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Debugging the "Gender Gap" in STEM

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Debugging the “Gender Gap” in STEM

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faculty in partial fulfillment of the requirements for the degree of
Master of Science

Major: Information Systems

Program of Study Committee:
Anthony M Townsend
(Major Professor)

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Iowa
2019

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Abstract

For the past six decades, the position and the situation of women in the United States of America has changed significantly. The most notable of this change has been in the American workforce. Today, more women are working outside the home than they have ever before. This is evident when we look at the number of people graduating each year with a degree in America. Today, the majority of college students graduating with a degree in the United States are women, compared to 23.9 % 60 years ago.

However, this growth has not been consistent. There are several sectors where the lack of diversity in the workforce, especially the lack of gender diversity is still very prevalent. Nowhere this difference is more prevalent than in the STEM (Science, Technology, Engineering, and Mathematics) related fields. Although, the percentage of women graduating with a college degree has been steadily increasing for decades, recent studies have shown that the number of female students enrolling in the STEM (Science, Technology, Engineering, and Mathematics) related disciplines has been decreasing for the past 20 years, while the proportion of women resigning from the STEM-related jobs is on the increase.

Researchers for long have studied the apparent imbalance between women's proportion of the population and the percentage of the job they hold. Till now, most of the previous research in this field has looked at the percentage of women working at the STEM-related jobs and analyzed

for the institutional and economic factors which contribute to the discrepancies in the levels of female representation in STEM jobs. However, there has not been much research done on this topic in recent years. In response to this scarcity of research on the topic, this paper will re-examine several of these factors, including socio-economic, institutional, and economic factors, in order to gain a better understanding of their relevance today. This paper will focus on Science, Technology, and Engineering fields in specific and study the changes over the past years.

Chapter 1

Introduction

Technology has had significant worldwide growth in recent decades. It has been one of the consistent sectors, outgrowing its competitors by a considerable margin, as can be seen in Figure (1). This sector is extremely dynamic and also has considerable potential for innovation and also introducing drastic changes impacting our society profoundly. Traditionally, the technology sectors demand a substantial number of workforce with expertise in science, technology, engineering, and mathematics (STEM) disciplines. With unprecedented growth over the past decades and similar predictions for the future, one may expect the sector to leverage as much as knowledge, creativity, and brainpower as possible. However, that has not been the case, as several studies indicate that it has been, and still is, a male-dominated sector with a tiny percentage of women representation.

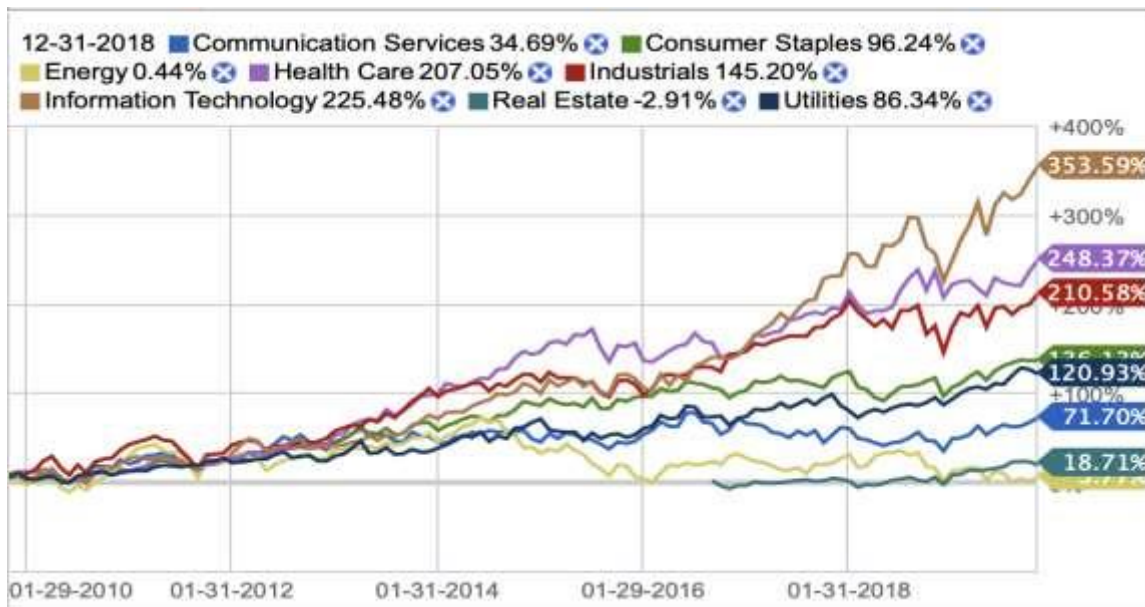


Figure 1: Industry growth rates (2010-2019)

Despite the significant growth in recent years, there remains segments of the population that are under-represented. Amongst those under-represented are the women in STEM. Science, technology, engineering, and mathematics (STEM) is widely regarded as one of the most critical fields for the national economy. These fields play a crucial part in deciding a country's innovative capacity and its standing in global competitiveness. Despite knowing all this, women are still significantly underrepresented in America in STEM-related jobs and among STEM degree holders even though representing nearly half of the U.S. workforce and half of the college graduates.

What is STEM?

STEM is a reasonably specific acronym, referring to Science, Technology, Engineering, and Mathematics. Despite this simple acronym, there is no standard definition for what aggregates a STEM job. In this report, STEM jobs would include scientists in all fields, all the technological jobs, and also will include all the engineering jobs. We will also be considering social and behavioral sciences and STEM college faculties. However, for this report, we will not be considering high school teachers and instructors related to STEM. While all these workers are definitely a part of a larger STEM workforce, their exclusion from the report is solely based on the unavailability of the data.

Based on a survey by the National Science Foundation, it is estimated that there are about 8.6 million people who worked directly in STEM or STEM-related jobs, representing 6.2 percent of

the total U.S. workforce (STEM Occupations: Past, Present, And Future). As mentioned earlier, this part of the workforce is considered to be crucial for the country's economy and productivity. The workforce for 2020-21 by the U.S. Department of Labor projects that 9 out of the ten fastest-growing jobs are STEM-related.

In 2018, 57.1 percent of all women participated in the labor force (figure 2). This is a marginal improvement on the 57.0 percent who participated in 2017. However, this is still three percent less than its peak in 1999. By comparison, the participation rate for males in the labor force is 69.1 percent for 2018. This has been constant for the past few years but is still 17.5 percent below the peak in 1948 of 86.6 percent.

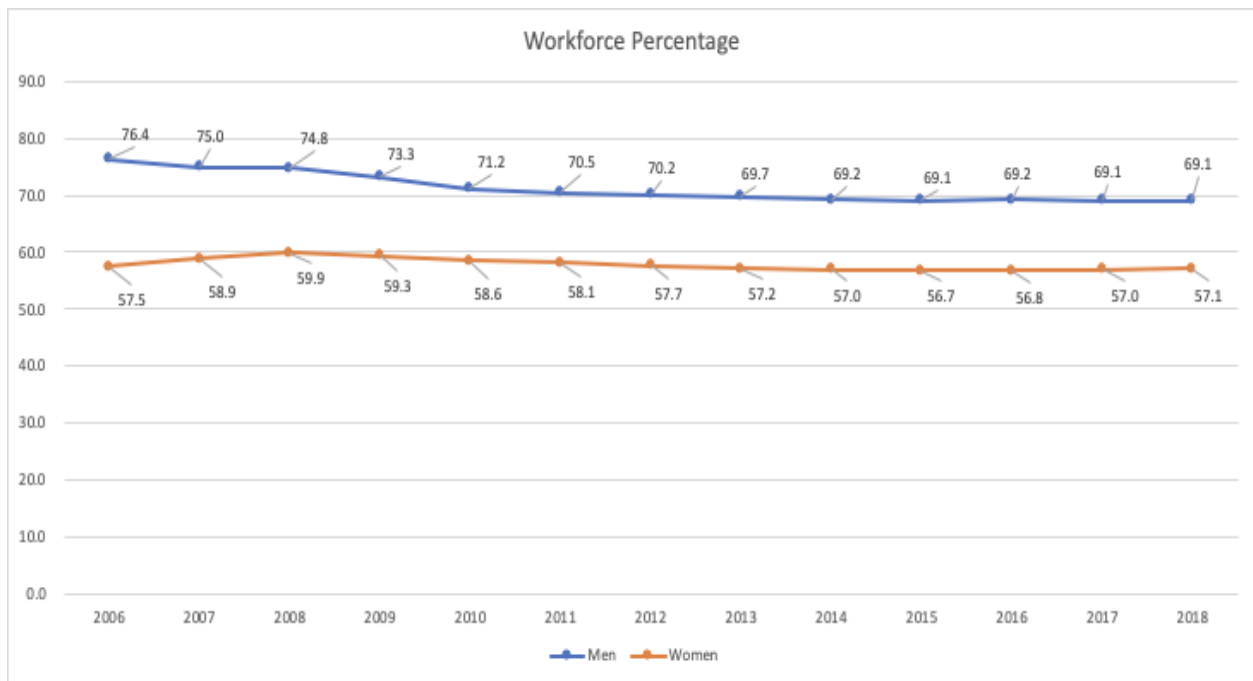


Figure 2: United State of America Workforce by gender

Although the figures are not where one might expect, they are much better compared to the past. In the 1950s, the participation rate for women was 34 percent. The second half of the 20th century is responsible for this rapid rise in women's labor force participation. The participation rate of women grew steadily throughout the 1960s, 1970s, 1980s, and 1990s (Figure 3). Over the years, the women's labor force participation increased even during several economic recessions. After reaching its peak in 1999, the participation rate gradually decreased. This decline was accelerated during the recession of 2008 and kept declining till it hit the low of 56.7 percent in 2015.

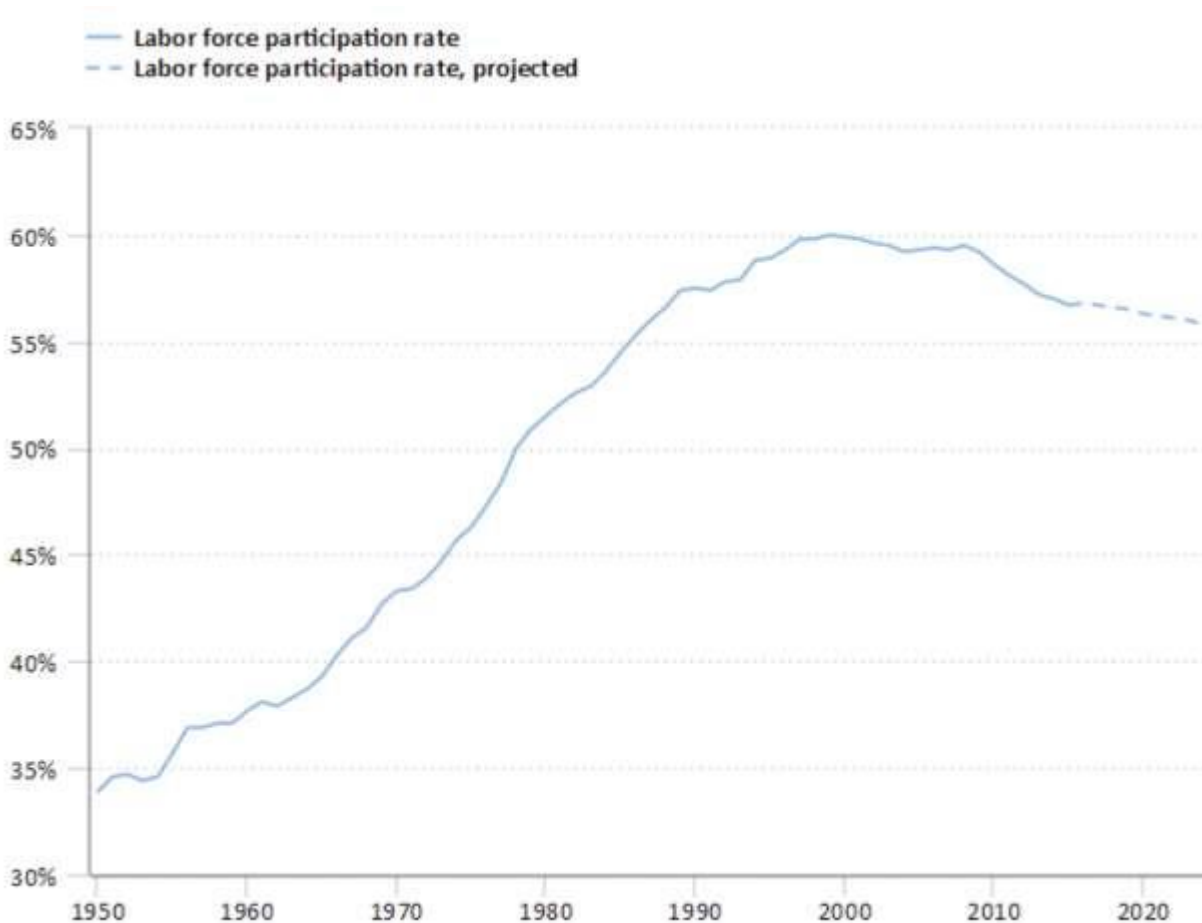


Figure 3: Women participation rate in labor force

Women's involvement in the workforce changed substantially since the 1950s. This shift can be attributed to the change in the socio-economic factors during that time. During this era (the 1950s-2010s), the percentage of women between the ages of 16 to 24 holding a bachelor's degree has quadrupled, whereas for men, it has doubled (appendix 1). At the same time, more women had also started to work year-round and full-time. In 2018, 62 percent of the women were working year-round and full-time, compared to 40 percent in the 1960's. (Appendix 2). Similarly, the percentage of women's earnings compared to men has also improved to 82 percent in 2017 compared to 62 percent in the 1970s (appendix 3).

Women in America represents 50.8 percent of the total population, and 47 percent of the total workforce. Even after sharing such a large share of the community and the workforce, there is one sector where they are highly underrepresented. The number of women working in STEM-related jobs is way less when compared to similar jobs in other fields. As mentioned earlier, there are close to 8.6 million STEM and STEM-related jobs, and women only contribute to 2 million of those jobs [Figure 4]. This shows that women hold only 23.25 percent of all STEM jobs and 1.58 percent when compared to all of the workforce.

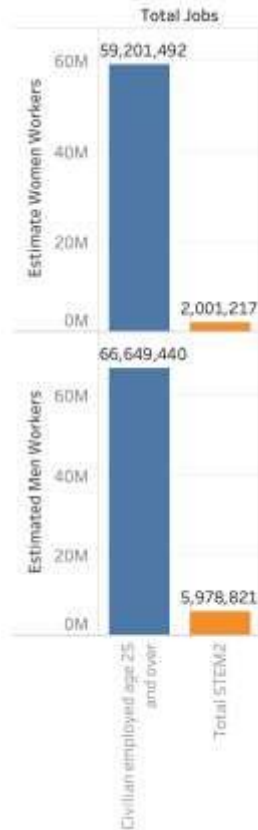


Fig 4: Number of STEM workers compared to the workforce based on gender

This research plans to find and study different factors that contribute to increasing gender disparities in STEM jobs and also how the women population in STEM compares to the dominated men population in these fields. We will also explore gender differences within and across STEM fields in higher education, enrollments, employment, and various other areas. Here we are going to look at different professions in STEM fields and compare several aspects common to both genders and then calculate how it differs for both. This study will provide us with insights that will help us understand the predominant gender gap in STEM jobs.

Research Question

This study aspires to identify and define different factors that contribute towards the increasing gender gap in STEM fields and understand how these factors affect the women population in these fields in comparison to the dominant men population. This following question guided this study:

Is there a significant difference between the male and female population in the STEM-related fields, if so, what are the contributing factors and how do they relate?

This research question might seem generic and broad; the research aims to dive deep into each of the factors and try to come up with a solution that could be explored under this central question. The focus of this research and research question could further be narrowed down based on some literature review on the topic.

Literature Review and Analysis

The purpose of this research is to study and analyze the current state of the Gender Gap in STEM. The way in which this challenge was pursued for this study was by exploring, in-depth, the previously published work related to this subject and by collecting and analyzing the data which is available through various surveys. Also, for getting a holistic view of the topic, few people were interviewed to understand their thoughts and views on the topic. Although this is a much talked about topic, there is little to no research that has been done in this field. The research for the present study desired a greater understanding of the reasons for the findings that were given.

Preparation in High School

Math and Science skills are considered crucial to be successful in STEM fields. In order to understand students' achievement in STEM, it helps to understand which courses students have taken in high school. Based on a study done in 2007 and 2013 (Tyson et al. 2007; Wang 2013), students who take more advanced mathematics and science in high school are more likely to complete college with a STEM degree.

The causes for the Gender Gap in STEM can be related to the number of students taking A.P. tests in their high school. As can be seen from (Figure 5), the percentage of males in most STEM fields is higher when compared to women. Men outweigh women in fields like physics, computer science, and calculus. One notable gain is women's increased representation in environmental science and biology. Here they outweigh men by a substantial percentage.

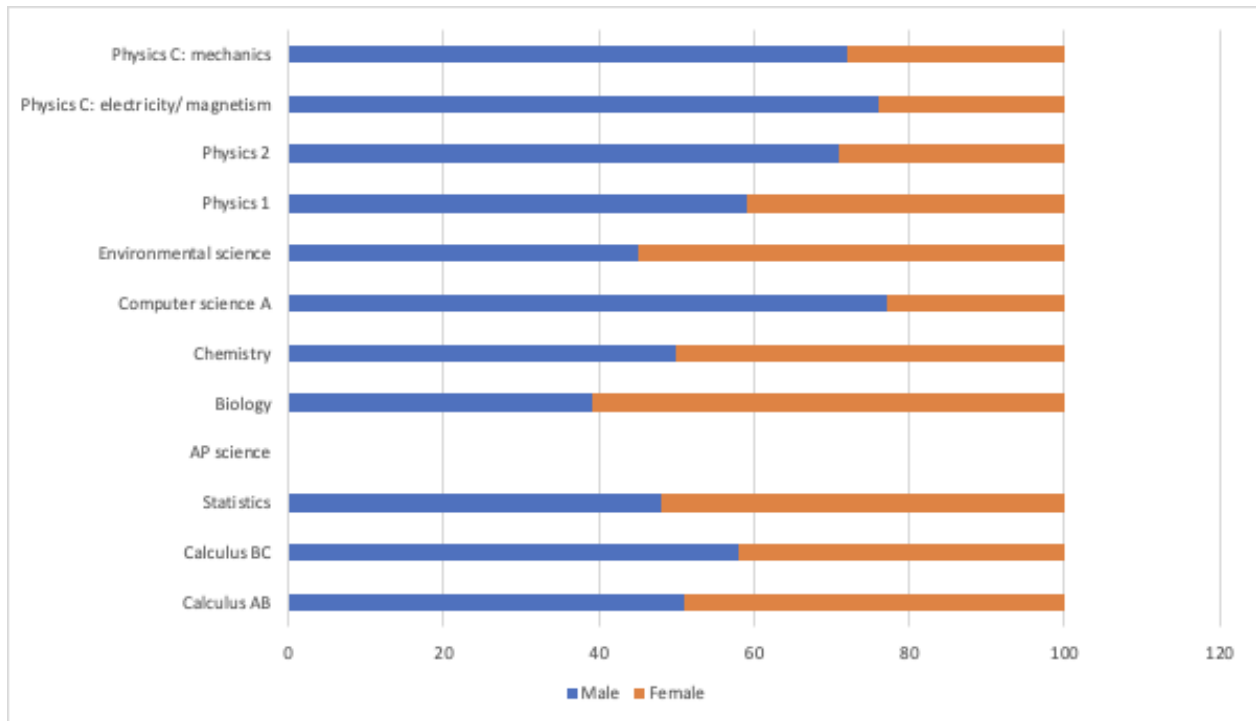


Figure 5: Students taking AP test based on gender

After graduating high school, some students join the workforce, some join the military, and a few others get occupied somewhere else. Nevertheless, the majority of the students go directly to pursue post-secondary education (Ingels et al. 2012). In 2015, 3 million students graduated high school, and from those 2.1 million students enrolled in a college in the following fall (Kena et al. 2016). This rate is known as the immediate college enrollment rate. It is defined as a percentage of annual high school completers aged 16-24 who enroll in a two or 4-year college. This ratio would help us get an idea of the number of people who go for college graduation and hence, possibly for a STEM degree. The percentage of students enrolling for a degree has been on a steady rise since the 1970s. The percentage of students pursuing a four-year degree, although growing, is still meager, just 45 percent of the students pursue a four-year degree. This reduces the pool of potential students for STEM degrees substantially. The situation is worse for a two-year course with just 25 percent.

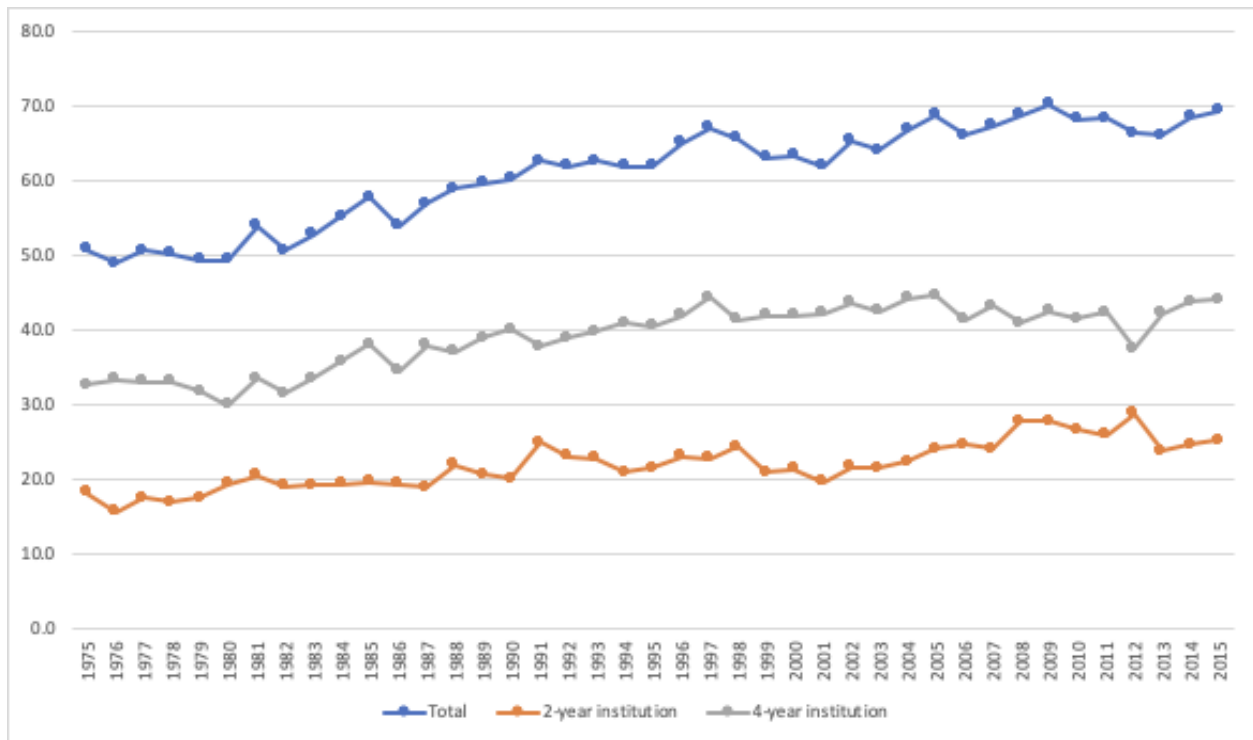


Figure 6: Immediate college enrollment rate for 2-year and 4-year programs

The high school graduating class of 2018 was tested separately and as a whole for graduates interested in STEM and non-STEM majors and careers. Figure 7 shows the ACT College Readiness Benchmark attainment percentages in STEM, math, and science fields. The benchmark was set at 26 points i.e., students meeting or exceeding the mark were considered ready for a first-year STEM-related college course. As can be seen from figure 7, just 29 percent of the interested students met the benchmark figure. However, students performed well on the science and math benchmarks with an average of 49 in math and 45 in science for students interested in STEM. Even though the numbers are better, but the percentage of students meeting these scores are still less. With an average of 50 percent for both math and science. This might help us understand where the students stand when they enroll for a STEM course. With such a

low percentage of a student ready to take a college STEM course, it is highly possible that they might switch to a non-STEM field in the future.

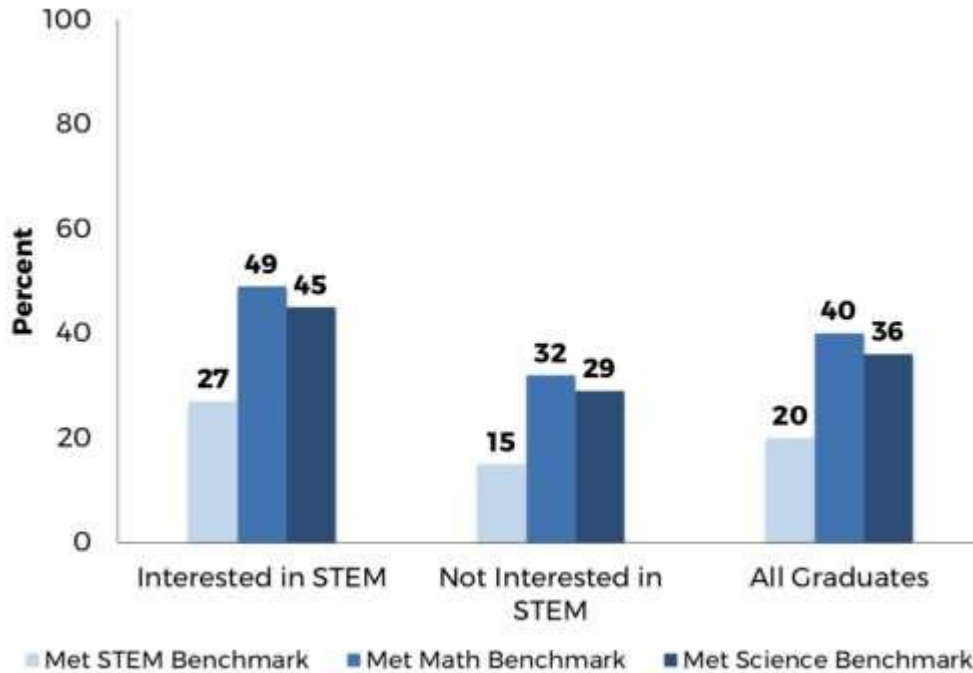


Figure 7: The Condition of College & Career Readiness

Women in Colleges and Universities for STEM

The transition to college from high school can be overwhelming for some students, the excitement of going to college mixed with the stress of choosing the subjects. This transition is a critical moment when many women turn away from a STEM career path. As seen earlier from Figure 7, almost 70 percent of the students, although interested, are not ready to take a first-year STEM class. This is where past studies have shown a drop in the enrollment of female students to STEM fields.

In 2016, 1.35 million male and 1.57 million freshman students enrolled in an undergraduate program all across the U.S. (figure 8). Although women comprised the majority of the undergraduate college population, they are far less likely to choose a STEM major compared to their male counterparts (figure 9).

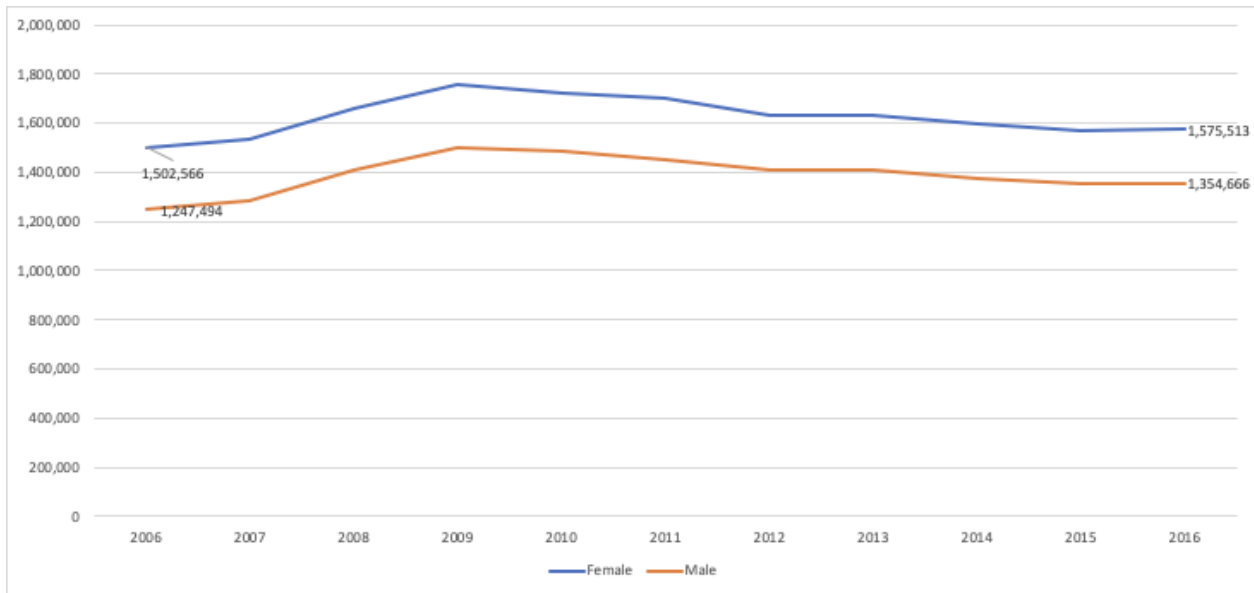


Figure 8: Net enrollment based on gender (2006-2016)

Almost one-fourth of all-male freshman i.e., 24.7 percent, compared to 20 percent of female freshmen had planned to take a STEM field as their major in 2016. This disparity becomes more prominent when social and physical science is not included. Just over 25 percent of the male freshman class had planned to major in engineering, mathematics, and computer science, compared to 8 percent of the female freshmen.

This is an essential indicator for analyzing the gender gap. As we had seen earlier, the gap for STEM fields in high school was not prominent when compared to the college. Nevertheless, this gap is bound to get worse as college progresses. Many of these women with stem degrees will

leave or change the major in their college careers, as do many of their male counterparts (Seymour & Hewitt, 1997).

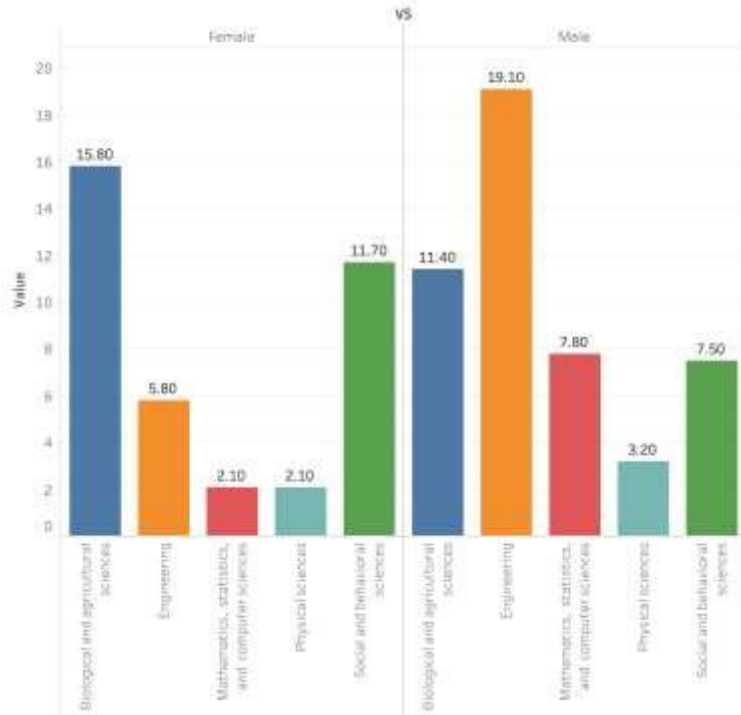


Figure 9: Freshmen intent on taking a STEM major

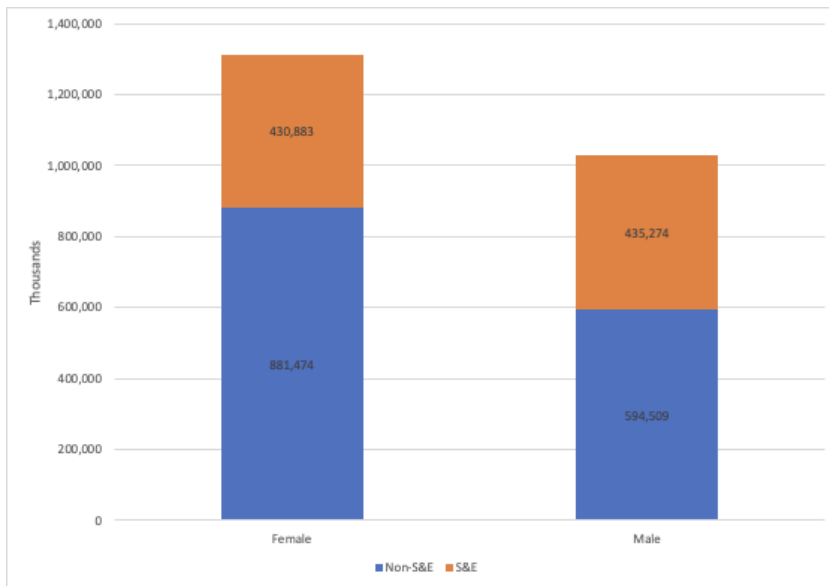


Figure 10: Stem non stem bachelor's degree holder by gender

Despite these comparatively small percentage of women majoring in STEM degrees, the overall number of bachelor's degrees awarded to women has increased over the past couple of years, although the proportion varies by the fields. Figure 11 shows the total number of degrees awarded over the past couple of years for different fields.

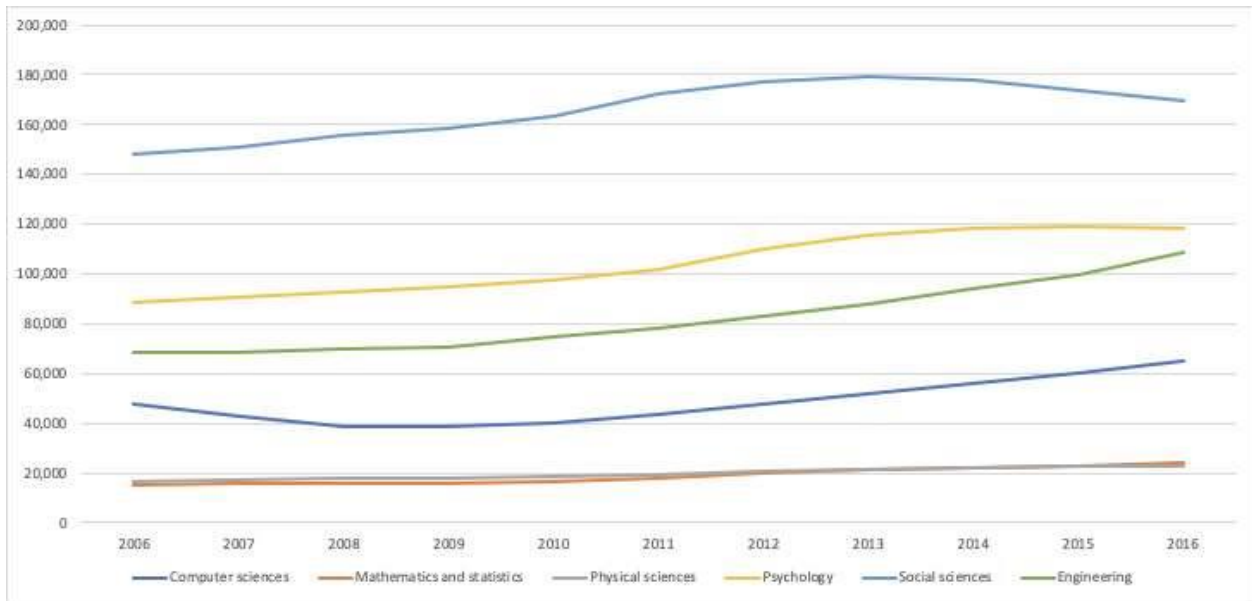


Figure 11: Number of bachelor's degrees awarded in different science fields (2006-2016)

Source: National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), Completions Survey; National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, <https://ncesdata.nsf.gov/webcaspar/>.

Since 2006, women have earned continuously more than one-third (77.6 percent) of the bachelor's degree in social science, half of all the bachelor's degrees in psychology, and also in math. However, women consistently had a much smaller percentage when it came to engineering and computer science. In the past ten years, the percentage of women getting a bachelor's in engineering has remained the same, close to 20 percent. In fact, women's representation in computer science has been on a decline, as is evident in figure 12.

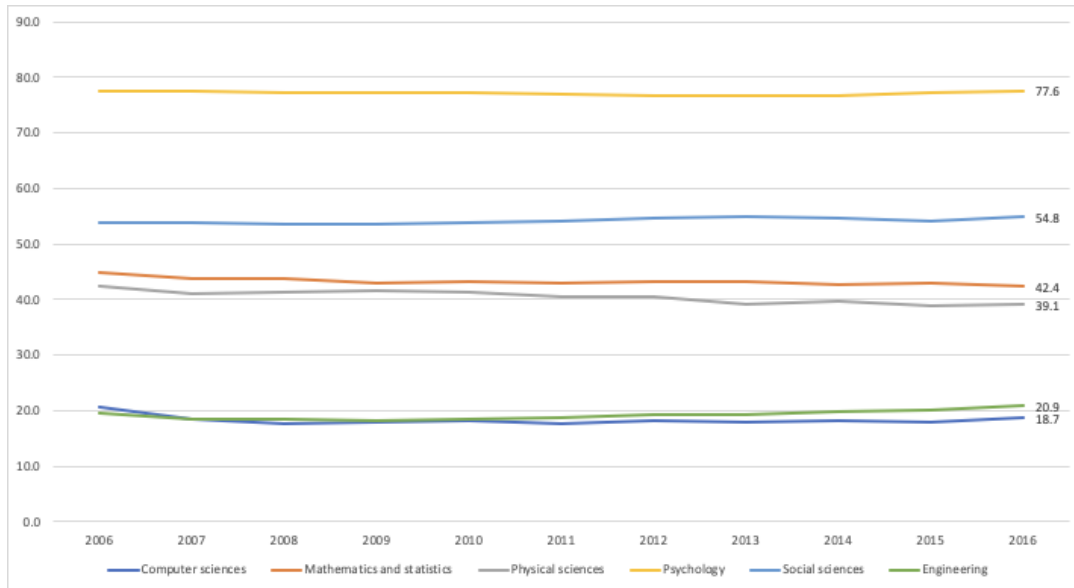


Figure 12: Women share of bachelor's degrees for STEM fields (2006- 2016)

Source: National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), Completions Survey; National Science Foundation, National Center for Science and Engineering Statistics, WebCASPAR database, <https://ncesdata.nsf.gov/webcaspar/>.

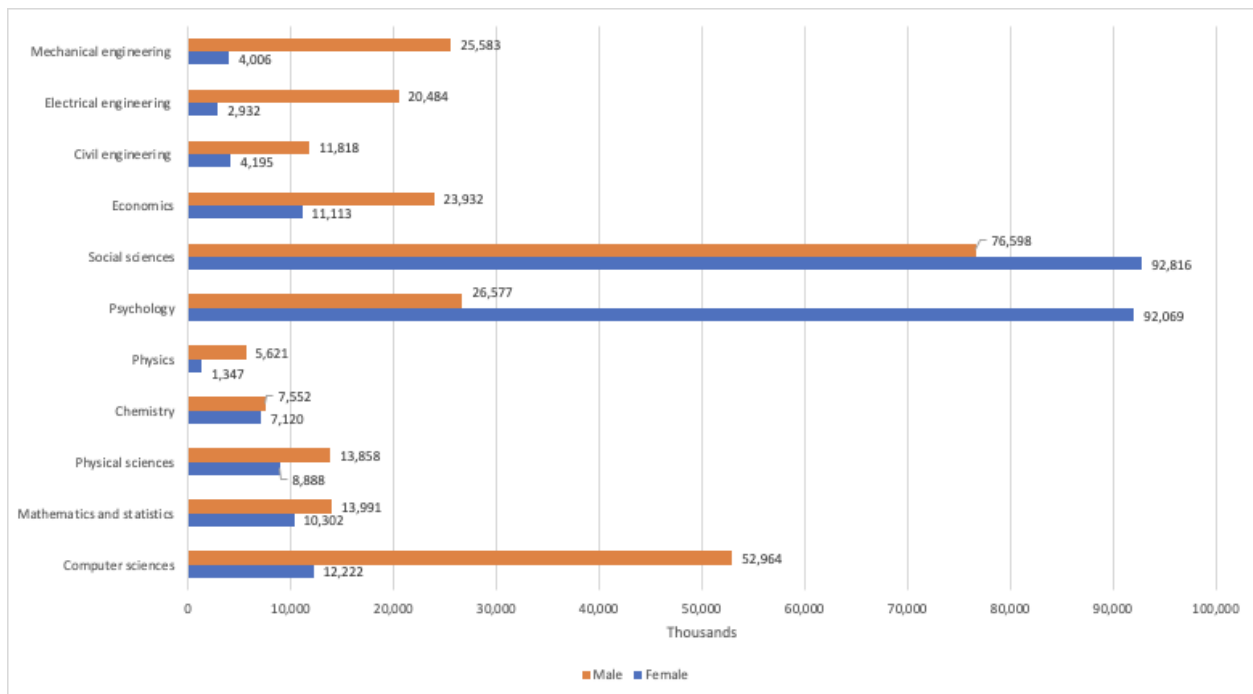


Figure 13: Number of bachelor's degree awarded to women in different fields

The Number of degrees awarded varies significantly depending on the STEM disciplines. As can be seen in figure 13, women earned 92,069 psychology degrees, compared to 26,577 degrees earned by men. Similarly, women have also outpaced men in social science degrees with getting 92,816 degrees compared to 76,598 by men. However, in comparison, men earned 52,964 computer science degrees, 25,583 mechanical degrees, 20,484 electrical engineering degrees, and 23,932 degrees in economics, far exceeding their female counterparts.

Women's representation among the master's degree recipients in STEM shows a similar flow as we saw for the bachelor's degree holders. We see a similar trend for Master of Social Science as saw for its equivalent bachelor's degree. The proportion of degrees received for masters in social science, physics, psychology, and chemistry has been constant for the past five years. However, the number of master's degrees has been on the constant decline for the fields of computer science, mathematics & statistics, and engineering, as can be seen from figure 14.

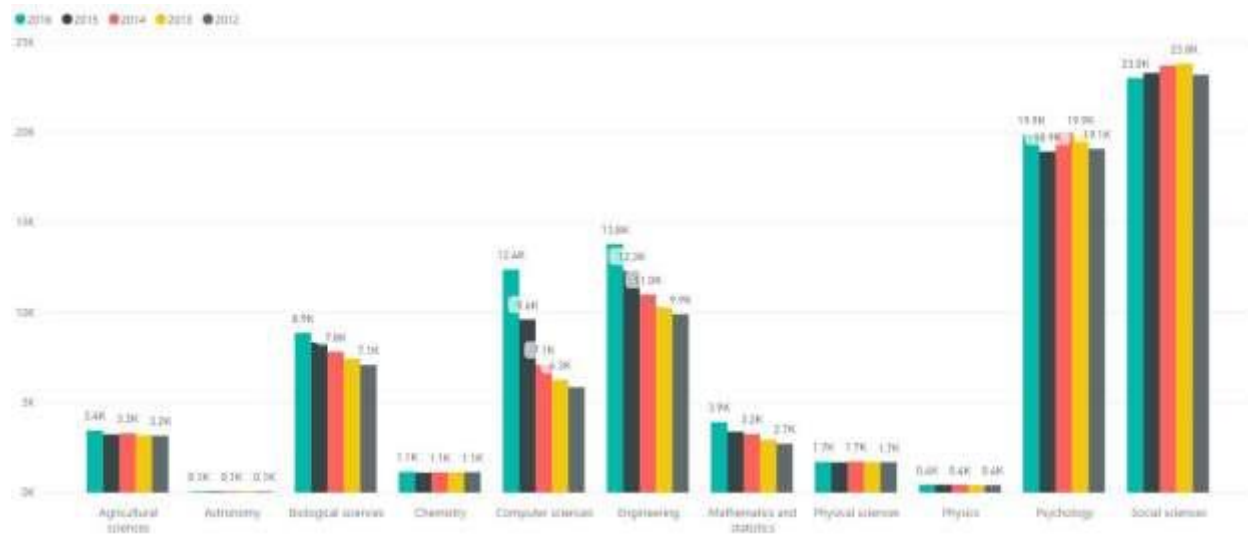


Figure 14: Number of bachelor's degree awarded to women in different fields

Women in STEM Workforce

Women's participation in the American workforce has been on a constant increase for the past few decades. Today, women constitute 47% of the total American workforce (Table 1). Similarly, the proportion of women in the STEM workflow has been on a constant upward trajectory. Currently, women constitute 24 percent of the total STEM workflow. Although this is the highest it has ever been in the past, there is clearly a considerable gender gap in the STEM workforce. Currently, there is only one woman in a STEM or STEM-related job for every three men (Table 1).

	Total	Men	Women	Percentile Women
Civilian employed age 25 and ov	125,850,932	66,649,440	59,201,492	47%
Total STEM	7,980,038	5,978,821	2,001,217	24%

Consistent with the increase in the STEM degree recipients, representation of women in the STEM workforce has also improved significantly over the past decades, yet, it can be seen from figure 15 that there are still several sectors of the industry where women are still under-represented. In sectors like social science, women had a significant presence since the 1960s, when women had 35 percent of the field. Fifty years later, women made up 63 percent of the field. On the different side of the spectrum, women counted for 1 percent of engineers in 1960. Today the rate is at 13.3 percent. This is a substantial increase, but still, women represent a minority stake of the working engineers.

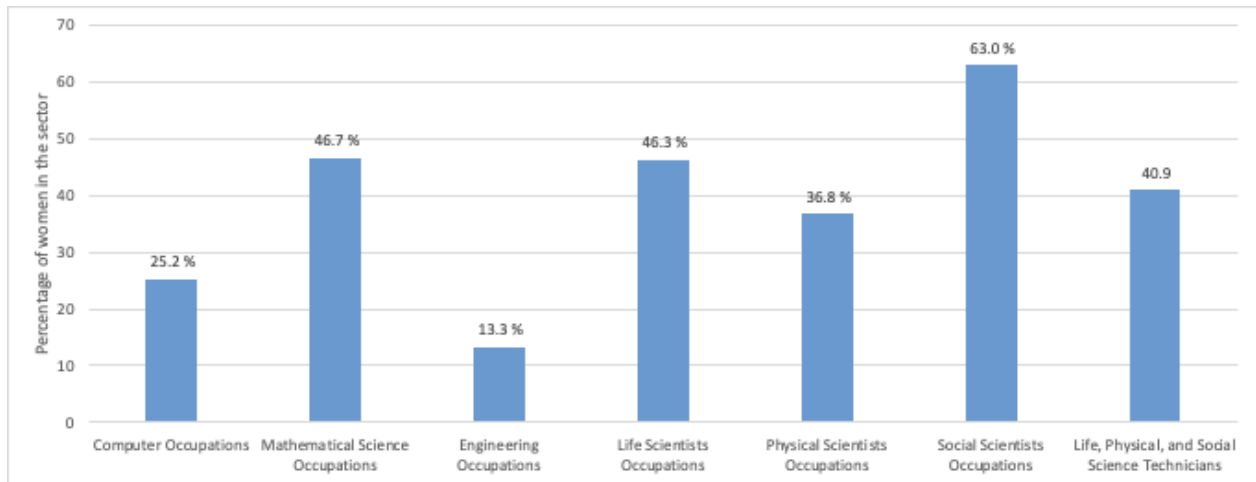


Figure 15: Percentage of women in STEM sectors

The research and analysis this far showed us that there is a substantial gender gap that exists in the workforce today in several of the major sectors and industries. We have also been able to identify a few of the factors that contribute and facilitate the existence of this gender gap. Now to get an even better understanding of the matter, we will look at the direction i.e., the industries and sectors students go to work after graduating with a STEM major.

Figure 16 to 23 gives us an opportunity and allow us to explore the relationship between college majors and occupations. The circle is divided into two parts, the left side signifying college majors and on the right side is divided into STEM, STEM-related, and Non-STEM sectors. The length of the segment of the circle shows the proportion of students graduating in each segment and where do they go to work in each occupation group. The width of the line between the major and the occupation signifies the proportion of students who decided to work for those fields after graduation. The lines highlighted in color show the proportion of students with a STEM degree who went to work in a STEM field.

Of all the students graduating with a STEM degree in 2016, only a quarter or 25 percent work at a STEM job after graduation; also, a small percentage of graduates (approx. 5 percent) went for a STEM-related job (figure 16). However, the vast majority of the students graduating with a STEM major decided to work in Non-STEM related fields. A similar trend can also be seen in the students who graduated with a STEM-related major. A lot of these graduates went to work for a STEM or STEM-related job, but a substantial number of these graduates decided to work in a NON_STEM field (figure17)

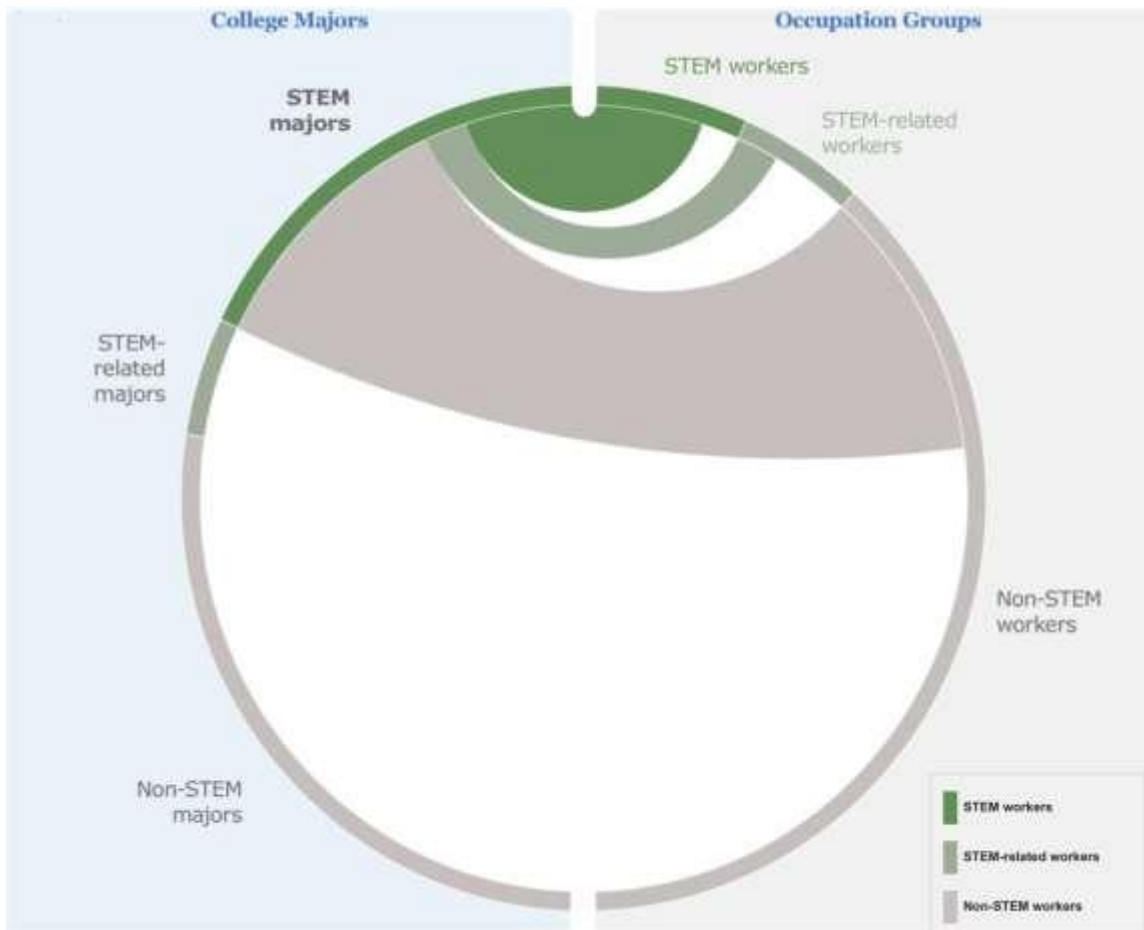


Figure 16: STEM majors and job for all students

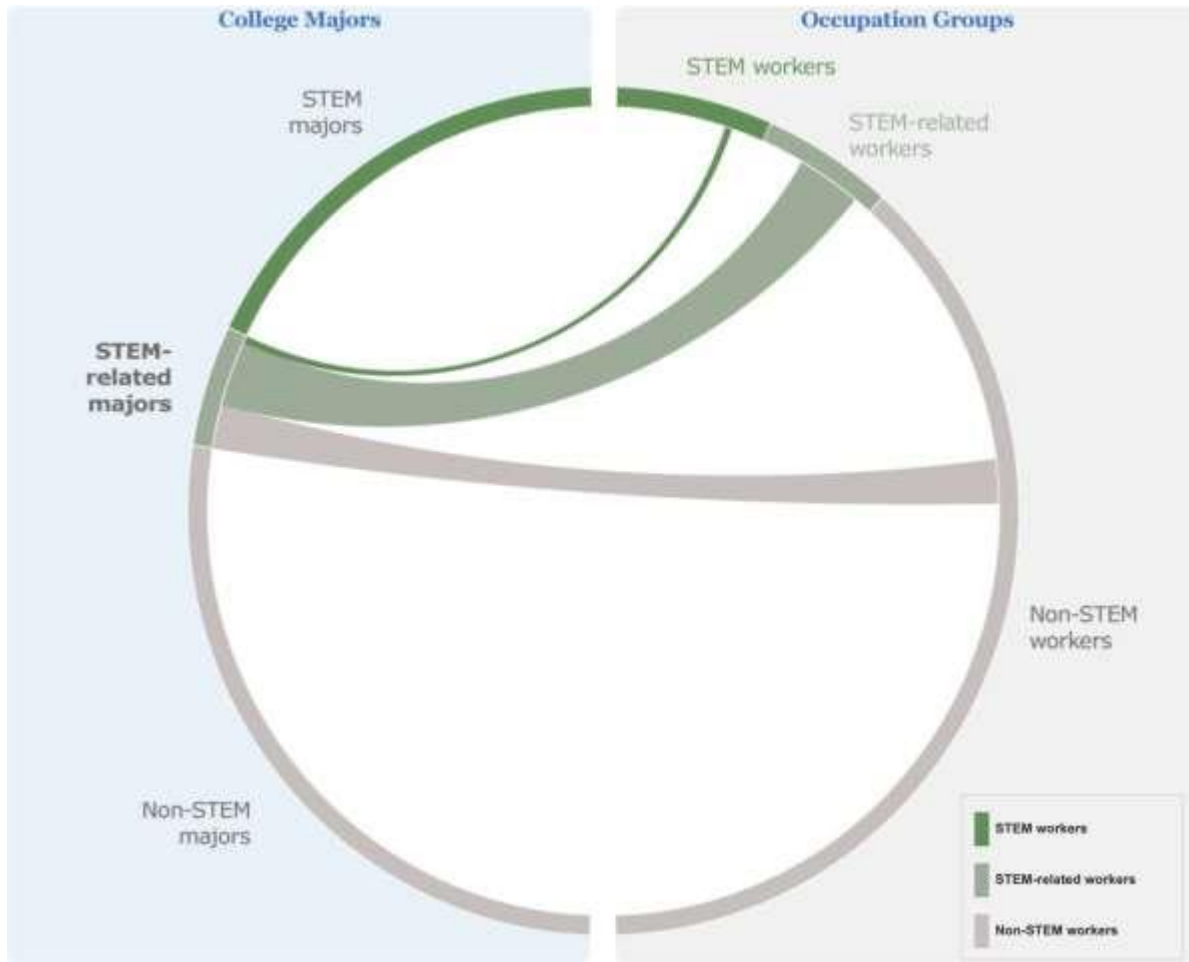


Figure 17: STEM-related majors and job for all students

Consistent in line with what we have seen earlier, figure 18 gives us a better view of how the women are distributed in the STEM majors. The majority of the female STEM students are enrolled in psychology, social, and environmental science, with psychology and social science accounting for the most significant shares. The proportion of students graduating in computing, mathematics, engineering, and physics represents a small subset of all the STEM graduates.

Of all the female students graduating with a computing, mathematics, or statistics degree, one-third of the graduates goes to work at a STEM job. As can be seen from figure 18, a majority of the students choose to go for a non-STEM field.

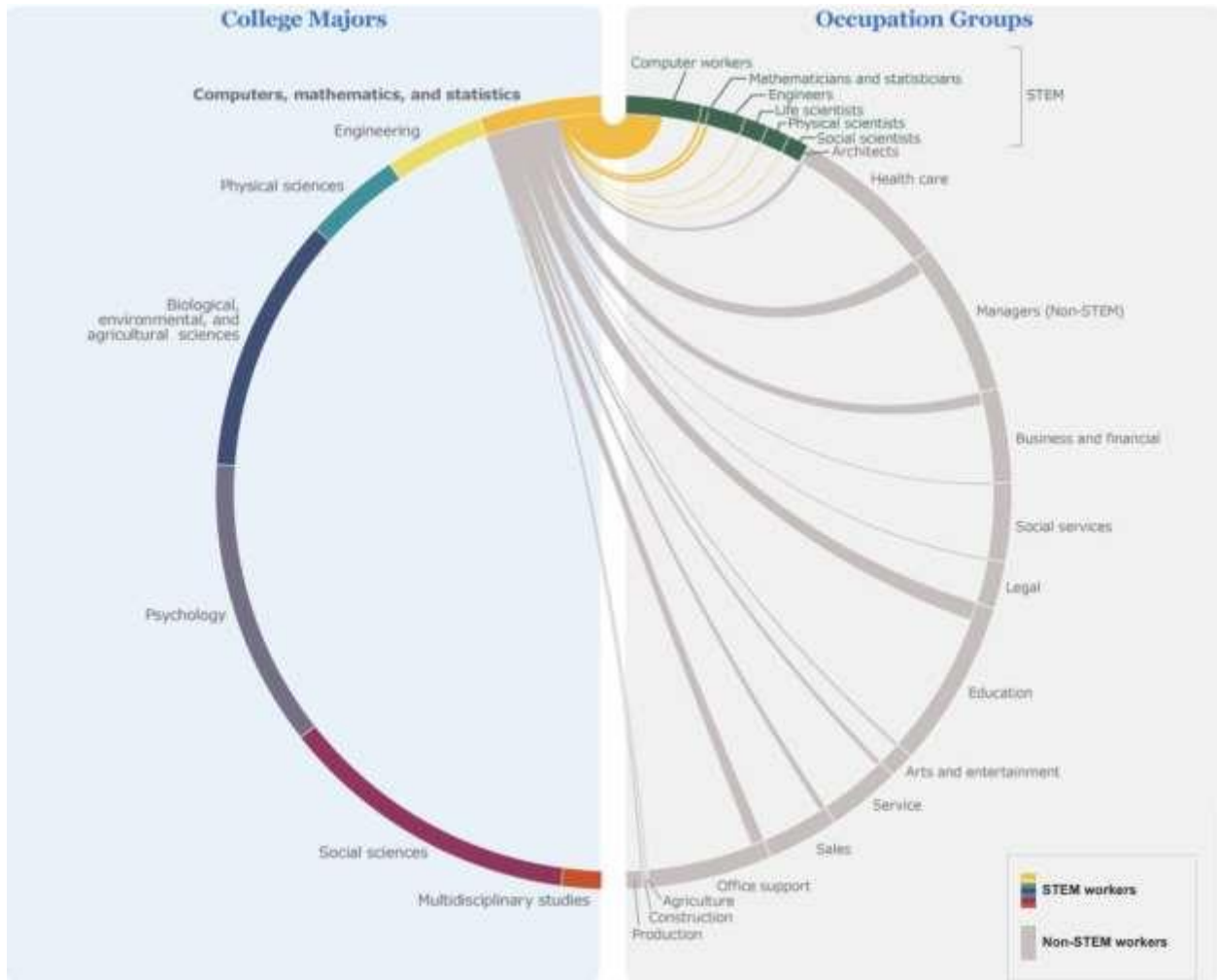


Figure 18: Job selection for women in computers, mathematics and statistics fields

The difference is significant when comparing the proportion of women and men who graduated with STEM majors going to work. As can be seen from figure 19, computing, mathematics, engineering, and physics represents a considerable chunk of the major's men are graduating in.

The numbers are twice what we had for the female students with the same degrees. Of the male students graduating in computing, mathematics, and statistics, the majority went to work for STEM-related jobs. This is again in contrast to what we saw for the female students.

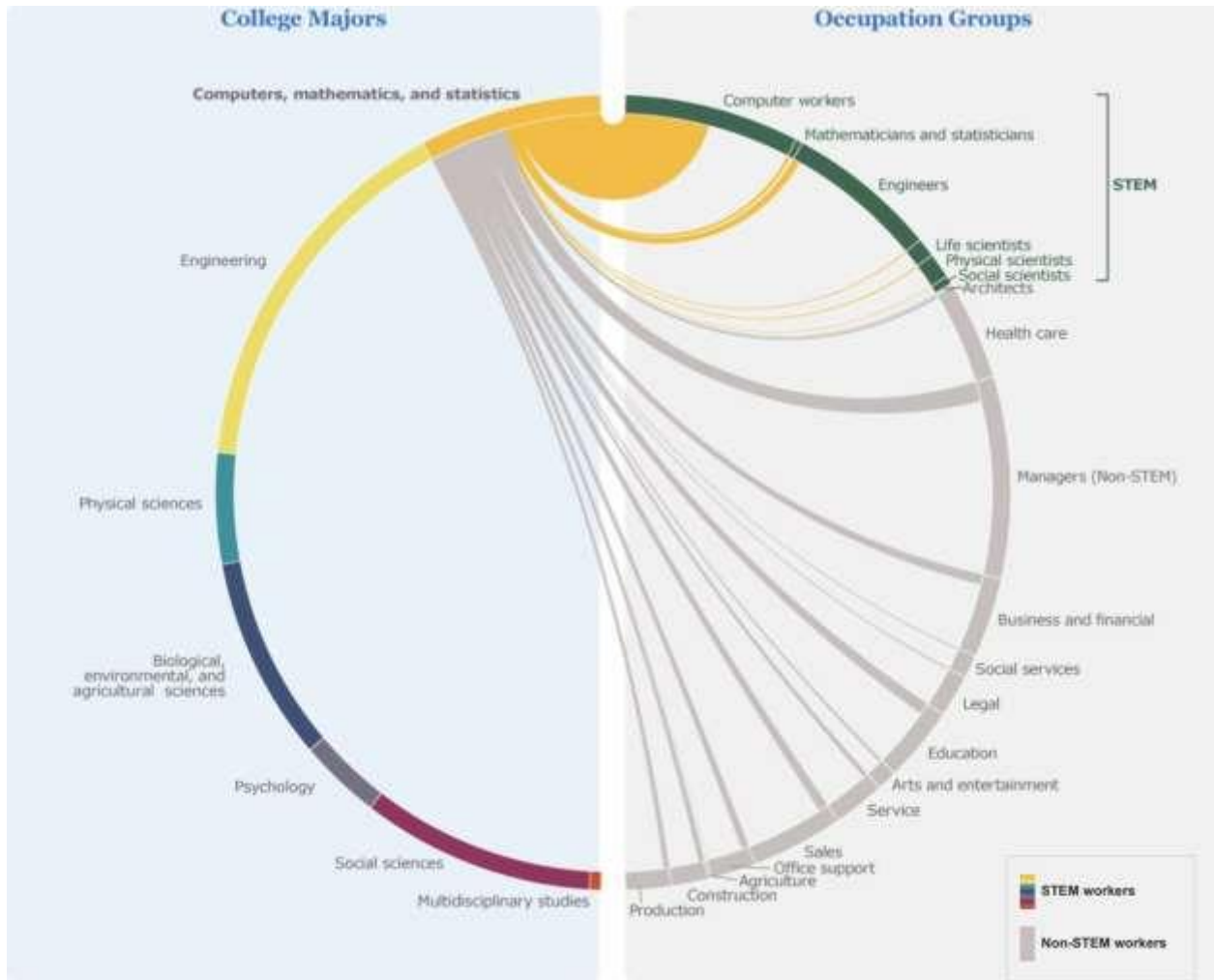


Figure 19: Job selection for men in computers, mathematics and statistics fields

Similar trends are seen when other STEM majors are compared. Figure 20 and 21 compares the proportion of male to female students who graduated with an engineering degree and the percentage of those who went to work for STEM fields. Women engineering graduates

accounted for 10 percent of all the female students graduating with a STEM degree in 2016, and half of those decided to work in STEM fields. This number is overshadowed when looking at male students graduating with an engineering degree. One-third of all the male STEM graduates graduated with an engineering degree. Given that more male students were pursuing an engineering degree, then female students put the situation in a new light. Nearly half of these male engineering graduates work in STEM fields.

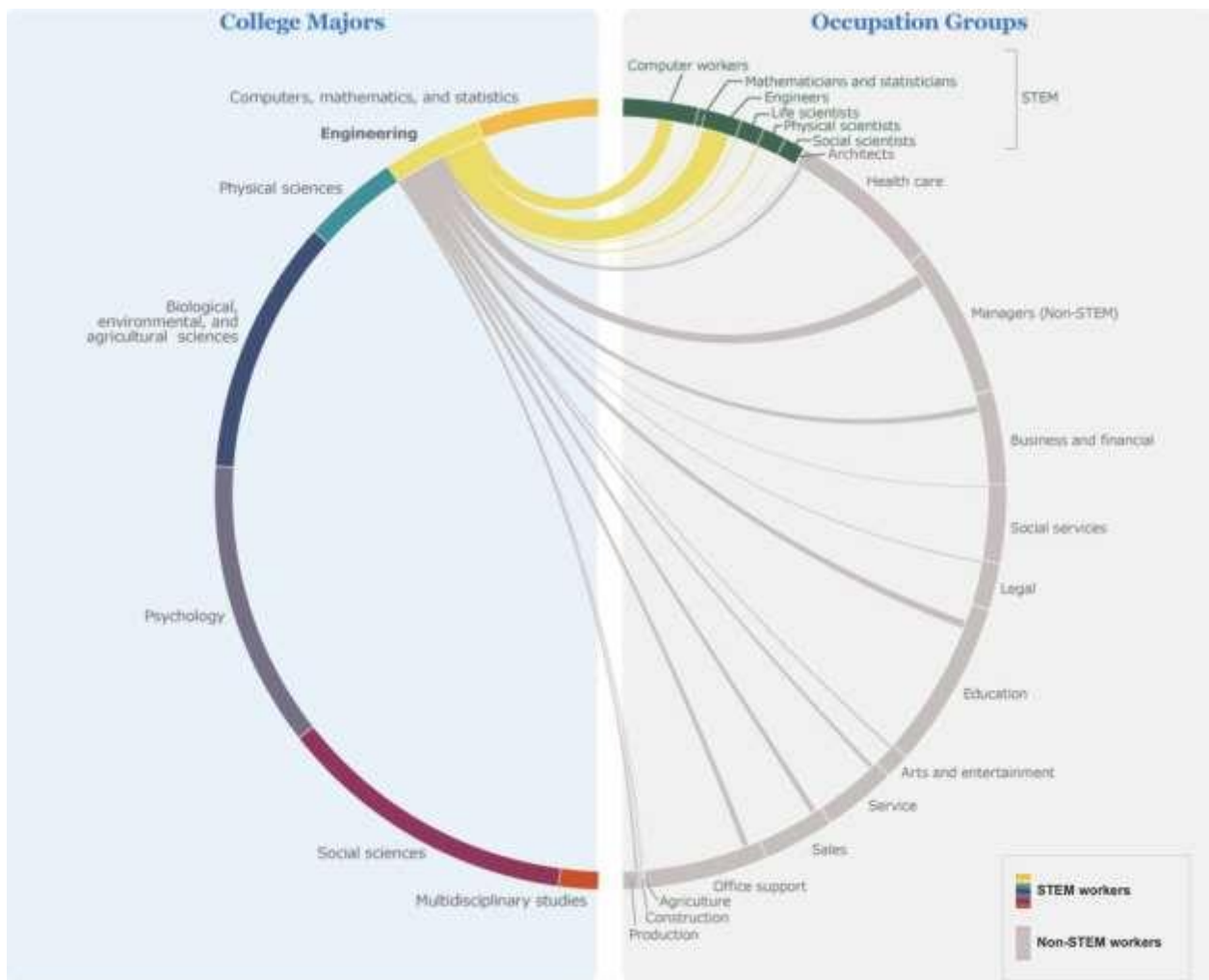


Figure 20: Job selection for women in engineering fields

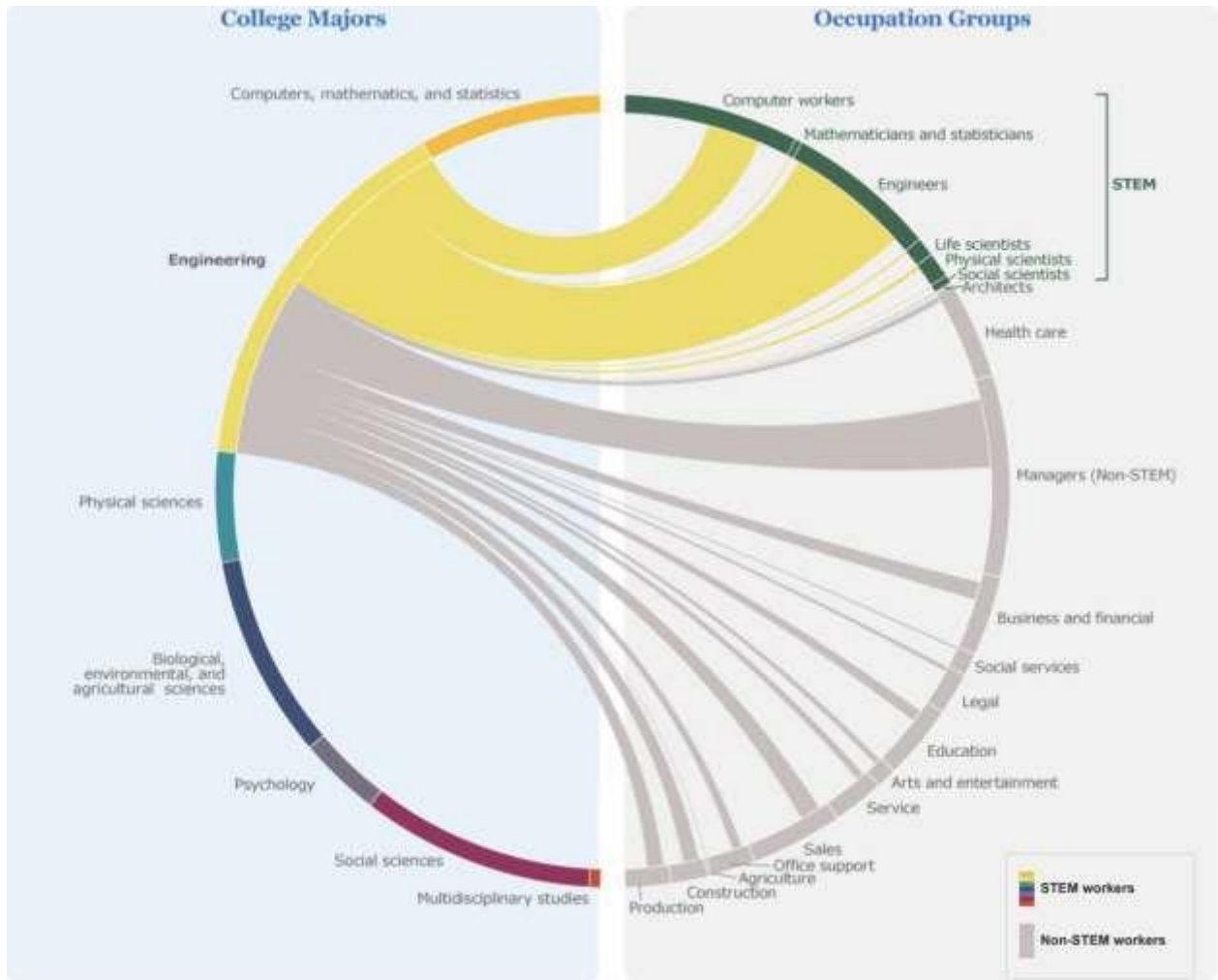


Figure 21: Job selection for men in engineering fields

Key Findings and Observations

- Women represent 50.8 percent of the American population and 47 percent of its workforce.
- The total workforce population of the United States of America is close to 126 million.
- Total STEM jobs available is around 8 million.
- Amongst those STEM jobs, there are 5.98 million men (75 percent) and 2 million women (25 percent).
- In 2016, 25 percent of the male freshman class majored in a STEM field compared to 8 percent of the female freshmen.
- In engineering fields, men outnumber women by 4 to 1, which is higher than the average for STEM of 3 to 1.
- Women get more bachelor's degrees in the fields of social science and psychology, whereas men tend to lead in the fields of computer science, engineering, and physics.
- Of all the STEM graduates, 30 percent chose to continue their careers in STEM fields.
- Female students who graduate in computer science and mathematics, one-third of those continue their carriers in the STEM field, compared to 50 percent who graduate with an engineering degree.

Conclusion

To answer the question of whether there is a "Gender Gap" present in the STEM fields, I would say, Yes. All the research above points to the fact that there exist a gap and under-representation of women in several of the fields of the STEM sector.

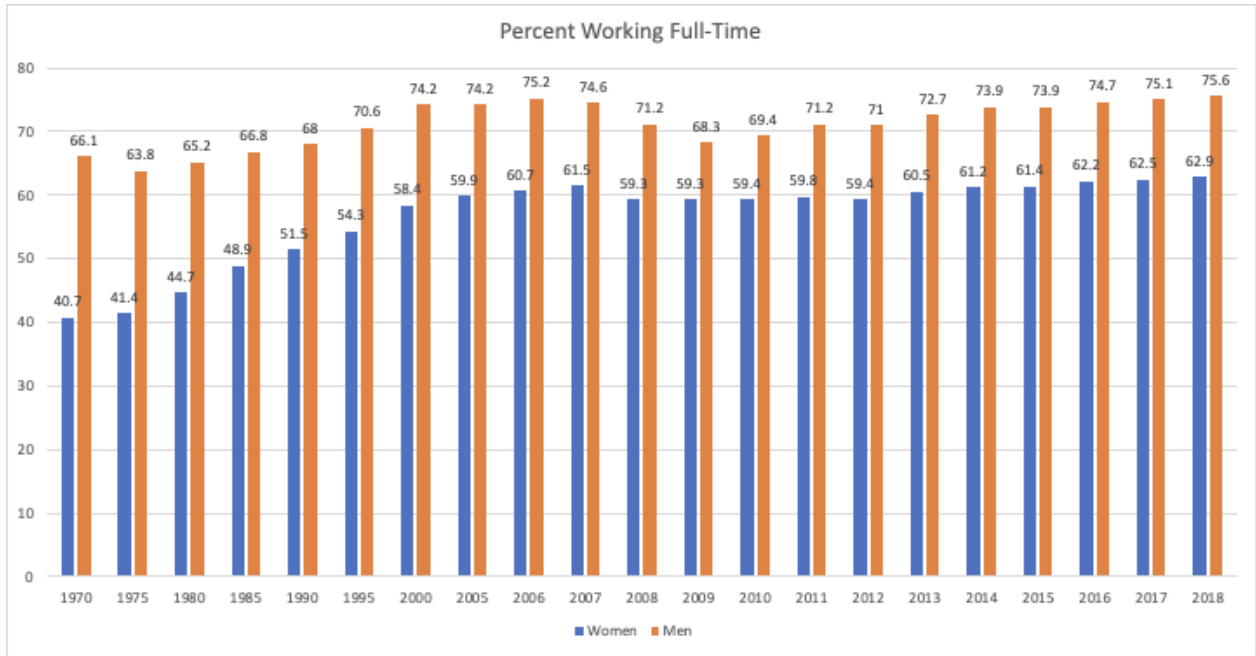
This research has examined and analyzed several data sources to find evidence to explain systematic and persistent differences between women and men across STEM fields. The gender diversity in STEM fields has been found to be a problem composed of several factors. Some of these factors include different choices made by men and women in their early high school days or the lack of female participation in STEM fields because of the lack of a role model. Every factor identified in this report has a different impact on the presence of the gender gap.

While this research cannot thoroughly explain why the gender gap exists, it does aim to identify the factors that help facilitate the gap. This research also aimed to provide enough data and insights to prove the existence of a gender gap.

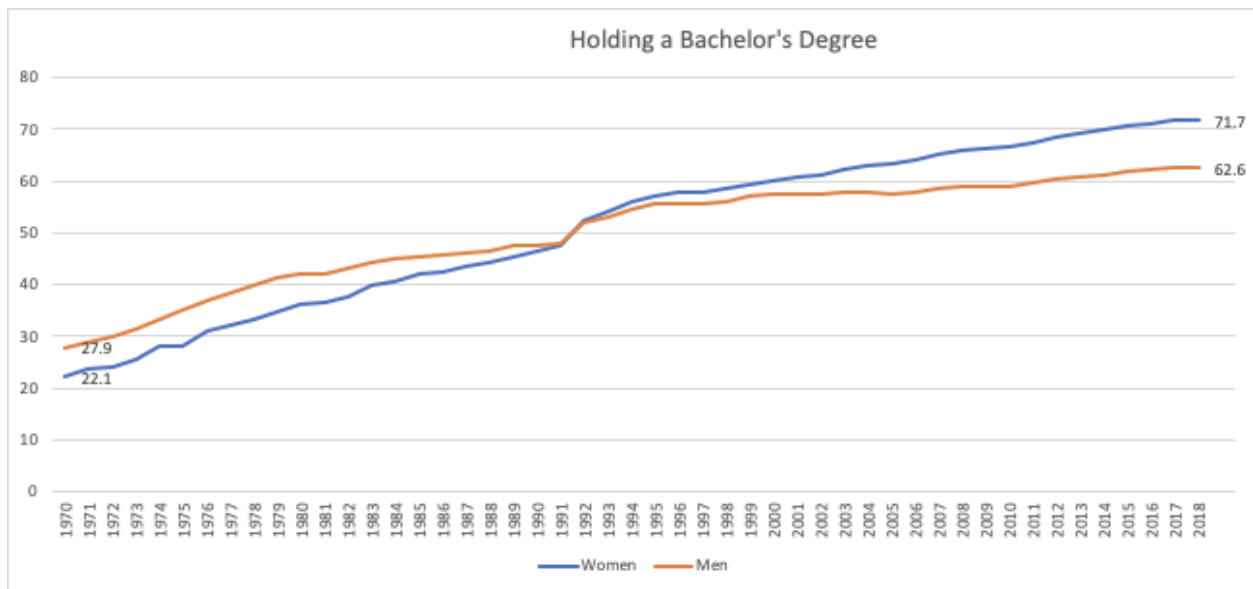
Here, there is a problem with cause and effect. The lack of women representation in STEM fields discourages other women from entering the field. Similarly, women currently employed in the field feel disempowered because of the lack of representation and role models. Therefore, policymakers and industries need to address both sides of the spectrum by making new policies and rules to encourage women to be a part of STEM.

Appendix

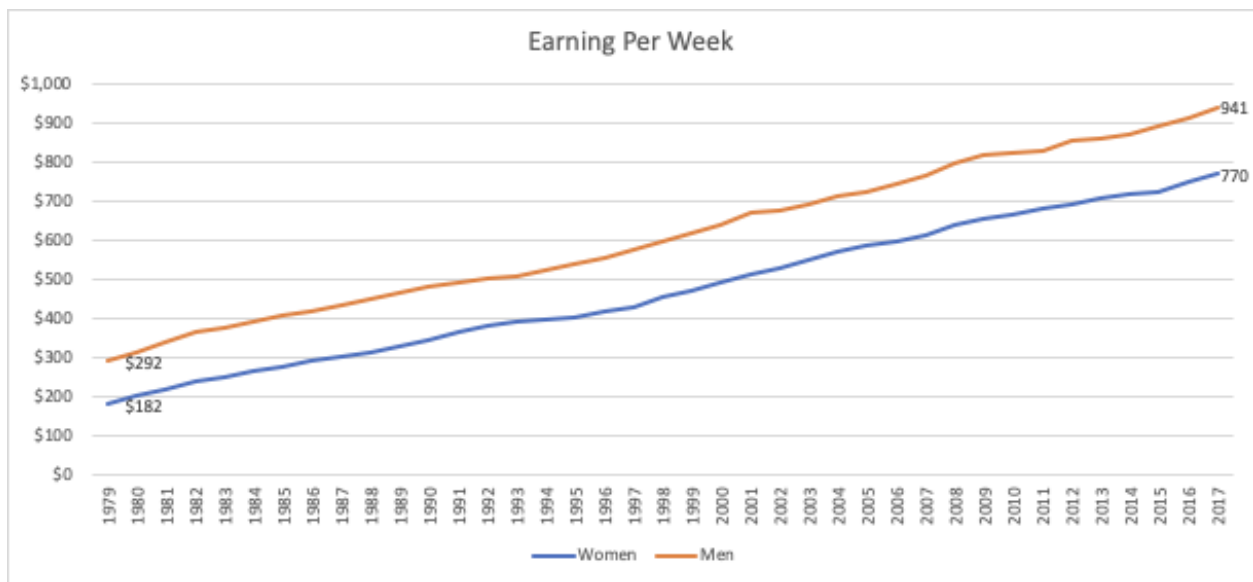
1. Men -Women holding Bachelor's degree



2. Men- Women Working Full Time (1970-2018)



3. Women's earnings as a percentage of men's



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