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Women in the Physics and STEM Pipelines: Recruiting, Retaining, and Returning in the Aftermath of a Global Pandemic

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Abstract

Designing strategies to implement diversity, equity, and inclusion (DEI) best practices have become a mainstream topic of conversation in the workplace. Surface-level changes are questioned, and more consequential actions and practices are sought out by employees (administrators and faculty in higher education) and their clientele (students) in industry and in academia. Both the academy and the corporate world have launched initiatives showcasing their efforts to recruit and retain diverse workforces within the STEM pipeline [1 - 2]. Still, various studies have demonstrated that women were more likely removed from the workforce or faced significant career setbacks as a result of the COVID-19 pandemic [3]. With a focus on women in Physics, this paper will provide a synthesis of the major research findings on the potential impact of the pandemic on both new and existing inequities faced by women on STEM career trajectories. These findings include those enlightened by informal discussions with women physicists at varying stages of their careers. We seek to uncover and identify how the pandemic may have further exacerbated those inequities already present in the workplace. By comparing and contrasting the underlying inequities and the role that the pandemic may have played in the corporate and academic workforces, we will explore and identify potential DEI solutions and best practices that organizations and institutions might implement to better support and retain their current workforces. For example, the pandemic has forced organizations and individuals to rethink work-life integration as they have attempted to achieve a new balance in what is often referred to as the *new normal*. Though neither academic nor industry STEM fields have yet found gender parity in their respective workforces, through a cross-sector comparison, this paper will address a fundamental shift that needs to occur in the way effort and performance is measured to retain and return female talent into the STEM pipeline. It is both timely and critical to take more immediate action to address gender-related DEI issues and their impact both pre- and post-pandemic on women in Physics and STEM career paths.

Introduction

DEI best strategies and practices have become one of the most critical and timely topics in higher education. While most of us have our own definitions of what DEI means, for the purposes of this paper, we offer the following working definitions. Diversity refers to the range of differences that exist within the academic or industrial workplace. Equity indicates the efforts to make sure that programs, policies, and procedures within a given workplace are fair, objective, and unbiased in order to facilitate equality in potential opportunities and outcomes. Inclusion signifies that everyone feels that they are a vital and valued member of the workplace and that their voices carry equal weight.

With these working recommendations in mind, in this paper, we explore the following research questions:

- In what ways are women in physics and STEM careers in the academy and industry being impacted by pandemic-related challenges?

- What are some ways in which potential changes made during the pandemic can be used to level the playing field in academia and industry for all people; and, especially women in STEM?

We ask these questions in light of the fact that many factors related to DEI issues, especially for women, have been at play in academia and in the workplace for a very long time. In the past two to three decades, for example, issues related to gender, the gender gap, gender bias and barriers, and discrimination have been widely reported in the literature [4 – 12]. Perhaps the only agreed upon conclusion based on this type of research is the fact that women are underrepresented in college majors, graduate school programs, and the professoriate in those fields that are math-intensive, such as engineering, computer science, and the physical sciences. Trautner, et al. [13] raised issues pertinent to a group of female faculty and professional engineers that had attended a 1993 conference sponsored by the Division of Civil and Mechanical Systems within the National Science Foundation (NSF). The discussion that followed further suggested that issues including bias, lack of professionalism shown toward women faculty, isolation, visibility/invisibility, patronization, faculty spouse issues, and other women not acknowledging women engineering colleagues are still very real and of great concern today. To address why the underrepresentation of women in engineering is an issue, Trautner, et al. cited three reasons:

1. It is unjust and against equal opportunity laws when women are not equally recruited and retained in engineering,
2. It is important for present and future female engineering students to have both female and male role models, and
3. 'What's good for women is actually good for society as a whole' (p. 46).

Following a discussion grounded in the current research literature and including the perspectives of several women in STEM at different stages of their careers in academia and in industry, we make research-based suggestions on what changes organizations and institutions might implement to better tackle the perhaps greater imbalance of DEI issues that have become even more pronounced during the pandemic. Before presenting these suggestions, in the sections that follow we offer some timely discussions of the issues facing women in both the academic and industrial workplaces. These discussions focus not only about the situations brought on by the pandemic but also on the situations, like those discussed above that were already at play in these two work environments. We begin with a look at the academic workplace.

Issues Faced by Women in Academia

Even before the pandemic, the research has underlined the alarming gender disparities in the various STEM fields in academia. It is well-known that many STEM fields still face a critical shortage of women. The reasons for the underrepresentation of women in STEM are complex and vary by discipline with physics, engineering and computer science having historically very low numbers. According to data from the American Institute of Physics, women are more underrepresented in physics compared to other field in STEM at both the bachelor's and doctoral levels. Based on 2017 data, women earned about 20% of bachelor's degrees in physics, engineering, and computer science, compared to 60 % in biological science, 50% in chemistry and 40% in mathematics [14]. In the years leading to the pandemic, efforts to recruit and retain women in the sciences were increasing. For example, in physics departments, women were being hired into tenured, tenure-track and permanent

position at higher rates than men. Although efforts to recruit women to pursue STEM careers have increased, there are still retention difficulties for women in STEM who hold faculty positions due to a lower social capital and the chilly academic climate for women [15].

The urgency of the pandemic required academic institutions to switch to different modalities of work and offer flexibility in their work policies. However, because these changes were intended to be gender neutral, they potentially widened the gender gap for career advancement of women in STEM [16]. During this time, women were publishing less than men, which ultimately impacts tenure and promotion since publishing is a major criterion for career advancement in academia [17]. Even though academic institutions have pushed back tenure and promotion clocks for early career scientists [18], this may be viewed as a short-term, surface-level fix, which is understandable given the urgency to act and make changes with the ever-changing status of the pandemic. However, this extra time only serves to widen the publishing gap long term. In fact, in some fields, the true impact of a lag in publication rates can span many years with respect to citation indices and how they are critical in the academic landscape for career advancement [19].

For doctoral students and early career scholars, challenges were numerous. The timeline to complete research projects and write dissertations was pushed back by at least a year. Many studies have shown that women in the academy, particularly early career faculty and doctoral students, are concerned by the disruptions and delay in their career advancement [20]. In fact, early career scholars and doctoral students stated that they need "resources in their professional contexts to support them in planning for changes to their research due to the impact of the pandemic" (p. 10). For example, many PhD students expressed the need for concrete guidance from mentors on how to conduct or adapt their projects to keep moving forward in their research endeavors. In speaking informally with several female physics PhD students, the need for guidance form mentors was corroborated. They needed help restructuring the timeline of their research projects when they could not get into the lab to conduct their experiments as scheduled when the pandemic started. Shifting to focus more on the data analysis or coding aspects of their projects required some significant time and effort from their advisors and their collaborators who were also challenged by these unprecedented circumstances.

Furthermore, a survey of engineering students and professionals conducted by the Society of Women Engineers revealed that over half of non-tenure track faculty expressed concerns about losing their jobs during the pandemic; and half of women engineering faculty, both tenure and non-tenure track, reported high levels of dissatisfaction with work-life balance because of the work from home policies [21]. Although many academic professionals indicated that their employers allowed them to adopt a remote and flexible schedule, women faculty with school-age children found it extremely challenging to balance at-home and faculty responsibilities. This significant work-life imbalance that primarily increased for women led to higher challenges associated with mental illness and overall wellbeing.

In speaking informally with a female physicist who worked in academia during the pandemic, she referenced that, initially, university expectations in moving to virtual instruction were more laxed and solely focused on completing the term. As time progressed, there was less understanding that teaching in a virtual setting required a completely different skillset than in-person instruction. University expectations evolved to assume that faculty would deliver the same quality of education virtually. Frustrated with trying to provide quality instruction in a virtual setting, she exited the academic field for industry a year into the pandemic.

Shifting expectations as the pandemic progressed is a phenomenon also experienced by women in industry STEM fields. Similar to academia, prior to the pandemic, certain industry sectors were making significant progress in gender equity. In the following section we offer a discussion of issues faced by women in industry during the pandemic.

Issues Faced by Women in Industry

Within industry STEM positions, gender parity was improving through 2019, though gains were largely uneven across sectors. As of 2019, while women represented 74% of health-related STEM roles, women accounted for only 25% of computer science-related STEM roles, and 15% of engineering STEM roles [22]. While recruiting women initially into STEM fields was one focus within industry, the high number of women leaving STEM positions also contributes to the existing gender gap. The three biggest reasons women cited for their departure from engineering STEM roles were: (1) departing due to unfair working conditions, (2) departing due to unequal compensation with male peers, and (3) departing due to familial care responsibilities. For women who cited familial care as a reason for departing the field, many engineers noted that they had an interest in moving to part time instead of leaving the field altogether. The real or perceived idea that part-time engineering roles do not actually exist caused many engineers to find work in an entirely new field rather than simply move to part-time work [23].

The pandemic amplified existing discrepancies within industry STEM fields. During the initial phase of the pandemic, women were twice as likely to have lost their jobs or to have been furloughed than their male counterparts [24]. Working mothers were also three times as likely to have left the workforce than working fathers during the pandemic. The creation of a gap in employment impacts all job seekers as they must explain the gap for all future job searches.

Many STEM jobs shifted from working in-person to working completely remote. The shift to virtual work provided some initial benefits like saved commuting time but the shift to virtual work has not helped facilitate an equal inclusive environment. Women in STEM fields are divided on whether the shift to virtual work has been beneficial to their career growth or not. 42% of women say it has had a negative impact while 41% it has had a positive impact. Comparatively, 54% of men say shifting to remote work has had a positive impact on women while 23% of men say it has had a negative impact on women.

Mothers working in STEM fields were more likely to indicate that the shift to virtual work was negatively impacting their career. The increase in home and childcare responsibilities for many women across industries caused less time for professional work along with an increase in distractions during work hours. In heterosexual couples, distribution of home and childcare responsibilities was already unequally distributed to the women prior to the pandemic. During the pandemic, even as both partners worked remotely, women were twice as likely to bear the primary responsibility for home and childcare efforts [25].

Regardless of a woman's familial status, burnout has increased across sectors leading to lower quality work and a more disengaged workforce. 52% of women report that their workload has increased since the beginning of the pandemic. Burnout has also led 38% of women within the Tech sector to report they intend to leave the field within the next two years [26]. For women in professional STEM careers, the pandemic further exasperated

existing inequalities. In the section that follows we compare and contrast some of the issues related to women in both academia and industry.

A Comparison of Issues Faced by Women in Academia and in Industry

There are many similarities in the ways the pandemic affected women in industry and in academic STEM careers, particularly as it progressed. A common experience several months into the pandemic was the dissatisfaction with the work-life balance that it imposed. Women took on an increased amount of work professionally and within the home.

With the initial financial uncertainty caused by the pandemic, women were more likely to lose their jobs than male peers at the onset. For women who did not lose their positions in industry, there was an increased concern for future layoffs and many individuals took on additional work. Within the academic STEM industries, women reported increased concern for their career advancement.

For women in academic and industry STEM positions, the pandemic also had a dramatic impact on future career planning goals. Within academia, the clock stopped for tenure track faculty. Though delaying the tenure clock allows more time, it also delays the economic opportunity to achieve higher salaries that come with tenure and the job stability it provides. For women in industry, there was an increase in burnout and more women plan to leave STEM industry fields in the near future. For women in academia, there was also an increase in burnout due to constant changes in university policies from semester to semester and within semesters since the pandemic started.

Despite the myriad of issues faced by women in academic and industry STEM fields, there are actions that organizations and institutions can implement to address gender inequity across their talent pipeline. We would now like to suggest some recommendations, based on the issues faced by women in academia and in industry, especially those brought on by the pandemic. As we discussed in the introduction, we are mindful of the fact that many issues were already present before the pandemic hit. In many cases the pandemic deepened these existing issues while simultaneously creating new ones.

Recommendations to Address Gender-Related DEI Issues

With the pandemic, the inequity epidemic only worsened, but the urgency of the pandemic required industry and academia to instantly rethink their policies and practices, showing that change in practices is possible and doable. Thus, we hope that some of the practices embraced during the pandemic are embraced long-term and enhanced with time to promote gender, equity, and inclusion of all people in STEM careers.

Tables 1 -3 provide an outline of proposed recommendations for both industry and academic organizations and institutions to focus on recruiting, retaining, and returning female STEM-talent as the pandemic continues.

Table 1. Recommendations for Recruiting Women in Industry and Academia

Recommendation	Implementation Suggestion
Shorten the length of job postings and review the language used.	Women tend to only apply to positions where they have 100% of the qualifications. Focus on

	emphasizing the core competencies needed rather than listing every activity ever completed.
Go beyond traditional recruitment channels [27].	Companies can support increasing diversity in the pipeline earlier through partnerships that help engage women in K-12 and college. Academic institutions can support increasing diversity within the student body as a way of further expanding the pipeline of future STEM workers. Focus on casting a wider net in terms of advertising positions. Working through various professional to post job vacancies is a good way to reach a more diverse pool of applicants.

Table 2. Recommendations for Retaining Women in Industry and Academia

Recommendation	Implementation Suggestion
Assign work based on skill sets [28].	Individual tendency is to call upon those who are similar to themselves for support. This leads to an imbalance in leaders subconsciously opting to provide opportunities to individuals that look like them. This reinforces a similar looking pipeline rather than offering opportunities equally for everyone to prove themselves.
Offer a flexible work schedule for everyone.	Shift to focusing on the content of work being turned in, not on the number of hours a person's online indicator is active during business hours.
Use the benefit of virtual conferences as a way to be more inclusive [29].	Continue to incorporate hybrid options at all scientific conferences, even post-pandemic. Virtual meetings are making engagement with the broader scientific enterprise more accessible for women who still often have more at-home responsibilities and for people with a range of medical issues and abilities [30]. Not only can underrepresented populations have access to attend conferences, but they may have more opportunity to be panelists and conference presenters, which will create more diverse voices to be heard at national and international conferences.
Tie in the informal mentorship of women in STEM into year-end reviews/career progression.	Create metrics for career advancement that track mentorship to measure the long-lasting impact of women faculty's efforts. Many women academics spend significant time in informal mentorships of undergraduates. This time spent often results in these relationships turning into long-lasting mentor-mentee relationships and students being recruited as research assistants and graduate assistants [31]. However, this time spent falls largely on women faculty and they are not compensated and incentivized to pay it forward.

Table 3. Recommendations for Returning Women to Industry and Academia

Recommendation	Implementation Suggestion
Create a returnship program.	Organizations like T-Mobile can be a model for implementing opportunities for women re-entering STEM fields. Provide a structural 8 – 12-week program with the optionality of hiring at the end of the program [27].
Modify applicant recruitment tracking software not to eliminate applicants with a gap in employment.	As more recruitment systems use advanced technologies to pre-screen resumes, prior to a human review, this also weeds out potentially great applicants that simply left for a variety of reasons. Build in a space in applications to allow applicants to explain resume gaps.
Give women in STEM the opportunity to catch up due to the amplified inequities of the pandemic [18].	Reduce service load on women scientists, particularly those in junior positions. This is particularly relevant in academia where women faculty are often asked to take on a disproportionately higher service load. Thus, until service work is more valued in career advancement, institutions should substitute some service work with network opportunities and conference travel that can help women STEM researchers rebuild their research programs and create new collaborations.

The pandemic has forced organizations and individuals to rethink work-life integration as they have attempted to achieve a new balance in what is often referred to as the *new normal.* Though neither academic nor industry STEM fields have yet found gender parity in their respective workforces, through a cross-sector comparison, we have synthesized possible actions that can be undertaken to recruit, retain and return female talent into the STEM pipeline.

Summary and What's Next

The pandemic did not introduce the concept of gender inequity in STEM fields, but it has regressed forward momentum. To recruit, retain, and return female talent into the STEM pipeline, there are concrete actions that organizations can take. And as other worker trends like the great resignation continue, organizations must take steps towards gender equity to compete for quality talent. Organizational change and commitment to improving equity in the workplace now will pay dividends in the future. Two of three women who left the workforce during the pandemic plan to return and they will be looking for organizations that support equity [32]. Thus, it is an opportune time for the academy and the corporate world to take concrete actions that address gender-related DEI issues and their impact on women in the Physics and STEM pipelines.

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