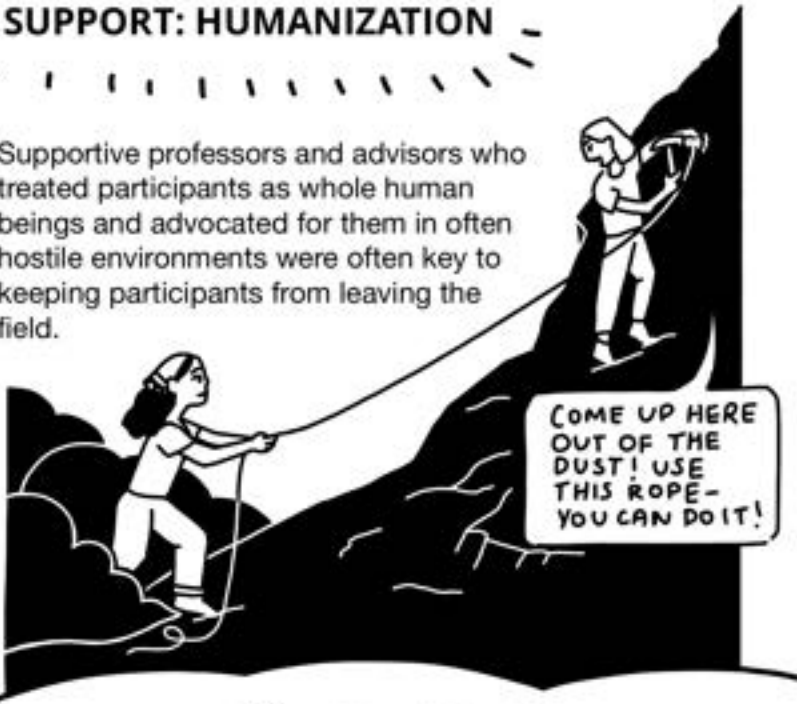


Sometimes, invisiblization took the form of dehumanization. Sofía, a Mexican American first-generation college student, noted that some professors - all white or Asian men - referred to students by their ID numbers instead of by their names. This made her feel unseen and like they had no concern for her, which negatively affected learning.



SUPPORT: HUMANIZATION

Supportive professors and advisors who treated participants as whole human beings and advocated for them in often hostile environments were often key to keeping participants from leaving the field.



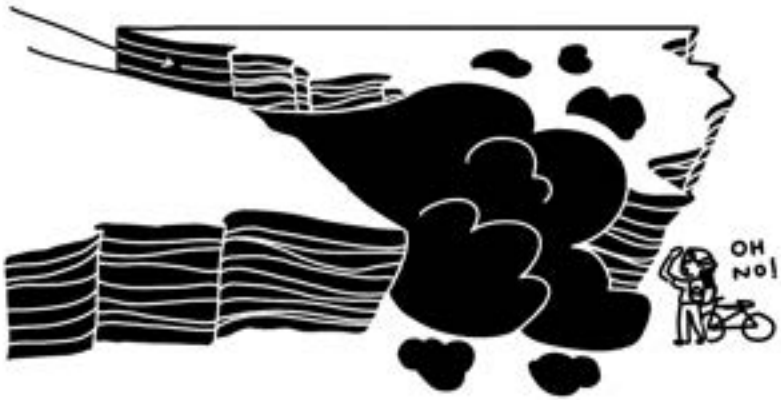
EXAMPLES

Sofía contrasted the dehumanization she experienced being referred to only by her student ID number with her experience with a math professor, a white woman, who told Sofía she was doing well but could do even better. This made her feel seen and understood, and she worked even harder to meet the professor's expectations.

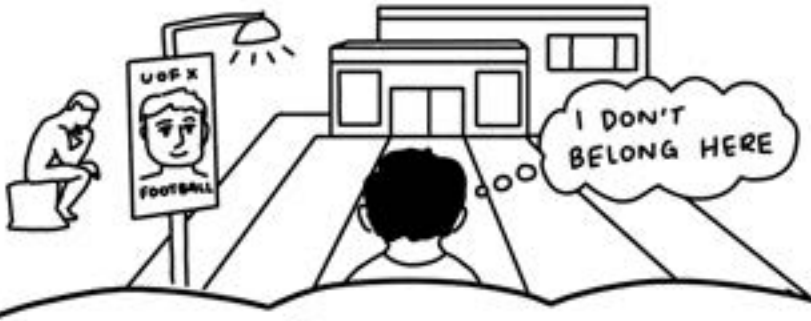
Participants also found mentors from outside sources.

For example, the director at an off-campus research center, who supported Gabriela through giving her opportunities to learn new skills and present findings at prestigious research conferences.

INSTITUTIONAL/STRUCTURAL INVISIBLIZATION

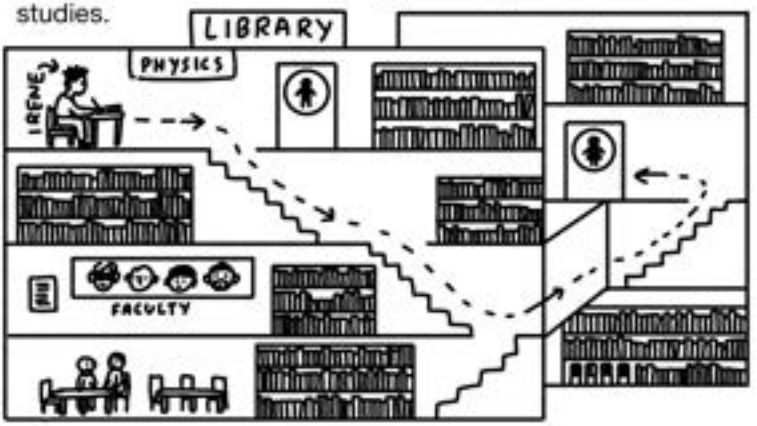


This invisiblization extended beyond the individual or interpersonal actions to institutional microaggressions as well. Kenneth González's research has shown how a lack of Chicano representation in the architecture of the buildings, sculptures, banners, posters, and other physical symbols found on campus led to the cultural alienation of Chicano students (González, 2002).



EXAMPLE

Irene experienced this structural non-belonging firsthand — the only restroom in the physics library floor was a men's room. To find a women's restroom, she had to trek to a different floor on the opposite side of the building — losing valuable time in her studies.



Additionally, the lack of faculty who looked like her in the photo gallery of physics department professors affected her own aspirations — it sent the message that if there wasn't anyone who looked like her there, then she didn't belong there either (p. 54).

INVISIBLIZATION BY PEERS

In addition to the competitive peer environment described earlier in the zine, participants also experienced being ignored, their knowledge not being trusted, and otherwise being made invisible by classmates.

EXAMPLE

In one class, Irene was helping an Asian American male engineering major with a "stereotypical nerd appearance" with his work, as he was struggling to pass the class. But peers perceived him as someone with expertise because of his appearance, while overlooking or ignoring Irene. Peers asked only him for help, not both of them and certainly not her.

This sent the message that her study partner, although failing, belonged in STEM while she did not. As Irene reflected, "I guess I just didn't have the appearance of someone who looks smart, someone who could do physics" (p. 50).

STRATEGY: PERFORMING SUPERIORITY

Participants also used a strategy of "performing superiority" to assert themselves as competent physicists amongst their peers and overcome discrimination (p. 135).

EXAMPLE

Amy "performed superiority" by sharing her test scores - the highest in the class — with her peers.

This led to Amy receiving invitations from classmates to join them for homework sessions. Irene did this by fearlessly debating peers and taking satisfaction in their realizing her superior knowledge. She would keep to herself during study sessions until someone accused her of doing a problem wrong, at which point she would take them to task, underscoring her competence and belonging in physics.

SUPPORT: ALLYSHIP

This invisiblization by peers did not end for participants once they graduated from school. Participants continued to experience being overlooked and ignored by peers as working professionals, but key allies provided support.

EXAMPLE

Tory recalls being in meetings as a PhD professional working at a national laboratory where the whole group of white men 10, 15, 20 years her senior would ignore what she would say.

Fortunately, she had an ally in her senior colleague Will. Will would write down what Tory said, repeat it whereupon it would be well received by the same group of men, and then credit Tory. He would also affirm Tory's experience of being ignored, saying to her, "I've never seen such blatant sexism in my life. I'm not going to change these people. The best I can do is just amplify you" (pp. 164-165).

INVISIBLIZATION OF SCIENCE IDENTITY

Participants also experienced having the burden of proof being placed upon them to prove they were actually scientists, rather than simply being believed upon claiming a science identity.

THEME 4

HARASSMENT

Sometimes, the obstacles aren't as subtle as holes in the path or lakes to cross. Sometimes, it's someone dropping a bucket of sludge on you that you just can't shake off.

All ten participants related that they experienced identity-based harassment that was due to their race, ethnicity, learning differences, immigrant status, or gender, or a combination of these identity markers. The fact that these identities are inseparable and intersecting in different ways means that participants' experiences with harassment cannot be often tied to a single identity.

As Laura said, "The fact that I don't have things in common with the guys in the [research] group, is that because I'm a woman, or is that because I'm a minority? Or is that because I'm both? … Or is that because I'm poor? … I can't really separate the three. I'm both. I'm all three" (p. 115).

GENDER-BASED HARASSMENT

Gender-based harassment includes verbal and nonverbal behavior that conveys degrading attitudes about members of one gender.

EXAMPLES

The following are three out of many, many, more experiences that Elena, a Latina physicist, had with gender-based harassment:

1. "A WOMAN LIKE YOU"

As a senior, Elena was asked by her professor, a middle-aged white man, to show a prospective student, a white teenage girl, around their department. Before the tour, the professor said to Elena:

Later, reflecting on this incident, Elena said:

"I took it very personally…I felt very diminished, and I felt very singular, separate because of my gender, and as if being a woman was something wrong." (p. 64)

2. "YOU CANNOT BE ATTRACTIVE *AND* THINK"

One evening while out wearing a skirt, Elena remembered that she had lab — instead of going to lab in a skirt, she bought pants.

"There was no way I was walking into a lab with thirteen males, who have said sexually derogatory things to me before. I feel like, 'Okay, you cannot be attractive *and* think.'" (p. 69)

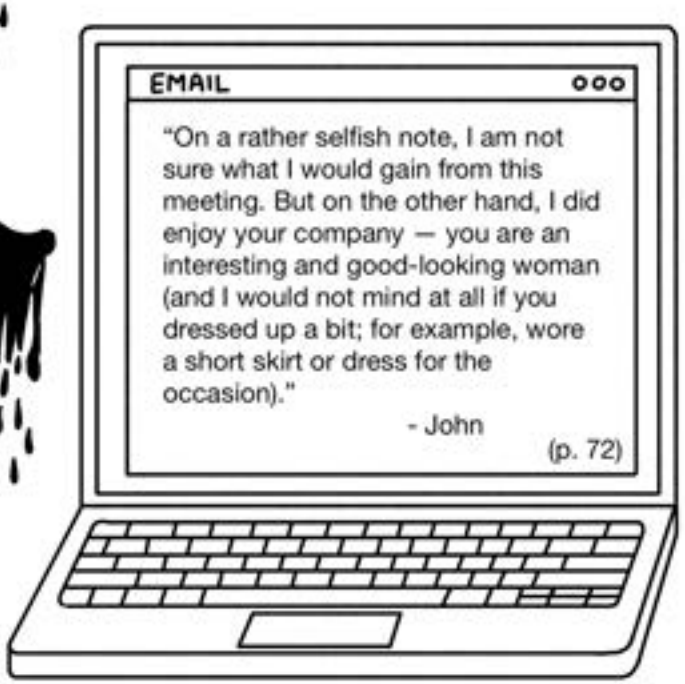
Over the course of her physics career, Elena changed how she dressed in response to the harassment she experienced from the "bro culture" (p. 67) of the physics world.

As a professional physicist, Elena still preferred dresses and skirts, but they stayed untouched in her closet — she wore only slacks and high-collared blouses to work.

Elena's accommodation of the cultural norm of masculine presentation in physics highlights a systemic institutional problem: that these cultural norms and who can be seen as belonging in physics are enforced through sexual and gender harassment.

3. "I WOULD NOT MIND IF YOU WORE A SHORT SKIRT"

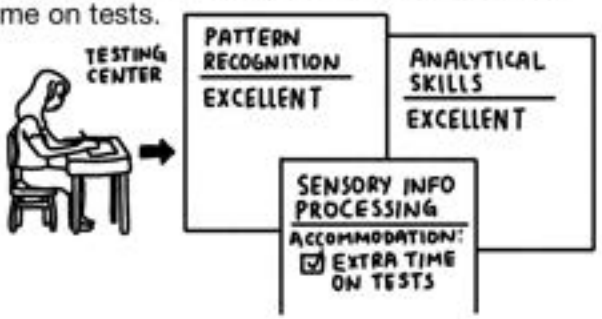
As a postdoctoral fellow, Elena was at a networking event where she had a conversation with John, an older white full professor interested in a similar mathematics topic as her. When she emailed him an invitation to meet to continue their discussion on the topic, his reply ended with:



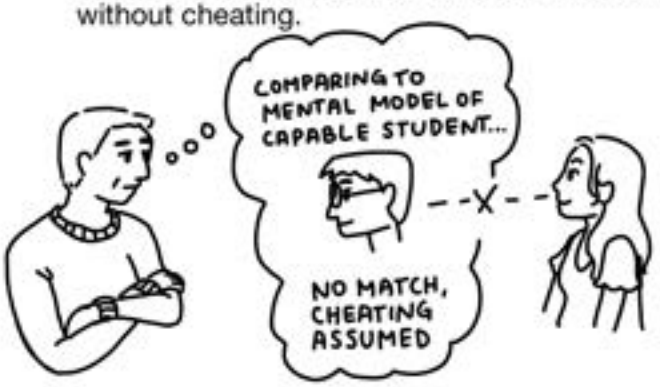
In an instant, Elena's hopes of having him as a mentor evaporated, and she also began to expend valuable time, energy, and worry deciding how to respond while also protecting her professional reputation.

HARASSMENT BASED ON LEARNING DIFFERENCES, RACE, AND GENDER

While an undergraduate, Elena was diagnosed by the University's learning accommodations office and found to have off-the-charts pattern recognition and analytical skills but slower sensory information processing, which qualified her for the accommodation of extra time on tests.



One of her professors believed that Elena did not deserve the high marks she received when she was granted this accommodation, and was cheating by feigning needing accommodations — and called a special faculty meeting to complain about this. This accusation was a form of identity-based harassment — because she is a person with a learning difference and a Latina, he did not consider her to be a student capable of achieving the marks she was getting without cheating.



She experienced this as both a self-doubting and then later a self-strengthening experience — having to make a case for herself as a competent physicist all the time. Surveys from the Association for Women in Science show that women of color in science disproportionately express reluctance to disclose learning differences or disabilities out of fear of harassment (Metcalf et al. 2018).

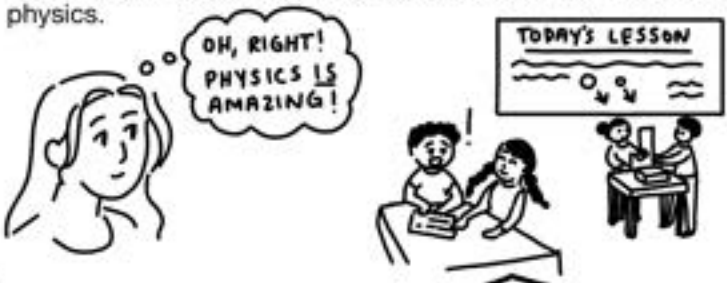
Looking back on the harassment incidences, Elena placed at least partial blame on the culture of science, which fosters an emphasis on intellectual development over other aspects of human development, such as learning to treat others equitably (p. 81).

One of the individual strategies that participants used to deal with the diminishment and trauma of harassment was taking a break.

Breaks allowed participants to protect themselves, recuperate, and rediscover their love for physics — to unpack and unload some of what they're carrying. What can be discarded, what can be looked at in a different way as a tool moving forward, what can be a lesson for how to prepare for the journey ahead?

EXAMPLE

Elena took time off between undergraduate and graduate school to contemplate questions about identity and belonging and intellect that, if she had not put herself in that environment, she could easily have remained oblivious to. She also volunteered as a science and mathematics tutor at a school with predominantly African American and Latinx children, reconnecting with the joy that she felt in physics.



THEME 5

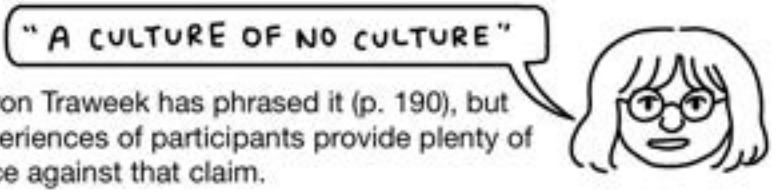
EXCLUSIONARY CULTURAL NORMS

Like the current in a river, physics has a culture that runs in a singular direction, forcing people to conform (even if it's unsafe), unless they choose to exert energy to leave the river or move against the flow.

Earlier, I talked about how the cultural and structural norms of physics were often uncommunicated to but expected of participants, and how the mismatch between the cultural norms they grew up with and the cultural norms of physics led to feelings of non-belonging and isolation.

But while communicating some norms may have helped participants navigate them, other norms of physics in the US are inherently at odds with values like caring for family, participating in community outside of science, and seeing people as whole.

Physicists may claim that physics is



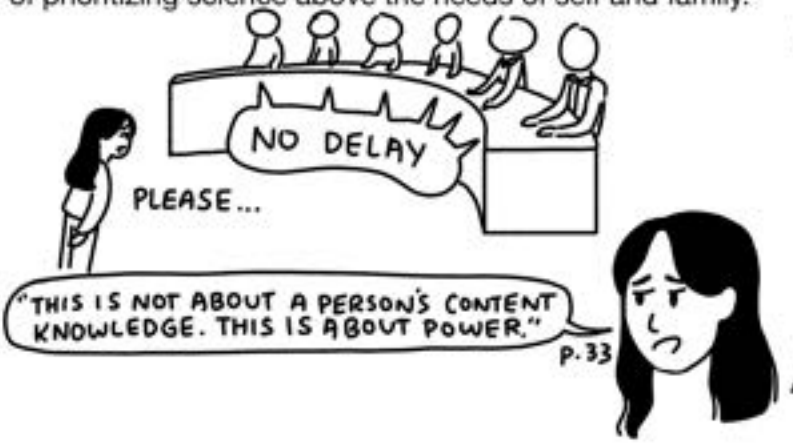
as Sharon Traweek has phrased it (p. 190), but the experiences of participants provide plenty of evidence against that claim.

PRIORITIZING SCIENCE ABOVE NEEDS OF SELF AND FAMILY

Participants were expected to put science first, even when catastrophe hit their lives or their families. There was little empathy from professors or bosses for any disruptions in their science.

EXAMPLE

After the sudden death of Gabriela's father during her qualifying exams, the white men who made up her panel of faculty judges refused to delay the last portion of her exams. The faculty insisted she abide by the cultural norm of prioritizing science above the needs of self and family.



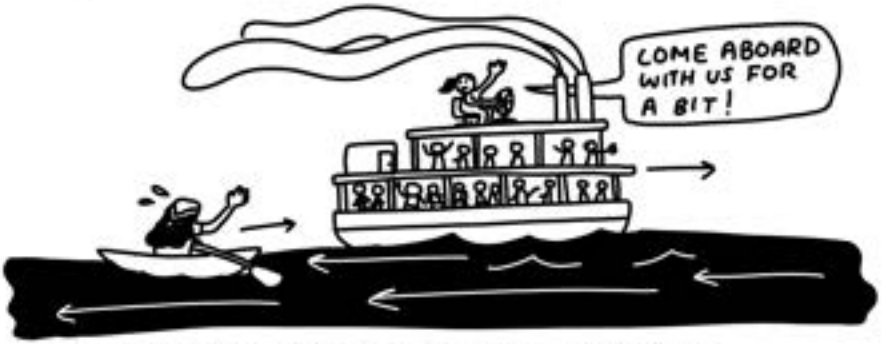
Later, Gabriela learned that two other students, a white man and a Latinx man, had been given different treatment and allowed to schedule a time to retake their exams after failing them. To Gabriela, these discrepancies were messages that these faculty believed she did not belong because she was a woman of color, leading to the internalized feeling that it didn't matter what she did to prove herself, they didn't believe she was smart enough, that she belonged there, that she did good work.

CULTURAL NORM OF SCIENCE AS OBJECTIVE

One major cultural norm in the math-based sciences like physics is that the field is objective and devoid of "social components" like racialized and gendered discrimination. This was a cultural norm that many participants had also internalized, and so the realization through experience that physics does have cultural norms, and that different rules apply to those who "belong," was both painful and unexpected.

Furthermore, upon this realization, participants who tried to remove the social and the self from their science to fit this norm realized that that does not change others' exclusionary behavior towards them.

COUNTERSPACE: IDENTITY-BASED STEM PROFESSIONAL ORGANIZATIONS



Participation in identity-based STEM professional organizations like the Association for Women in Science (AWIS), Society of Indigenous Physicists (SIP), and the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS) allowed participants to embrace both their cultural and STEM identities (p. 176). These organizations were important in providing participants with a sense of belonging, professional development, and funding — elements often missing from their home institutions.

They were also often a source of friendships, mentorships, and other community that provided participants with support beyond the bounds of the formal programs or organizations.

CULTURAL NORM OF THE IDEAL WORKER

To many women of color, physics functioned as a field that "doesn't allow reality" (p. 117).

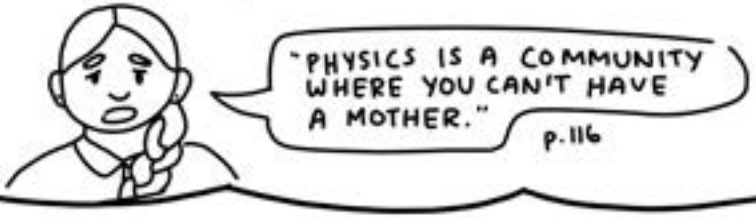
The culture of physics did not take into account students needing to graduate with urgency to attend to familial or financial responsibilities, and assumed all physicists had the freedom of time to sit and think indefinitely.

"The ideal worker norm in physics is not just a cartoon image of a white man in a lab coat; rather it involves a set of assumptions about one's availability — in terms of time, finances, relationships, and priorities — to prioritize scientific work above all else. …This cultural norm is particularly entrenched in physics academia, which is considered to be the intellectual apex of the field yet provides mediocre salaries…" (p. 125).

EXAMPLE

When Laura was a PhD student, she was financially supporting her immigrant mother and needed to graduate as early as possible in order to find a job that paid better than her minimal graduate student stipend. The structure and norms of physics did not allow that, as she was expected by her advisor and other professors to work on various side projects with colleagues. As white men without financial obligations to extended family and often with spouses to rely on for childrearing and other life work, they did not understand Laura's familial financial pressures.

While Laura was deeply passionate about learning and teaching new scientific knowledge, she knew that she would go into industry rather than academia in order to have financial stability for herself and her family. As she said:



NARROW EXCLUSIONARY DEFINITION OF SUCCESS

One of the norms of physics is prioritizing achieving "excellent science" and "getting there first" through single-minded dedication to science (p. 146). A minimum of 12-hour days, 6 or 7 days a week was a standard work week.

EXAMPLE

When Amy became pregnant, she was still expected to work the long days and weeks even when not feeling well. This led to her thinking:

SUPPORT FROM FAMILY

While participants carried the weight of extra responsibilities and pressures from supporting family, family also provided reciprocal love and support that made it possible for participants to have families and still succeed outside of the "ideal worker" norm.

EXAMPLE

While Laura's PhD program experience was deeply shaped by her filial responsibility to her mother, it was the support of her mother that later made it possible for her and her husband to work while still having childcare for their child.

THEME 6

MAKING THEIR OWN PATHS

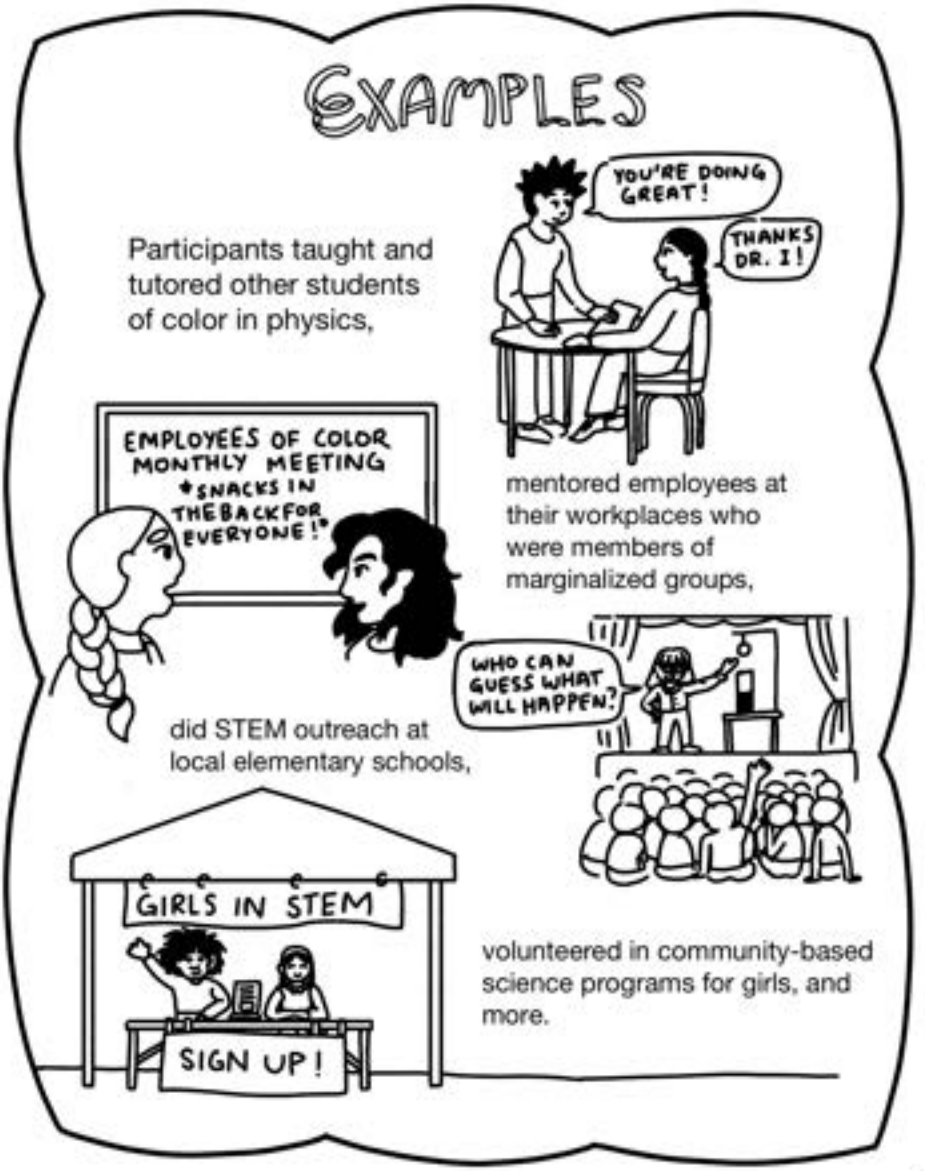
The women of color physicists in this study demonstrated powerful agency to change their paths to fit their needs and desires better, when confronted with a dominant culture that was at odds with the ways of life they desired.

However, it requires more energy to make your own path and to help others along the path — not just yourself. Additionally, this work was often devalued or tokenized professionally, rather than being recognized as an integral part of professional physics.

STRATEGY OF TURNING TO TEACHING AND OUTREACH

Many participants found new ways to define physics success by turning to teaching and outreach to underrepresented students as an alternative and more gratifying path than research.

These participants who have embraced an "altruistic scientist identity" (Carlone & Johnson, 2007, p.1203) find satisfaction in providing current students with the guidance, advice, and support that they themselves did not have as students, and see it as a form of "paying it forward" for the support that they did receive.

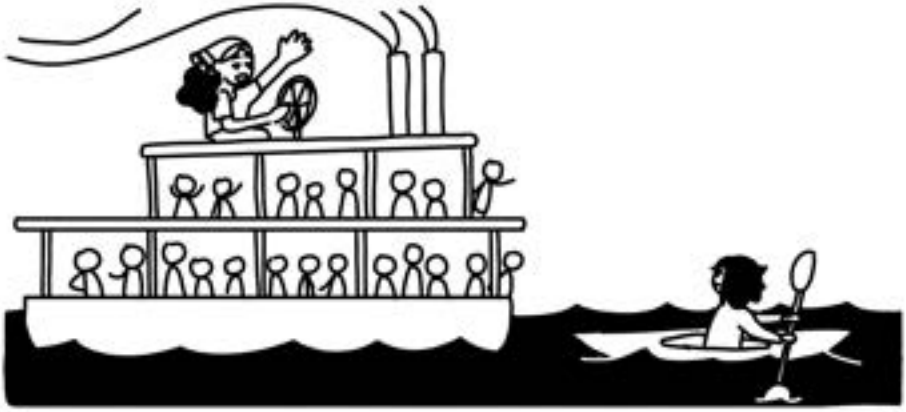


EXPLOITATION OF OUTREACH WORK, LABOR, AND CONNECTIONS OF WOMEN OF COLOR

However, participants experienced colleagues either ignoring/ belittling work with community groups, or only acknowledging such work in tokenized ways, such as naming connections to community organizations in proposals in order to get grant funding.

LEADERSHIP IN COUNTERSPACES

As the women of color advanced in their professional trajectories, their roles in counterspaces also changed as they became the role models, mentors, and allies that supported junior members.



EXAMPLE

They did this through informal mentorship and formal advising, amplifying their voices by suggesting them for leadership positions, creating working groups around diversity, equity, and inclusion, and more.

EXPECTATION OF ADDITIONAL LABOR

While most participants chose to participate in outreach activities for fulfillment and to give back, for other participants there was also the expectation that, as members of underrepresented groups, they would put time and energy into additional labor to support other members of these groups.

Laura expressed that one reason she decided not to go into academia was because they would expect her to do additional unpaid labor.

CONCLUSION

Ultimately participants expressed gratitude for their experiences, positive and negative, as they learned more about themselves and the kind of physics professionals they wanted to become.

True to this reflection, the study participants represent many different kinds of physics professionals in their current careers. These include a tenured physics professor happily working with predominantly Black and Brown and low-income students at a public university; an administrator in a university physics department promoting positive experiences for underrepresented students; a physical sciences lecturer and senior researcher in a renowned research group; a previous deputy director who is currently struggling to find a new job that recognizes her experience and worth; and a senior researcher at a national laboratory who cofounded a leadership group focused on diversity and inclusion.

These women started their physics journeys with passion, curiosity, and responsibility. As they made their ways along their physics journeys, they showed incredible resilience, agency, and resourcefulness in the face of an often hostile or exclusionary landscape. They made their own paths and found strategies for dealing with heavy weights and obstacles — contributing to physics research and the development of the next generation of underrepresented physicists along the way.

They expressed happiness and satisfaction with their lives and how they've navigated impossible choices — but also flashes of anger and sorrow because of the way that many choices along the way were presented as all or nothing. Many felt forced to leave research because there was only one accepted culture and way to do physics research — a culture that was often exclusionary of participants' inherent existence as women of color, as well as their access to resources and their desires to live whole lives. "I think there's a lot of contribution that I could have made without making such draconian sacrifices" (p. 148).

RECOMMENDATIONS

So as we look back on this journey, we see the power but also the limitations of individual strategies for removing barriers to successful physics lives for women of color.

Structural changes are also needed in order to change the representational landscape of physics:

1) Acknowledge that physics has a culture, and allow its norms to be questioned and changed.

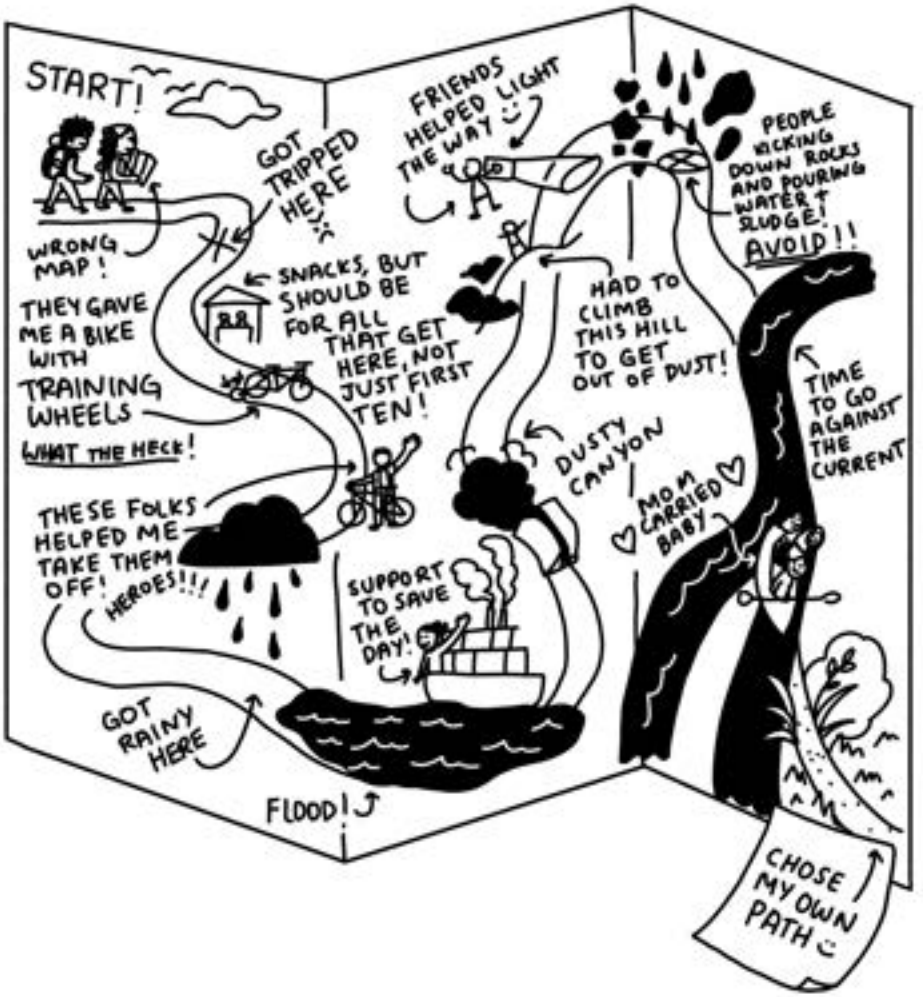
2) Enact accountability for all forms of identity-based harassment and stereotyping.

3) Listen to women of color and other marginalized students; their navigation strategies point to barriers that should be removed, environments that need fixing, and supports that work.

4) Fund and support women of color's participation in identity-based organizations and counterspaces; make room for multiple cultures and whole selves inside physics spaces.

5) Broaden the definition of success and change the definition of a successful scientist.

The journeys of these women of color have given us a deeply detailed map for change — now, it is our collective responsibility to take action towards a better physics world, and a better world for all of us.



This zine is based on Dr. Maria (Mia) Ong's 2023 book, *The Double Bind in Physics Education: Intersectionality, Equity, and Belonging for Women of Color*, published by Harvard Education Press.

Support and feedback for the zine was provided by Dr. Ong and Jaclyn Parks, Senior Director of Brand Strategy and Communication at TERC.

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