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Perceptions about Women in Science and Engineering History

Abstract

This study investigated college students' perceptions about the contributions of women to the history of science, technology, engineering and mathematics (STEM) (N = 1,147). Students were asked to write down as many famous or historically important scientists, inventors or engineers they could think of. After one minute, they were instructed to write down as many famous or historically important women scientists, inventors or engineers they could think of. For the first question, 95% of the responses referred to male scientists, inventors or engineers. For the second question, respondents named on average less than one woman (M=.86), and those named were more often from non-STEM fields (e.g., Rosa Parks) than actual scientists, inventors or engineers. Additionally, while respondents named a total of 279 distinct men, they named only 35 distinct women. Students in STEM fields could name significantly more male scientists, inventors or engineers than non-STEM students, but could not name significantly more women. The implications of these results are discussed, along with suggestions for educators on how to integrate the contributions of women in STEM into the classroom.

Introduction

For at least forty years, women's historians have delved into the historical record to deconstruct familiar narratives around who is responsible for advances in science and technology. These historians have worked to dismantle the assumptions and practices that have typically excluded women's scientific contributions throughout history. For example, the extensive scholarship on the history of women in science and technology in Margaret Rossiter's two-volume *Women Scientists in America*,[1] demonstrates that tens of thousands, if not hundreds of thousands, of women have worked as scientists in fields as diverse as zoology and computing, genetics and astronomy. While these facts have been recovered, it remains to be seen whether this information has made its way into the classroom and into cultural consciousness.

Few studies have examined the broader cultural context of societal perceptions about women's contributions to scientific and technological advances throughout history. A few studies that have investigated the public's knowledge of scientists have noted a deficit. In a recent survey, 23% of people from the U.S. couldn't name a single scientist.[2] Those who could name a scientist were most likely to identify Einstein. Faring even worse was Great Britain, where a survey showed 2/3 of the public was unable to name a famous scientist.[3] A survey sponsored by the Royal Society showed that 88% of 18-24 year-olds could not name a female scientific figure, either current or historical.[4]

College students, especially STEM students, should do a far better job at naming important people in the science and engineering fields than the general public. The question central to this study is, does their improved ability extend to naming significant women in these fields?

Research Questions

RQ1: Do college students name significantly more men than women when asked to name famous or historically important scientists, inventors or engineers?

RQ2: Do college students name significantly more men when asked to name famous or historically important scientists, inventors or engineers than they name women when asked specifically to name famous or historically important women scientists, inventors or engineers?

RQ3: Do male or female students name more famous or historically important male or female scientists, inventors or engineers?

RQ4: Do STEM students name more famous or historically important male or female scientists, inventors or engineers than non-STEM students?

RQ5: What famous or historically important scientists, inventors or engineers do students name most frequently?

Research Methods

Participants

Participants consisted of freshmen through senior college students from both STEM and non-STEM courses at three universities in the Western United States. The participant population was a convenience sample of students who were in classes whose instructors had learned through word of mouth or e-mail requests that the research team was seeking classes to volunteer. Potential participants were told that they had the opportunity to participate in an anonymous survey on their perceptions about famous or historically significant figures in science and technology. A total of 1,147 students (55% female; 45% male) participated, consisting of 866 STEM majors and 281 non-STEM majors, excluding 16 students with incomplete demographic data (Table 1). The age of participants ranged from 18 to 77, with a mean age of 22 years.

STEM majors included physical, biological and health sciences, mathematics, computer science and engineering disciplines.

Table 1. Student Gender (Male vs. Female) * Student Major (STEM vs. Non-STEM) Crosstabulation.

		Student Major (STEM vs. Non-STEM)		
		STEM	Non-STEM	Total
Student Gender (Male vs. Female)	Male	389	124	513
	Female	477	157	634
Total		866	281	1147

Survey

As approved by the Institutional Review Board, students were presented with the survey specifics via PowerPoint slides to inform the potential volunteers about the purpose of the study

and their role and rights as participants. The PowerPoint slides and a printed answer sheet informed students that answering the questions and turning in the survey served as their consent, and they were given the option of discontinuing the survey and opting out at any time. The three survey questions were shown one at a time on a PowerPoint presentation, and each question was read aloud exactly as printed by a survey administrator. The first prompt asked participants to "Please write down as many famous or historically important scientists, inventors or engineers that you can think of, in one minute." At the end of one minute, the next slide asked participants to "Please write down as many famous or historically important women scientists, inventors or engineers that you can think of, in one minute," and informed them, "You may repeat people you named in Question 1." At the end of one minute, the third slide asked participants to "Please write down ways you think women have changed the world." For the purposes of this paper, the responses for the first two questions only are analyzed and discussed.

Analysis

Responses to questions one and two were transcribed onto an Excel file. About 3% of answers were removed when they were partial or contradictory (e.g., "Glenn," "Mary something"), overtly tongue-in-cheek (e.g., "Pooh Bear," "Dr. Evil"), or did not answer the question, (e.g., "lol," "there aren't any"). Descriptive statistics were conducted on the remaining names. We conducted statistical analyses to determine whether there were statistically significant differences between 1) the mean number of men listed on question one and the mean number of women listed on question one, 2) the mean number of men listed on question one and the mean number of women listed for question two, 3) the mean number of male and female figures listed by male students and the mean number of male and female figures listed by female students, and 4) the mean number of men listed by STEM versus non-STEM students and the mean number of women listed by STEM versus non-STEM students. Using SPSS v. 19, we first conducted non-parametric tests (Wilcoxon Signed Ranks tests and Mann-Whitney tests) as a conservative method, and then we conducted parametric tests (t-tests). We found that both types of tests resulted in the same statistical conclusions. We chose to report the results obtained from the t-tests for simplicity. Finally, the list of names was analyzed to discover which male and female names were listed most frequently, along with a preliminary analysis of which names were really of "famous or historically important scientists, inventors or engineers" and which were of other types of men and women, such as social scientists or personal connections.

Results

RQ1: Do college students name significantly more men than women when asked to name famous or historically important scientists, inventors or engineers?

When the question was gender-neutral (Q1 on the survey), students named more male figures than female figures ($M = 5.02$ and $M = .25$, respectively), and this mean difference was statistically significant ($p < .01$).

RQ2: Do college students name significantly more men when asked to name famous or historically important scientists, inventors or engineers than they name women when asked

specifically to name famous or historically important women scientists, inventors or engineers?

Even when students were asked to think specifically about historical female figures (Q2 on the survey), the number of female figures that they listed was lower than the number of male figures they voluntarily listed when the question was gender-neutral (Q1) (M = .86 and M = 5.02, respectively). This mean difference was statistically significant ($p < .01$).

While not one of our research questions, we thought it would be interesting to see whether there is a statistically significant difference between the mean of women named in Q1 and the mean of women named in Q2. The number of female figures that students listed when they were asked to think specifically about historical female figures (Q2) was higher than the number of female figures that they voluntarily listed when the question was gender-neutral (Q1) (M = .86 and M = .25, respectively). This mean difference was statistically significant ($p < .01$). Statistical results for RQ1 and RQ2 are presented in Tables 2 and 3.

Table 2. Descriptive Statistics for R1 and R2.

	N	Mean	Std. Deviation	Minimum	Maximum
Q1 Female Figures	1147	.25	.525	0	6
Q2 Female Figures	1147	.86	.970	0	6
Q1 Male Figures	1147	5.02	2.179	0	13

Table 3. Test Statistics for R1 and R2.

	Q1 Male Figures - Q1 Female Figures	Q1 Male Figures - Q2 Female Figures	Q1 Female Figures - Q2 Female Figures
t	73.99	67.35	-22.71
df	1146	1146	1146
Sig. (2-tailed)	.000	.000	.000

RQ3: Do male or female students name more famous or historically important male or female scientists, inventors or engineers?

We tested gender effects on the numbers of famous or historically important male and female figures that students listed, and the statistical results are presented in Tables 4 and 5.

When the question was gender-neutral (Q1), on average, both male and female students listed about five male figures (M = 5.14, SD = 2.20 and M = 4.91, SD = 2.15, respectively), and the mean difference due to gender was not statistically significant ($p > .05$). However, the average numbers of female figures that male and female students included in their answers were less than one (M = .18, SD = .48 and M = .31, SD = .55, respectively). Although female students included more female figures than male students did, and the mean difference due to gender was statistically significant ($p < .01$), the effect size was small (d = .25), indicating a small degree of practical significance.

When students were asked to think about important female figures only (Q2), male and female students listed about one female figure (M = .78, SD = .96 and M = .93, SD = .97, respectively). Again, female students listed more female figures than male students did, and the mean difference due to gender was statistically significant ($p < .05$). However, the effect size was small (d = .15). It should be noted that the majority of the female figures named here were not, upon close reflection, from STEM fields, but rather other socially important fields. More about this will be discussed subsequently.

Table 4. Group Statistics for R3.

	Student Gender (Male vs. Female)	N	Mean	Std. Deviation	Std. Error Mean
Q1 Male Figures	Male	513	5.14	2.204	.097
	Female	634	4.91	2.155	.086
Q1 Female Figures	Male	513	.18	.482	.021
	Female	634	.31	.550	.022
Q2 Female Figures	Male	513	.78	.962	.042
	Female	634	.93	.972	.039

Table 5. Test Statistics[a] for R3.

	Q1 Male Figures	Q1 Female Figures	Q2 Female Figures
t	1.775	-3.307	-2.570
df	1145	1145	1145
Sig. (2-tailed)	.076	.001	.010

a. Grouping Variable: Student Gender (Male vs. Female)

RQ4: Do STEM students name more famous or historically important male or female scientists, inventors or engineers than non-STEM students?

We tested student major effects on the numbers of famous or historically important male and female figures that students listed, and the statistical results are presented in Tables 6 and 7.

When the question was gender-neutral (Q1), both STEM and non-STEM students named more historical male figures than female figures. On average, STEM students named more male figures than non-STEM students did (M = 5.27, SD = 2.18 and M = 4.25, SD =1.98, respectively). The mean difference due to student major was statistically significant ($p < .01$), and the effect size was moderate (d = .48). However, the average numbers of female figures that STEM students and non-STEM students included in their answers were less than one (M = .27, SD = .54 and M = .20, SD =.44, respectively), and the mean difference due to student major was not statistically significant ($p > .05$).

When students were asked to think about important female figures only (Q2), STEM students and non-STEM students listed about one female figure (M = .89, SD = .96 and M = .76, SD = .97, respectively), and the mean difference due to student major was statistically significant ($p <$

.05). STEM students listed more female figures than did non-STEM students; however, the effect size was small (d = .13).

Table 6. Group Statistics for R4.

	Student Major (STEM vs. Non-STEM)	N	Mean	Std. Deviation	Std. Error Mean
Q1 Male Figures	STEM	866	5.27	2.183	.074
	Non-STEM	281	4.25	1.981	.118
Q1 Female Figures	STEM	866	.27	.548	.019
	Non-STEM	281	.20	.445	.027
Q2 Female Figures	STEM	866	.89	.966	.033
	Non-STEM	281	.76	.978	.058

Table 7. Test Statistics[a] for R4.

	Q1 Male Figures	Q1 Female Figures	Q2 Female Figures
t	6.941	2.188	2.058
df	1145	1145	1145
Sig. (2-tailed)	.000	.064	.040

a. Grouping Variable: Student Major (STEM vs. Non-STEM)

RQ5: What famous or historically important scientists, inventors or engineers are named most frequently?

When the question was gender-neutral (Q1), the sample named a total of 279 men and 22 women that were clearly in STEM fields. The 15 most frequently named men were: Einstein (N=919), Edison (N=494), Newton (N=414), Darwin (N=393), Mendel (N=386), (Ben) Franklin (N=341), Crick (N=235), Watson (N=234), Graham Bell (N=183), Galileo (N=175), Jobs (N=120), DaVinci (N=113), Gates (N=109), Tesla (N=100), and Wright Bros. (N= 88). The five most frequently named women for this question were (Marie) Curie (N=179), (Rosalind) Franklin (N=66), Nightingale (N=9), Goodall (N=8) and Menten (N=6).

When students were asked to think about important female figures only (Q2), they named a total of 35 women. (They were told that they could repeat any women that they had named in question one). The eight most frequent names were: Curie (N=376), (Rosalind) Franklin (N=204), Earhart (N=57), Nightingale (N=23), Menten (N=13), Carson (N=12) and Ride (N=10).

Incidentally, we accepted descriptions of historical figures in science in lieu of actual names. When it came to identifying women, this practice was relatively common. For example, rather than writing "Rosalind Franklin," participants often wrote "the X-ray lady" or "the girl who helped Watson and Crick." Similarly, rather than "Goodall," we saw "chimpanzee anthro lady," rather than "Curie" we saw "the lady about radioactivity," and rather than "Earhart" we saw "the lady who flew the plane and got lost." Rarely did students describe rather than name male figures.

Interestingly, the female names that commonly emerged (other than Marie Curie who tops our lists for both questions one and two) were often tied to recent events in the classroom or community. For example, the name "Jane Goodall" appeared frequently at a university that had just hosted her for a lecture. "Rosalind Franklin" appeared frequently in a class of students we were told had just received a lesson on her a week before the survey. "Maude Menten" showed up particularly among students in a class of a chemistry faculty who admires her work and includes it in the course content.

While we did not count names of non-STEM individuals toward the totals in this section, it is interesting to note the frequency with which students named socially or personally important women, rather than historically important STEM women when responding to Q2. Examples include women who have made an impact in politics (e.g., "Hillary Clinton," "Susan B. Anthony") or society (e.g., "Rosa Parks," "Helen Keller"). Names with significant personal connection, such as those of resident female STEM professors and graduate students, also occurred regularly and underscored the importance of role models and mentors. Indeed, it has been posited in ongoing national policy conversations that the lack of role models is a central limiting factor affecting women, minorities and people with disabilities as they enter STEM fields.[5]

We also noted that while many students couldn't name even one significant woman, they could name specific or relatively obscure men. Examples include: "Octave Chanute," a French American aviation pioneer and railway engineer in the late 1800s; "Rudolf Virchow," a German scientist considered the founder of modern pathology; and "Linus Torvalds," a present-day Finnish American who initiated the open source Linux kernel. These notable STEM figures were named by a male civil engineering student, a male pre-med student, and a male materials science and engineering student, respectively.

Discussion

The results of this study show that college students in STEM and non-STEM fields alike, even those who have great knowledge of the contributions of men, are missing knowledge on the contributions of women to the history of science and innovation. Male and female students in both STEM and non-STEM fields could name significantly more historically important men in the sciences than women. For question one, when the question was asked in a gender-neutral way, more than 95% of the names listed were men. Participants listed, on average, five male figures, and less than one female figure. For question two, when asked specifically about women, 43% of the sample could not think of a single female figure, whether STEM or non-STEM. Those who did offer a name often provided the name of a woman who has contributed in non-STEM fields, such as politics or social sciences. For the names of famous or historically important figures that were clearly from STEM fields, the sample named a total of 279 distinct men, and only 35 women. A number of questions emerge from these results.

The first question is why are students able to name so few women when the historical research of the past 40 years shows that women's contributions to STEM fields have been significant? Social historians have pondered the question of why the public might be ignorant in this area and

there are many possible answers. The first may be the power of stereotypes. Most people, including educators, hold the stereotype that scientists are white, socially awkward,[6] and male.[7] Our study shows a small yet significant increase in distinct female names when respondents were asked specifically to think about women's contributions in STEM, which perhaps helped them set aside a preconceived notion about gender and scientific accomplishment. When 150 secondary-school physics teachers in training were asked to name "outstanding female and male engineers or physicists," most could name well over 20 men but only one woman.[8] Other studies have also found that a strong majority of teachers in training think of people in STEM fields as men.[9] This could certainly be a problem if teachers use the stereotypes to inform their teaching. A related answer comes down to old-fashioned sexism. "With few exceptions [such as Marie Curie] women have been left out of the standard histories of science, mathematics, engineering, medicine and the social sciences."[10] Thus, even in the 21st century, 'science' is viewed by the public as 'masculine' and therefore something that women do not do. In our study, question two elicited comments supporting the masculine as normative viewpoint, including "They don't exist," "Funny joke," and the symbol for the null set. The public, even when exposed to examples of women's accomplishments in science, views them as exceptional and therefore misleading.[11] We might like to think that this is only a K-12 problem, but given the average age of our participants (22 years) and their distribution across all years in college, in combination with other research on adult populations[12], it appears that a lack of awareness about women in science permeates all levels of education.

A follow-up question is whether or not educators and students alike would be open to learning about the contributions of women. Based on some of the anecdotal information gained from our study, the answer is "yes," particularly for women. Female respondents named more women figures on average for both study questions than did male respondents. Some of the female participants spontaneously wrote things on their survey that indicated a) embarrassment that they didn't already know more about the topic, and/or b) that they had a feeling that women have made contributions that were not being discussed in the classroom. For example, when these students couldn't think of the name of a woman for question two, instead they sometimes wrote: "Oh God, I don't know!" (female, animal biology major) or "This is bad…" (female, chemistry major). In contrast, when male respondents couldn't think of a name, they sometimes made spontaneous comments that illustrated a certainty about the lack of contribution by women, such as: "Psh… nonexistent" (male, art history major), or "Joke?" (male, mechanical engineering major). This kind of anecdotal evidence may indicate a greater readiness, even eagerness, by women to learn about those women who have contributed to STEM fields, and potentially a greater resistance by some men to do the same.

A final question that emerges as a result of this study is: What can educators do to make students more aware of the significant women in the history of science, engineering, and technology, both in deed and in name? The first step for an educator is simply to educate oneself on women's contributions and talk about them with students. In the current study, in those classes where the professor had discussed a woman scientist, the name of that scientist showed up more frequently on the survey (e.g., "Rosalind Franklin" and "Maude Menten"). Students are unlikely to seek out this information on their own; it must be provided to them by an educator who is interested in sharing the whole historical story, not just the same old (male-biased) story. Moreover, our study demonstrates significant student major effects when STEM and non-STEM students named historical male figures. It also indicates that although student major effects were not

statistically significant when listing female names in response to a gender-neutral question (Q1), these effects were of practical significance when considering female contributors only (Q2). Thus, it appears STEM educators in particular have an obligation to bring women's role in science and innovation to the fore, by familiarizing themselves with the historical record of women's contributions to their own fields and sharing them effectively with the next generation.

The transformative nature of narrative may be particularly powerful, not only in relaying women's technological advancements, but also in helping people remember and relate to individuals' lives and processes of discovery. School children learn the story of Alexander Graham Bell calling, "Mr. Watson, come here," when his prototype telephone succeeded, or the story of the Wright Brothers and their iterations of the early airplane, and even the stories of Bill Gates' and Steve Jobs' rise to technological greatness. The prevalent use of Albert Einstein's image in professional and popular venues in addition to well-known personal accounts could contribute to his name occurring most often in our study and others.

Why not include such narratives and imagery for women? Certainly, stories and examples do exist. Consider the three top female names (Earhart, Carson, and Ride) appearing in response to question two in our study after having been overlooked by participants in question one. Their inclusion may have resulted from stories more well-known to the general public. For example, *Amelia*[13] was a 2009 biographical film starring Hilary Swank. Rachel Carson's book *Silent Spring*[14] has been widely read after its selection as a New York Times best seller. NASA's Mission Control played the famous R&B song *Mustang Sally*[15] for astronaut Sally Ride as the morning wake-up on one of her Space Shuttle missions. Song lyrics, "Ride, Sally, Ride," were, in fact, included in the survey responses.

There are more stories ready for the telling. Women like Emily Warren Roebling, who played an essential role in building the world famous Brooklyn Bridge after her husband and chief engineer, Washington Roebling, became gravely ill. Or Lillian Moller Gilbreth, who was the first person to integrate psychology with engineering to improve human efficiency and was the first woman inducted into the American Society of Mechanical Engineers, the Society of Industrial Engineers and the Society of Women Engineers. Or Grace Hopper, whose foundational work in computer programming languages eventually enabled the development of today's ubiquitous computing. Or the female students who indicated on their survey responses that they eagerly anticipate being listed as influential women in science and technology in the future. Since stories are the way that societies have learned throughout history, bringing stories of women scientists into the classroom indeed may have a significant impact on how students see the role of women in these fields.

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