

# WITH GREAT POWER COMES GENDER DIVERSITY: SUPERPOWERS AND STEM STEREOTYPES IN MARVEL COMICS

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## ABSTRACT

Gender representation inequality occurs across various STEM sub-disciplines. For example, the sub-disciplines of computer science and engineering are male-dominant, while psychology and biological sciences are female-dominant. One possible cause of this gender inequality is the STEM professional stereotype; created, in large part, by media portrayals of STEM scientists. Across four studies I analyze the gender representation in portrayals of STEM skills in Marvel comics and their relation to real-world STEM educational outcomes, namely, bachelor's degrees attained in STEM. Study #1 shows that the portrayals of many STEM skills are gender biased for Marvel characters debuting before 1991. Study #2 shows that this gender bias in Marvel comics correlated with real-world STEM educational outcomes. Study #3 shows that Marvel characters debuting after 2000 show no gender biases in the portrayals of STEM skills. Finally, Study #4 makes predictions of how real-world educational outcomes are expected to change due to the increased gender equality in the portrayal of STEM skills in popular media.

*Keywords:* STEM, comics, graphic novels, gender, stereotypes.

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“STEM” is an acronym used to broadly encompass the disciplines of science, technology, engineering, and math. STEM professionals<sup>1</sup> play a vital role in our society, creating the technological innovations and products that shape our world (Margolis et al. 105). Many of our ideas about STEM and STEM professionals come from media portrayals in films, TV series, genre fiction, comics and graphic novels (Steinke et al., 50; Cheryan et al. “Cultural Stereotypes as Gatekeepers” 4). Here I will present three main themes of analysis: i) how the stereotypes surrounding STEM professionals affect gender representation across sub-disciplines of STEM, ii) how Marvel has portrayed STEM skills in their male and female characters over time, and

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<sup>1</sup> The term “STEM professional” will be used to refer to people working in a STEM career, including, but not limited to, scientists (i.e. those doing research and development), engineers, computer programmers, and any other professions that can be classified as STEM (e.g. clinical psychologist).

iii) the possible future effects of Marvel's recent approach to gender diversity for its characters (Johns).

## I. STEM AND GENDER REPRESENTATION

Even though STEM encompasses the broad areas of science, technology, engineering, and math, much of the research on STEM and gender representation tends to focus on mathematics, computer science and engineering (e.g. Ceci et al., "Women in Academic Science" 75; Cheryan et al., "Cultural Stereotypes as Gatekeepers" 1). To gain a broader understanding of the issues surrounding the perception of STEM professions and education in society, it is important to remember that STEM encompasses a wide variety of sub-disciplines. For the purposes of this paper, I will follow the classifications used by the *National Science Foundation* (<https://www.nsf.gov/>) and partition STEM into the following sub-disciplines: i) agricultural sciences, ii) biological sciences, iii) computer sciences, iv) earth, atmospheric, and ocean sciences, v) mathematics and statistics, vi) physical sciences, vii) psychology, viii) social sciences, and ix) engineering ("Women, Minorities, and Persons with Disabilities in Science and Engineering Table 5-1").<sup>2</sup>

### 1.1. GENDER INEQUALITY IN STEM

One pressing issue regarding STEM education and the related labor market is the inequality in gender representation across multiple STEM sub-disciplines (Cheryan et al., "Cultural Stereotypes as Gatekeepers" 1). Using the percentage of bachelor's degrees awarded to women in 2018 as a metric ("Women, Minorities, and Persons with Disabilities in Science and Engineering Table 5-1"), figure 1 shows the gender representation for each of the STEM sub-disciplines in order from most male-dominated to most female-dominated.

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<sup>2</sup> This is by no means an exhaustive list, but is used as a starting point for a broader approach.

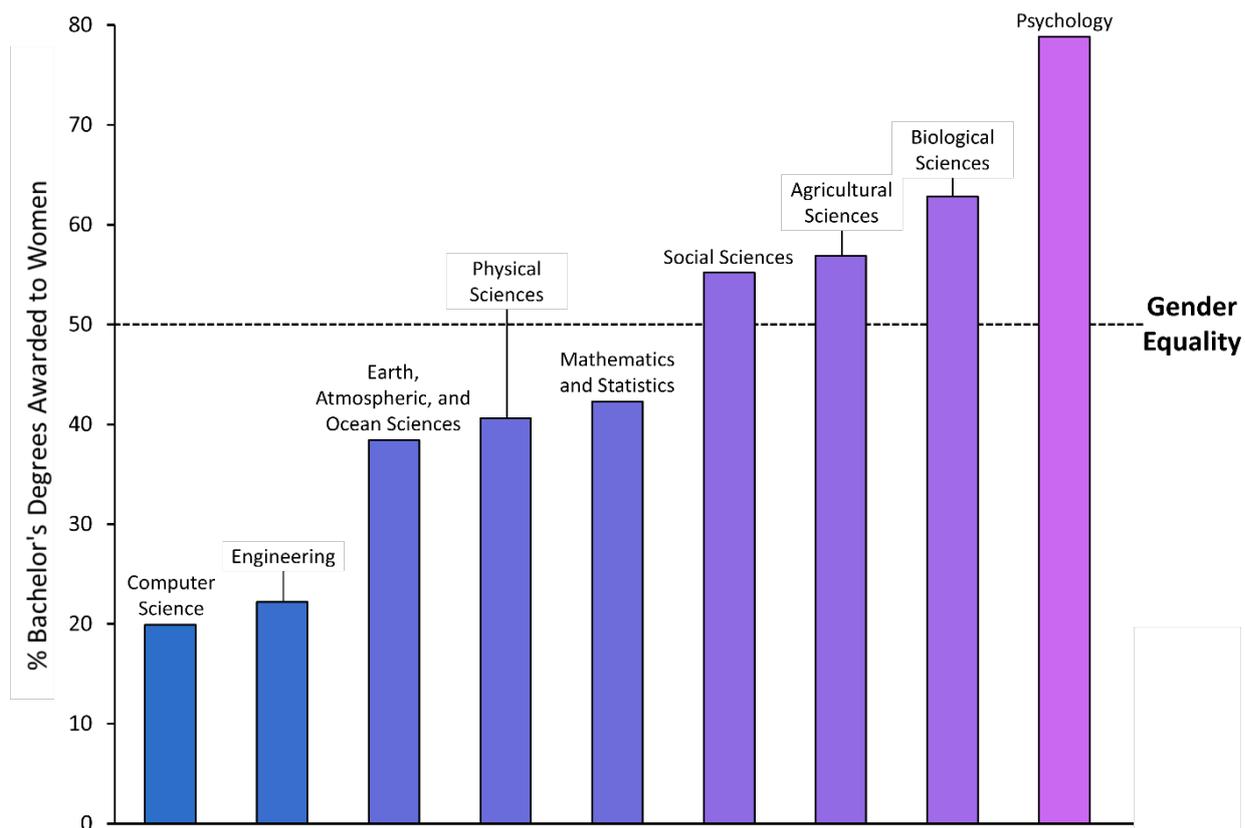


Figure 1 Percentage of STEM Bachelor Degrees Awarded to Women in 2018 (data from “Women, Minorities, and Persons with Disabilities in Science and Engineering Table 5-1”).

The STEM sub-disciplines with highest gender inequality due to male dominance are computer science and engineering (20% and 22% of bachelor’s degrees awarded to women, respectively). On the other side of the spectrum, STEM sub-disciplines with the highest gender inequality due to female dominance are psychology and biological sciences (79% and 64% of bachelor’s degrees awarded to women, respectively, see figure 1).

Research has shown that gender inequality in computer science and engineering is not simply an issue with respect to the attainment of undergraduate degrees. It is found across multiple metrics, such as: i) classes taken in high school, both conventional (Shashaani 352) and Advanced Placement classes (College Board), ii) interest in pursuing a STEM career (Weisgram and Bigler 334; “Chapter 2. Higher Education in Science and Engineering Figure 2-11”), and iii) graduation rates from advanced degree college-level STEM programs (“Indicator 26: STEM Degrees”). Research on other sub-disciplines, however, is less available.

## 1.2. EFFECTS OF GENDER INEQUALITY IN STEM

Gender inequality in STEM-related fields can have widespread negative effects on both the outcomes of scientific research and its application in society. In science, diversity, including gender diversity, is crucial for providing different ways of looking at the world around us

(Medin et al.) and different approaches to problem solving. Bringing a variety of perspectives to a problem makes new scientific advancements more likely, whereas a single, uniform perspective can impede scientific progress (Medin et al.). A lack of diversity in STEM impacts the wider public as well in, for example, the nature of the products that STEM sub-disciplines produce for society. Computer scientists, agricultural scientists, physicists, and engineers design products that shape society (Margolis et al. 105). Having a variety of perspectives and experiences during the design process will lead to the creation of products that are useful and appropriate for broader segments of the population (105). Gender representation inequality in STEM can have negative effects both on the advancement of science and on the products created from that advancement.

### 1.3. CAUSES OF GENDER INEQUALITY IN STEM

Before turning to the possible causes of gender inequality in STEM, it is important to point out that I will be using research done predominately in the sub-disciplines of computer science and engineering and extrapolating these findings across all STEM sub-disciplines. Many of the theories on the causes of gender inequality in computer science and engineering draw on general psychology theories that can be applied to any STEM sub-discipline (e.g. Hasdorf and Cantril, 132; Zajonc 269; Meissner 517; Leaper et al. 1653, Miller and Reeves 36; Fujioka 53). Therefore, there is no logical or scientific reason to believe that these causes would only operate in computer science and engineering. Likewise, much of the research revealing the negative effects of gender inequality in computer science and engineering proposes causal factors that would be harmful in any STEM sub-discipline (e.g. stereotypes) (Steele 614; Schmader et al. 336). Lastly, research has shown that single factors may account for gender inequality across STEM fields, applying to both male-dominated and female-dominated sub-disciplines. For example, the belief that innate talent or genius is a requirement for success in a STEM sub-discipline is positively correlated with the percentage of male Ph.Ds. and negatively correlated with the percentage of female Ph.Ds. across all STEM sub-disciplines (Leslie et al. 262). This one factor, innate talent, may possibly explain both the high percentage of males/low percentage of females in computer science and the high percentage of females/low percentage of males in psychology. So, while much of the research I report here is focused on the sub-disciplines of computer science and engineering, I will be extrapolating the conclusions of that research to all STEM sub-disciplines.

What, then, are the possible causes of gender inequality in STEM? Consider the sub-disciplines of computer science and engineering, where only 20% and 22% of bachelor's degrees, respectively, are awarded to women ("Women, Minorities, and Persons with Disabilities in Science and Engineering Table 5-1"). It is easy to assume that this inequality is caused by, "Women... choosing not to enter, presumably because they don't want to; presumably because they (by and large) don't like these fields." (Gelernter). This same reasoning, applied to men, could be used in an attempt to explain why only 21% of bachelor's degrees in

psychology are awarded to men (“Women, Minorities, and Persons with Disabilities in Science and Engineering Table 5-1”). However, this reasoning misses the significant social barriers that prevent men and women from freely choosing to pursue a career in certain STEM sub-disciplines (Ceci et al., “Women's Underrepresentation” 220).

One important social barrier in STEM is produced by the STEM professional stereotype (Cheryan et al., “Cultural Stereotypes as Gatekeepers” 3; see figure 2). The STEM professional stereotype is our culture’s general, shared concept of what a STEM professional is. The STEM professional stereotype includes the physical features, typical behaviors, personality traits, and skills that come to mind automatically when we think of a person working in a STEM field. Physical features of the STEM professional stereotype include being male, white, elderly or middle-aged, and unattractive (Finson 341, 335; Steinke, “Adolescent Girls” 2). The stereotypical STEM professional wears glasses and a white lab coat (Finson 336; Steinke, “Adolescent Girls” 2). The personality of a stereotypical STEM professional is geeky or nerdy, and they are socially awkward (Steinke, “Adolescent Girls” 2). They mostly work alone (Steinke, “Adolescent Girls” 2), in a laboratory (Finson 335), performing dangerous experiments (335), and their work is dissociated from communal goals (Diekman et al., “Seeking Congruity” 1054). Lastly, the stereotypical STEM professional is very intelligent (Ward 8), often due to an inborn brilliance or genius (Leslie et al. 263).



Figure 2 Dr. Bruce Banner (alter-ego of the Incredible Hulk) possesses many of the features of the STEM professional stereotype.

The STEM professional stereotype is extremely widespread in US culture. This stereotype is found in elementary-school students (Barman 20), high-school students (Cheryan et al., “Cultural Stereotypes as Gatekeepers” 4), and college students (Cheryan et al., “Stereotypical Computer Scientist” 59; Diekman et al., “Seeking Congruity” 1052; Beardslee and O’Dowd 997). The stereotype is held by both men and women, and across different socioeconomic backgrounds and ethnicities (Mead and Métraux 385).

This STEM professional stereotype, like all stereotypes, has the power to determine a person’s attitudes, behaviors, and choices (Hasdorf and Cantril 132; Steele 614; Schmader et al. 336). This power allows the STEM professional stereotype to act as a social barrier to entry in STEM fields by constraining who enters these fields (Cheryan et al., “Cultural Stereotypes as Gatekeepers” 2). Importantly, the STEM professional stereotype has this influence because of our shared beliefs in the stereotype, even if the stereotype has no basis in reality (3). If the features of the STEM professional stereotype are perceived negatively by an individual, that individual is less likely to pursue education in STEM (Finson 335). The corollary to this finding is that, if features of the STEM professional stereotype are perceived positively, that individual is more likely to pursue STEM courses of study.

If this is the case, it follows that there must be different STEM professional stereotypes for different STEM sub-disciplines. For example, research specifically on the computer scientist stereotype has shown that many of the features of this stereotype are perceived negatively by women (Diekman et al., “Malleability in Communal Goals” 906; Cheryan 185; Leslie et al. 262). For example, the computer scientist stereotype includes being physically unattractive and dissociated from communal goals; neither of these are qualities that are valued by women (Diekman et al., “Malleability in Communal Goals” 906; Cheryan 185; Leslie et al. 262; Cheryan et al., “Cultural Stereotypes as Gatekeepers” 4). It is highly likely, then, that female-dominated STEM sub-disciplines such as psychology have stereotypes portraying qualities that are, in general, valued by women (Diekman et al., “Seeking Congruity Between Goals and Roles” 1055; Leslie et al. 264; Cheryan 185). For example, the psychologist stereotype likely includes being involved in community goals (e.g. the primary role of a psychologist is to help and support other people).

For STEM sub-disciplines, the incompatibility of the qualities possessed by the STEM professional stereotype with the qualities valued by an individual produces a feeling of “lack of fit” (Van Veelen and Derks 4). This perceived lack of fit then leads to lower feelings of belonging in STEM (Barth et al. 276), which in turn are associated with less intention to pursue STEM (Evans and Diekman 240; Good et al. 707; Smith et al. 134), lower likelihood to enroll in STEM education (Finson 338), and lower academic achievement for those that do enroll (Lewis et al. 020110-2). Clearly, stereotypes can have a large impact on the gender representation in STEM sub-disciplines.

#### 1.4. POPULAR MEDIA AND THE STEM PROFESSIONAL STEREOTYPE

The STEM professional stereotype is created, in large part, by popular media portrayals of STEM disciplines and scientists (Fujioka 54; Finson 337). Media portrayals are cultural constructions that convey assumptions about STEM fields to society (Steinke, “Cultural Representations” 52; Steinke, “Adolescent Girls” 3). Media portrayals of STEM professionals, both real and fictional, shape public perceptions (Gamson et al. 389; Steinke, “Adolescent Girls” 4), teach the cultural patterns of scientific behavior (6), and contribute significantly to the mental concepts people form about STEM and STEM professionals (Finson 337). In other words, media portrayals of STEM professionals shape and maintain features of the STEM professional stereotype (Leaper et al. 1660; Steinke, “Adolescent Girls” 7).

The importance of media portrayals of STEM professionals in forming our stereotypes comes, to a great extent, from the precedence and preeminence of media in our culture. Media portrayals of STEM professionals in films, TV series, genre fiction, and comics and graphic novels are often our earliest and most frequent exposure to STEM professionals (Steinke, “Adolescent Girls” 4). This “vicarious contact” (Fujioka 67) via media images is the most influential source in developing the STEM professional stereotype (Steinke et al. 50; Cheryan et al., “Cultural Stereotypes as Gatekeepers” 4). Media portrayals play a role in how children view STEM professionals (Tan and Jocz 6), with adolescents often relying on popular media as their main source for this information (Song and Kim 966; Scherz and Oren 982; Steinke et al. 50). This, in turn, affects their interest in STEM (Lee 209) and influences whether they choose to pursue a STEM career (Steinke 4).

#### 1.5. STEM STEREOTYPICAL SKILLS

Previous research has predominantly focused on the physical appearance, personality, and behaviors of the stereotypical STEM professional (Steinke, “Adolescent Girls” 2; Finson 336; Cheryan et al., “Cultural Stereotypes as Gatekeepers” 3; Cheryan et al., “Stereotypical Computer Scientist” 59). From here on in, however, I will focus my analysis on a specific aspect of the STEM professional stereotype, specifically the skills and abilities that are stereotypically assigned to STEM professionals. I will look at how these skills are portrayed across genders in popular media, where certain STEM skills may be portrayed predominately in male characters, while other skills are portrayed predominantly in female characters. These portrayals help create aspects of the STEM professional stereotype, both in general and for specific STEM sub-disciplines. For example, the common stereotype that “girls are bad at math” coupled with the STEM professional stereotype that exceptional math skills are necessary for engineering could create a social barrier preventing women from pursuing engineering (Van Veelen and Derks 4). Similarly, the stereotype that women are more empathetic than men coupled with the STEM professional stereotype that empathy is necessary for psychology could likewise create a social barrier preventing men from pursuing psychology. As such, an understanding of how STEM skills and abilities are portrayed across gender in popular media is

important in identifying the stereotypes being created. To this end, I will present an analysis of the portrayal of STEM skills and abilities in male and female characters as portrayed in Marvel comics.

#### 1.6. STEM PROFESSIONALS AND SKILLS IN MARVEL COMICS

As already mentioned, one source of media portrayals of STEM professionals are comicbooks. Numerous Marvel characters have careers in STEM fields; for example, both Tony Stark (Iron Man) and Reed Richards (Mr. Fantastic of the Fantastic Four) are inventors with advanced knowledge that spans multiple sub-disciplines of STEM (see figure 3). The Marvel Database lists 1609 Marvel characters as “scientists” (with a grand total of 3492 entries if Multiverse versions of the same character are included; see “Scientists”). In addition to this, there are many other characters who, while not explicitly portrayed as scientists, demonstrate attributes that are associated with STEM. That is, they possess the real-world skills, fictional superpowers, and/or other characteristics that are part of the STEM professional stereotype, all without being explicitly labeled as “scientists.” They may also possess skills that, while not part of the STEM professional stereotype, are in reality beneficial to success in STEM. For example, Nico Minoru (from Marvel’s Runaways) possesses both intelligence and the soft-skill of leadership (“Nico Minoru,” see figure 4). Jean Grey (Phoenix of the X-Men) possesses the real-world skill of empathy and the fictional superpower of telepathy (“Jean Grey”), both perceived as valuable to the STEM sub-discipline of psychology (see figure 4).



Figure 3 Tony Stark (Iron Man, left panel) and Reed Richards (Mr. Fantastic of the Fantastic Four, right panel) are inventors with advanced knowledge that spans multiple sub-disciplines of STEM. Both characters also possess many of the features of the STEM professional stereotype.



Figure 4 Nico Minoru (from Marvel's Runaways, left panel) and Jean Grey (Phoenix of the X-Men, right panel) possess abilities that are perceived as valuable to success in STEM.

Superhero comicbooks have a wide readership and, very importantly, this readership includes children and young adults, providing them with early exposure to portrayals of STEM professionals. In 2017, approximately 50% of superhero comicbook buyers were under 30 (Alverson). While it may be tempting to dismiss the impact of superhero comics on females, as superhero comicbook readership skews towards a male audience (78% male vs. 22% female), this would overlook the fact that female superhero comicbook readers are, on average, younger (Alverson). This is extremely important, given the greater impact of early exposure to images of STEM professionals. Finally, comicbooks reach a wide audience; in 2022 52% of Americans aged 18-34 had read at least one comic book (Kentic).

While reading just one comicbook portrayal of a STEM professional may not seem important, research has shown that exposure to a single media portrayal of a STEM professional can either increase or decrease an individual's interest towards STEM. For example, after reading a single article portraying the stereotypical STEM computer scientist, women expressed less interest in majoring in computer science than women who read a non-stereotypical portrayal (Cheryan et al., "Stereotypical Computer Scientist" 67). Clearly, comicbooks can have an impact on the creation and maintenance of the STEM professional stereotype. By increasing the diversity in the presentation of STEM professionals, comicbooks can expand the demographics of the STEM professional stereotype. However, they can also continue to present the STEM professional stereotype as it currently is, leading to a strengthening of the stereotype.

## II. STUDY #1: GENDER REPRESENTATION OF STEM IN MARVEL PRE-1991

How are the real-world skills, fictional superpowers, and/or other qualities that are either part of the STEM professional stereotype or are actual skills beneficial for STEM portrayed across gender in Marvel comicbooks? For this first investigation, I will limit the analysis to Marvel characters that debuted pre-1991, as these are the portrayals that would have contributed to the STEM professional stereotype affecting recent STEM graduates.

### 2.1. METHOD

The STEM sub-disciplines chosen for analysis were those listed in the National Center for Science and Engineering Statistics report on bachelor's degrees awarded in STEM ("Women, Minorities, and Persons with Disabilities in Science and Engineering Table 5-1"). To reiterate, these included: i) agricultural sciences, ii) biological sciences, iii) computer sciences, iv) earth, atmospheric, and ocean sciences, v) mathematics and statistics, vi) physical sciences, vii) psychology, viii) social sciences, and ix) engineering (see table 1). For each STEM sub-discipline, I matched the superpowers and abilities of Marvel characters that would be beneficial to that sub-discipline (see table 1). The superpowers and abilities associated with each STEM sub-discipline are either real-world skills that are related to the sub-discipline (e.g. genetic manipulation for biological sciences) or superpowers that are exaggerated abilities associated with

the sub-discipline (e.g. telepathy for psychology). I also included products (real or fictional) used by Marvel characters that are produced or specifically used by a STEM sub-discipline (e.g. gadgets for engineering)<sup>3</sup>. Some abilities were unique to certain sub-disciplines (e.g. psychometry for social sciences), while others were shared across multiple sub-disciplines (e.g. intellect was associated with all sub-disciplines).

Stem Sub-Discipline	Superpower, Ability, or Product
Agricultural sciences	Animal control, Earth manipulation, Genetic manipulation, Intellect, Plant control, Water control, Weather control
Biological sciences	Animal control, Genetic manipulation, Intellect, Plant control, Tracking
Computer sciences	Animation, Electronic interaction, Gadgets, Intellect, Omni-lingual, Technopathy
Earth, atmospheric, and ocean sciences	Earth manipulation, Gravity control, Ice control, Intellect, Magnetism, Sand manipulation, Sub-mariner, Water control, Weather control
Mathematics and statistics	Intellect
Physical sciences	Animal control, Cosmic awareness, Earth manipulation, Electricity control, Electronic disruption, Electronic interaction, Emotion control, Energy absorption, Energy-enhanced strike, Energy manipulation, Genetic manipulation, Gravity control, Ice control, Implants, Inertia absorption, Magnetism, Mesmerize, Necromancy, Phasing/ghost, Plant control, Postcognition, Psychometry, Reality manipulation, Sub-mariner, Telepathy, Time manipulation, Time travel, Tracking, Voice-induced manipulation
Psychology	Emotion control, Empathy, Hypnosis, Intellect, Mesmerize, Psychic, Telepathy, Voice-induced manipulation
Social sciences	Intellect, Necromancy, Postcognition, Psychometry, Time travel
Engineering	Animation, Electricity control, Electronic disruption, Electronic interaction, Gadgets, Implants, Intellect, Power item, Power suit, Technopathy

Table 1: Superpowers/Abilities/Products Associated with Each STEM Sub-Discipline.

This initial analysis was limited to Marvel characters that debuted pre-1991, as these are the portrayals that would have contributed to the STEM professional stereotype affecting recent STEM graduates. Given that the average age for graduating from a bachelor's program is 21.8

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<sup>3</sup> The selection of superpowers/abilities/products were restricted to those specifically associated with each STEM sub-discipline. For example, super-speed was not included, because no STEM sub-discipline requires super-speed to be successful, even though it would be immensely useful in any sub-discipline. Likewise, a power suit was included as a product in engineering, but not in earth, atmospheric, and ocean sciences, where it would be useful but is not considered a product of that sub-discipline (i.e. earth, atmospheric, and ocean scientists would hire an engineer to design their power suits).

years old (full-time students) or 27.2 years old (part-time students) (Brunner), Marvel characters that debuted pre-1991 would have contributed most to the STEM professional stereotypes that influenced students attaining bachelor’s degrees between 2012-2018, the years for which the most recent data was available at the time of the study (“Women, Minorities, and Persons with Disabilities in Science and Engineering Table 5-1”). The list of Marvel characters included in the analysis was taken from the *Official Handbook of the Marvel Universe Master Edition* (Kaminski), as this provided an authoritative (though not exhaustive) list of Marvel characters that debuted prior to 1991 (the publication date of the first issue was December, 1990). Only characters with individual entries were included in the final list, which totaled 550 characters (149 female, 401 male, and 0 non-binary).

Each of the 550 characters was cross-referenced with their Comic Vine character page (“Comic Vine”) to attain a list of their superpowers/abilities/products. For each superpower/ability/product associated with a STEM sub-discipline (see table 1), a character was categorized as to whether or not they possessed that particular superpower/ability/product.

## 2.2. RESULTS

An independent-means *t*-test analysis with an  $\alpha = .05$  was conducted for each of the 47 superpowers/abilities/products (see table 1). Each *t*-test compared the percent of male versus female characters that possessed a superpower/ability/product. A post-hoc Benjamini-Hochberg procedure was used with a 25% false-discovery rate to control for multiple comparisons.

This analysis revealed that the gender representation of some superpowers/abilities/products were male-dominant (e.g. gadgets and power suit), some were female-dominant (e.g. empathy and intellect), while others were equally represented between the genders (e.g. electricity control and post-cognition; see table 2).

Gender Representation	Superpower, Ability, or Product
Male-dominant	Gadgets, Matter absorption, Omni-lingual, Power item, Power suit, Technopathy
Female-dominant	Animation, Empathy, Energy based constructs, Energy shield, Hypnosis, Intellect, Levitation, Light projection, Psychic, Sand manipulation, Water control, Weather control
Equally represented	Cosmic awareness, Genetic manipulation, Implants, Inertia absorption, Phasing/ghost, Time manipulation, Time travel, Animal control, Earth manipulation, Electricity control, Electronic disruption, Electronic interaction, Emotion control, Energy absorption, Energy manipulation, Energy-enhanced strike, Gravity control, Ice control, Magnetism, Mesmerize, Necromancy, Plant control, Postcognition, Psychometry, Reality manipulation, Sub-mariner, Telepathy, Tracking, Voice-induced manipulation

Table 2: Superpowers/Abilities/Products that are Male-Dominant, Female-Dominant, or Equally Represented

## 2.3 DISCUSSION

Of the 47 superpowers/abilities/products analyzed, six (12.8%) were male-dominant (see table 2). That is, six superpowers/abilities/products occurred at a significantly higher percentage among male characters than female characters. On the other hand, 12 (25.5%) were female-dominant, meaning that 12 superpowers/abilities/products occurred at a significantly higher percentage among female characters than male characters. The remaining 29 (61.7%) superpowers/abilities/products were equally distributed among male and female characters.

A closer look at the male-dominant superpowers/abilities/products reveals that most of them came from the STEM sub-disciplines of computer science and engineering (5 of the 6). Alternatively, most of the female-dominant superpowers/abilities/products came from the STEM sub-disciplines of psychology, agricultural sciences, and earth, atmospheric, and ocean sciences (7 of 12). This mostly follows the pattern seen in the percentage of bachelor's degrees awarded to women in 2018 (see figure 1). Specifically, the male-dominant superpowers/abilities/products are in computer science and engineering, which have the highest gender inequality due to male dominance (20% and 22% of bachelor's degrees awarded to women, respectively). Meanwhile, the female-dominant superpowers/abilities/products are in two of the STEM sub-disciplines with the highest gender inequality due to female dominance, psychology and agricultural science (79% and 57% of bachelor's degrees awarded to women, respectively). The exception to this correspondence was biological science. Biological science is a female-dominated STEM sub-discipline (64% of bachelor's degrees awarded to women); yet the superpowers/abilities/products related to biological science were represented equally across genders, rather than being female-dominant. Overall, however, the pattern of gender representation of STEM superpowers/abilities/products corresponds to the percent of bachelor's degrees awarded to men and women in STEM sub-disciplines.

These results are consistent with the theory that the gender representation of superpowers/abilities/products in media portrayals influences the stereotypes we have about the STEM skills possessed by men and women in the real-world. These skill gender stereotypes become incorporated in to the STEM professional stereotype, influencing the academic disciplines that men and women pursue, leading to high gender inequality in computer science and engineering (due to male dominance) as well as high gender inequality in psychology and agricultural science (due to female dominance).

### **III. STUDY #2: DOES GENDER REPRESENTATION OF STEM IN MARVEL CORRELATE WITH REAL-WORLD STEM OUTCOMES?**

Study #1 showed that superpowers/abilities/products related to the STEM sub-disciplines of psychology, agricultural sciences, and earth, atmospheric, and ocean sciences tended to be portrayed more often in female Marvel characters, while superpowers/abilities/products related to computer science and engineering tended to be portrayed more often in male Marvel characters. If these portrayals are influencing men and women on their decisions to pursue a

STEM sub-discipline, then the same patterns should be found in STEM educational outcomes. In fact, the general correspondence between superpowers/abilities/products and STEM bachelor's degrees awarded supports this idea. I now test the statistical strength of this correspondence between superpowers/abilities/products and educational outcomes in STEM to determine if the correspondence truly exists, or if it is an illusion created by chance variation.

### 3.1. METHOD

To measure educational outcomes in STEM, I will once again use bachelor's degrees attained in STEM sub-disciplines. The previous discussion noted a possible correspondence between STEM superpowers/abilities/products and bachelor's degrees awarded in 2018. For this analysis, we will use the percentages of bachelor's degrees awarded to men and women during the years 2008-2015 ("Women, Minorities, and Persons with Disabilities in Science and Engineering Table 5-1"). The rationale for choosing these years, rather than including the most currently available data, is to isolate, as much as possible, any potential relationship between Marvel characters that debuted pre-1991 and educational outcomes. That is, given the average ages for attaining a bachelor's degree used in the previous analysis (21.8 and 27.2 years old for full- and part-time students, respectively) (Brunner), students born before 1991 would generally attain bachelor's degrees between 2008-2015. Of course, many students born before 1991 would have attained bachelor's degree much earlier. However, restricting the analysis to 2008-2015 allows us to analyze the most contemporary effects of the pre-1991 Marvel characters.

Using the data collected for Marvel characters that debuted pre-1991 (see Study #1), I calculated a *gender representation bias* score for each superpower/ability/product. Gender representation bias was calculated as:

$$\text{gender representation bias} = (\% \text{ female characters with power}) / [(\% \text{ female characters with power}) + (\% \text{ male characters with power})]$$

If a superpower is equally distributed between male and female characters, the gender representation bias score is 50. For example, consider a superpower that is possessed by 10% of female characters and 10% of male characters. The gender representation bias score for this gender-equal superpower is 50 (i.e.  $10\% / (10\% + 10\%) = 50$ ). If a superpower is male-dominant, the gender representation bias score will be below 50. For example, a superpower that is possessed by 5% of female characters and 10% of male characters will have a gender representation bias score of 33 (i.e.  $5\% / (5\% + 10\%) = 33$ ). Finally, if a superpower is female-dominant, the gender representation bias score will be above 50. For example, a superpower that is possessed by 10% of female characters and 5% of male characters will have a gender representation bias score of 67 (i.e.  $10\% / (5\% + 10\%) = 67$ ).

The gender representation bias score is a weighted measure and was used for two reasons. First, there were many more male characters (401) than female characters (149), making a straight frequency comparison uninformative. Second, even though the number of female characters was low, female characters have a regular presence in Marvel comicbooks. Many

Marvel female characters have high numbers of appearances (“Marvel: Characters”), and 70% of all superhero teams have at least one female member (Shendruk). Given the uneven number of male-to-female characters coupled with the high prevalence of female character appearances, a weighted measure of gender representation would best reflect how superpowers/abilities/products are distributed across gender.

Once a gender representation bias score was calculated for each STEM superpower/ability/product, I then calculated the average gender representation bias score for the superpowers/abilities/products related to each STEM sub-discipline (see table 1). These average gender representation bias scores were then correlated to the average percentage of bachelor’s degrees awarded to women in each STEM sub-discipline between 2008-2015.

### 3.2. RESULTS

A Pearson Correlation Coefficient analysis with an  $\alpha = .05$  was conducted to determine the correlation direction and strength of the relationship between the percentage of bachelor’s degrees attained by women and the gender representation bias score for superpowers/abilities/products across STEM sub-disciplines. The analysis revealed a strong, positive correlation,  $r(7) = .78, p = .006$  (one-tailed, see figure 5).

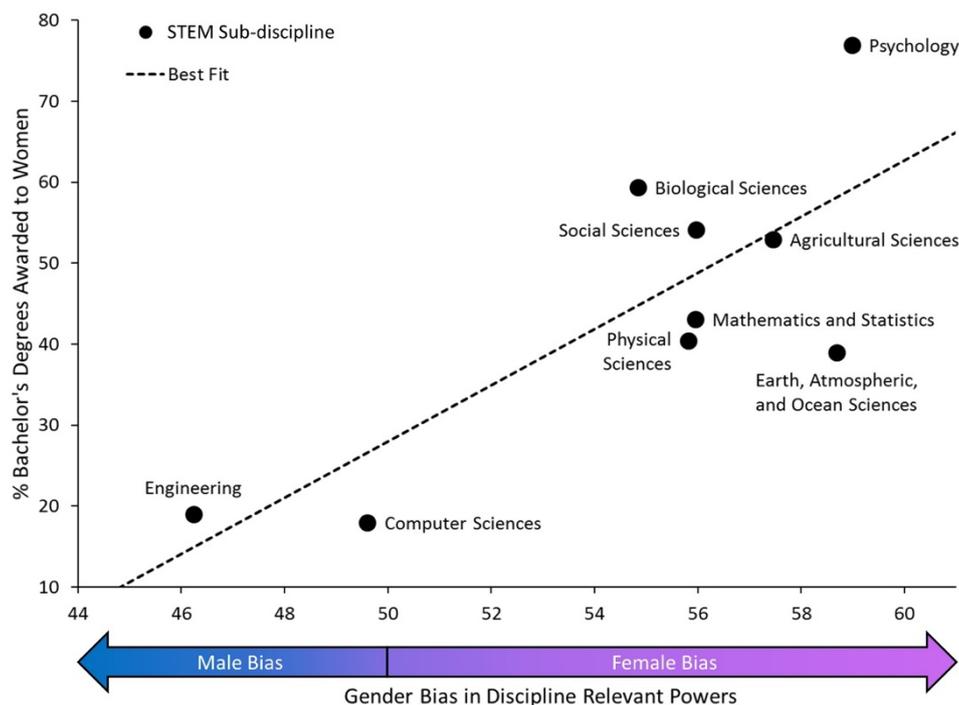


Figure 5 Strong, positive correlation between the percentage of bachelor’s degrees attained by women and the gender representation bias score for superpowers/abilities/products across STEM sub-disciplines.

### 3.3. DISCUSSION

The results revealed a strong, positive association between the gender representation of STEM superpowers/abilities/products in Marvel characters and bachelor’s degrees attained by

women. In other words, STEM sub-disciplines that were associated with superpowers/abilities/products that were more male-dominant tended to have lower percentages of women attaining bachelor's degrees. Alternatively, as the gender representation of superpowers/abilities/products in STEM sub-disciplines changed from male-dominant to female-dominant, the percentage of women attaining bachelor's degrees also increased. This supports the idea that media portrayals of STEM skills and abilities are influencing the decisions of young adults on their choice to pursue an education in a STEM sub-discipline and, thereby, helping to create and maintain the unequal gender representation in various STEM sub-disciplines.

The strength of the association revealed is classified as a "strong" correlation (Akoglu 92). One interesting possibility for this strong relation could be that there is a large overlap between individuals who read superhero comics and individuals who choose STEM careers. That is, the association may have been so strong because people who tend to read superhero comics are more likely than non-superhero comics readers to also be interested in STEM. If so, the portrayal of STEM superpowers/abilities/products in superhero comics would then become even more important to STEM, as the readership would already consist of those most likely to pursue STEM, with the portrayal of characters influencing their choice of a STEM sub-discipline.

#### **IV. STUDY #3: GENDER REPRESENTATION OF STEM IN MARVEL COMICBOOKS POST-2000s**

Studies #1 and #2 focused on Marvel characters that debuted before 1991. I now turn to how the gender representation of STEM superpowers/abilities/products have changed since that time. Specifically, what are the gender representations for superpowers/abilities/products for characters that made their Marvel comics debut after January 1<sup>st</sup>, 2000? Have the gender representation biases in the portrayal of pre-1991 Marvel characters changed for characters introduced in the current millennium?

##### **4.1. METHOD**

The methods used were the same as in Study #1, but limited to Marvel characters that debuted after January 1<sup>st</sup>, 2000. The list of Marvel characters was taken from Wikipedia ("List of Marvel Comics superhero debuts"), and included characters that debuted as late as March 2021. The final list had 237 characters (116 female, 119 male, and 2 non-binary).

##### **4.2. RESULTS**

Due to the extremely low number of non-binary characters, the analysis only looked at male and female characters. An independent-means *t*-test analysis with an  $\alpha = .05$  was planned for each of the 47 superpowers/abilities/products associated with a STEM sub-discipline (see table 1). However, the superpower of *inertia absorption* was removed from the analysis as no post-

2000 debuting characters possessed that superpower. Each remaining 46 *t*-tests compared the percent of male versus female characters that possessed a superpower/ability/product. A post-hoc Benjamini-Hochberg procedure was used with a 25% false-discovery rate to control for multiple comparisons.

This analysis revealed that all 46 superpowers/abilities/products were equally represented between the genders<sup>4</sup>. That is, there were no male-dominant or female-dominant superpowers/abilities/products.

### 4.3. DISCUSSION

The analysis of the gender representation of superpowers/abilities/products for Marvel characters debuting post-2000s revealed gender representation equality for all superpowers/abilities/products. In other words, superpowers/abilities/products that were previously mainly portrayed in male characters (e.g. Gadgets, Power Suit) or mainly portrayed in female characters (e.g. Empathy, Hypnosis) were now portrayed equally by both male and female characters. This more gender equal portrayal is a stark contrast to what was found for Marvel characters that debuted pre-1991 (see table 2).

This shift indicates that recently introduced Marvel characters have created more gender diversity in the portrayal of STEM skills (Johns). This diversification of the portrayals of STEM skills is potentially an effective strategy in battling the STEM professional stereotype, as a more diverse presentation of what STEM is necessarily dilutes the effects of any existing stereotype (Cheryan et al., “Cultural Stereotypes as Gatekeepers” 6).

## V. STUDY #4: USING MARVEL CHARACTERS TO PREDICT FUTURE STEM GENDER REPRESENTATION

Stereotypes can affect how an individual not only sees themselves in the present, but also how they imagine their possible, future self (Markus and Nurius 954). These concepts of a possible future self, in turn, motivate behavior towards certain career goals, such as STEM careers (Steinke, “Adolescent Girls” 7).

Study #2 revealed that the gender representation of STEM in Marvel characters correlates with real-world STEM educational outcomes with respect to gender (see figure 5). If this relationship between media portrayals and educational outcomes continues, what might we expect the STEM educational outcomes for men and women to be in the future? That is, Study #4 revealed that Marvel characters that debuted post-2000 are offering a more gender diverse portrayal of STEM superpowers/abilities/products. What does this new diversity predict for STEM educational outcomes in the future?

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<sup>4</sup> While null results must always be interpreted with caution, it is worth noting that in a separate analysis other, non-STEM superpowers were significantly different. For example, the gender representation of *berserker strength* was male-dominant for Marvel characters that debuted post-2000.

## 5.1. METHOD

Using the data from Study #2, I modeled the relationship between gender representation bias scores for pre-1991s Marvel characters as predictors of the percentage of bachelor's degrees awarded to women between 2008-2015 using a linear-regression equation. This produced a model of the relation between portrayals of STEM superpowers/abilities/products and educational outcomes. To derive predictions of future bachelor's degrees awarded, I substituted the gender representation bias scores of pre-1991s Marvel characters with those of post-2000s characters into the regression model.

## 5.2. RESULTS

The linear-regression analysis revealed that, for Marvel characters that debuted pre-1991, gender representation bias significantly accounted for variation in the percentage of bachelor's degrees attained by women,  $\beta = .83$ ,  $t(9) = 8.42$ ,  $p < .001$ . In other words:

$$\text{percentage of bachelor's degrees attained by women} = 0.83 \times \text{gender representation bias.}$$

This regression model was then used to predict the future percentages of bachelor's degrees attained by women, by substituting the gender representation bias scores for post-2000 debuting Marvel characters into the model (see table 3).

STEM Sub-Discipline	Percentage of Bachelor's Degrees Attained by Women		Change towards or away from gender representation equality?
	2008-2015	Future	
Engineering	19.0	43.0	Towards
Agricultural sciences	52.9	46.4	Away
Biological sciences	59.4	45.3	Towards
Computer sciences	18.0	42.7	Towards
Earth, atmospheric, and ocean sciences	39.0	49.0	Towards
Mathematics and statistics	43.1	47.8	Towards
Physical sciences	40.4	35.9	Away
Psychology	76.9	49.7	Towards
Social sciences	54.2	46.5	Towards

Table 3: Summary of the Percentage of Bachelor's Degrees Attained by Women from 2008-2015 and the Predicted Future Percentages.

## 5.2. DISCUSSION

The future percentages of bachelor's degrees attained by women predicted by the regression model are much closer to gender representation equality. In seven of the nine STEM sub-disciplines, the percentages moved towards gender representation equality. Only for agricultural sciences and physical sciences did the percentages move away from gender equality. For agricultural sciences, this is likely due to a statistical margin of error, as the 2008-2015 percentages were already very close to 50% (i.e. 52.9%). However, the predicted move away from equality for the physical sciences is less clear and warrants further study.

It is important to keep in mind that the overall predicted increase in gender equality in the present analysis is based solely on the portrayal of STEM superpowers/abilities/products in Marvel comics. The rationale is that: i) media portrayals of the STEM professional stereotype are different today than they were in pre-1991, ii) media portrayals of the STEM professional stereotype influence decisions to pursue an education in STEM (Finson 335), and iii) decisions to pursue a STEM education lead to attainment of a bachelor's degree in a STEM sub-discipline. The first part of this rationale is critical as research has shown that media portrayals of STEM stereotypes are particularly well suited to creating cultural change (Cheryan et al. "Cultural Stereotypes as Gatekeepers" 4). If the second and third parts of the rationale hold, then we can expect a shift towards greater gender equality in almost all STEM sub-disciplines in the future.

The portrayals of STEM superpowers/abilities/products in Marvel comicbooks post-2000 reflects a cultural change in the direction of greater gender equality in STEM. However, caution must be exercised when interpreting predictions of this sort, as no single issue can be the primary cause of gender inequalities in STEM (Blickenstaff 384). STEM gender inequalities are a complex problem that will require a multi-faceted solution (384). Encouragingly, to the extent that comicbooks are a part of this solution, Marvel characters are pushing towards gender equality in STEM.

## VI. GENERAL SUMMARY

Gender representation inequality in STEM is a pressing concern for society (Cheryan et al., "Cultural Stereotypes as Gatekeepers" 1). Some STEM sub-disciplines, such as computer science and engineering, are male-dominant, while others, such as psychology and biological sciences, are female-dominant. Research has shown the importance of the STEM professional stereotype as a social barrier preventing men and women from entering certain STEM sub-disciplines (Ceci et al., "Women's Underrepresentation" 220). Here I provided evidence: i) of the unequal gender representation of STEM superpowers/abilities/products in Marvel characters that debuted pre-1991, ii) that the gender representation of STEM superpowers/abilities/products in Marvel characters that debuted pre-1991 is strongly correlated with STEM educational outcomes, iii) of the equal gender representation of STEM superpowers/abilities/products in Marvel characters that debuted post-2000, and iv) that the predicted future

STEM educational outcomes are expected to move towards more gender equality across most STEM sub-disciplines.

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## IMAGE SOURCES

*Fantastic Four*. By James Robinson, illustrated by Chris Samnee, vol. 1, no. 643, Marvel Comics, Apr. 2015. (Fig. 3, right panel)

*Hulk Visionaries: Peter David*. By Peter David, illustrated by Dale Keown, vol. 8, trade paperback, Marvel Comics, Aug. 2011. (Fig. 1)

*Invincible Iron Man*. By Brian M. Bendis, illustrated by Mike Deodato Jr., vol. 3, no. 14, Marvel Comics, Dec. 2016. (Fig. 3, left panel)

*Runaways*. By Rowell Rainbow, illustrated by Kris Anka, vol. 5, no. 28, Marvel Comics, Feb. 2020. (Fig. 4, left panel)

*X-Men: Phoenix Endsong*. By Greg Pak, illustrated by Greg Land, vol. 1, trade paperback, Marvel Comics, Dec. 2005. (Fig. 4, left panel)