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Article

Women in STEM Leadership in the Academy

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Abstract: A considerable body of research exists on women in leadership and likewise on women in STEM (science, technology, engineering, mathematics) fields. However, the intersection of the two is terra incognita: women in leadership in STEM. At the most fundamental level, we don't even have a solid idea of how many women hold leadership positions in STEM. This study determined the proportion of women in leadership positions in several academic STEM areas via a sampling of institutions across the United States and other countries. In every area studied, women held fewer leadership positions than the proportion of female PhDs in those fields. The proportion of women in non-STEM specific top academic leadership roles was also examined to see what proportion of those individuals leading academic institutions might have background in a STEM discipline and how that compares to men in the same positions. This study opens the door to exploring the experiences of women who lead in STEM, which is likely to promote women's participation in these fields.

Keywords: gender; leadership; science; STEM; department chair

1. Introduction

In 2018 the United States saw an unprecedented number of women running for leadership roles in government at all levels. This is part of a broader movement in our society that has seen women becoming more involved in leadership of every kind, as well as a general rebalancing of power dynamics between men and women, which involves everything from a desire for fair pay to an effort to address the increasingly visible issue of sexual harassment.

Over the last few years, news headlines have pointed up the problem of sexual harassment in many areas: Hollywood, academia, industry. In most of these cases, the accused was a male in a position of power who was harassing women less powerful than himself. Similarly, women in STEM (science, technology, engineering, mathematics) have started to speak up about their experiences of sexual harassment [1] and discrimination. Many times these problems have been allowed to continue because peer leaders are unwilling to stand up and risk their own reputation. Usually, the peers of these harassers are also men.

In the US, the National Academies have recently published a report "Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine." [2] In this report, the authors explain the costs of harassment: "a significant and costly loss of talent in academic science, engineering, and medicine, which has consequences for advancing the nation's economic and social well-being and its overall public health" (p. 4). One of the five factors they found supporting environments where sexual harassment is likely to occur is the male-dominated workplace, where men are in positions of authority.

How might the incidence of harassment and discrimination change if we had more women in leadership positions in STEM? How many potential women leaders have we lost to this environment? How can we best help women in leadership positions fight against discrimination and harassment? These are a but a few of the myriad questions that arise from the vastly understudied area of women in STEM leadership. We really know next to nothing about women in STEM leadership. An important first step toward addressing these questions begins with learning how many women are in STEM leadership positions. We can best explore what will help women in leadership in STEM if we start with the foundations: how many women in STEM are in leadership positions? How many women in leadership positions have a STEM background?

This study is one step toward exploring the intersection of women, STEM, and leadership. This paper explores numbers of women in STEM leadership and how women with STEM backgrounds stand more broadly in overall leadership among academics. There is much literature on women and leadership; an even greater amount of research on women and STEM. It is more than past time to look at the points of intersection.

2. Materials and Methods

A first step in learning about the experiences of women in STEM leadership is to find out how many women are in these positions. Academia is used as a starting point because the data for people in leadership positions in higher education are relatively easy to find online. While the numbers from industry would be valuable as well, it poses a much harder task because the data on industry lab managers and other leaders are not easily located in public searches.

A major barrier to collecting this data is the temporary nature of common leadership positions in academia. For many, leadership equates to administration. Most people would agree that a university president or a provost is a leader. Deans and department heads are also considered leaders. People in such positions often hold the role for no more than three to five years before another individual steps in. Any census of women in STEM leadership is a snapshot which quickly loses its currency. By the time you have reached the end of a list, the beginning of the list is out of date.

This study does not claim to be a complete census of women in STEM who are leaders. Rather, it is a mostly random sample of female leaders in schools and departments across a one-year timeframe. While the data lacks longitudinal precision, it does give us an idea about the representation of women in STEM leadership roles, which has simply not been available before.

Along with women in STEM-specific leadership roles, it is also interesting to look for women in general academic leadership positions who had a STEM background. Looking from both directions (leadership to STEM, and STEM to leadership) gives a richer view for study.

All data were collected in the calendar year 2017. Schools were chosen based on "top school" lists for the most current year available; sources are provided. Departments chosen randomly were selected from online lists of departments. Online lists such as what students would encounter and use were chosen rather than formal lists such as the US Department of Education listing. This also provides more consistency when comparing to international lists. University websites provided the names of people in leadership positions.

An important caveat: though the article uses the words "gender" and "sex" in this article for simplicity's sake, what was actually examined was an individual's gender presentation as determined based on a combination of factors: name, picture, and pronouns. Any time the author felt uncertain as to an individual's gender presentation she double checked her impression with another person.

3. Results

3.1. Institutional leadership

The leadership of the top STEM schools in the US [3] exhibits a higher proportion of women at the top of the organizational chart than in mid-level positions (Table 1). A background in STEM was

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common among the institutional leaders in these institutions; a reassuring trend for schools known for their STEM areas. It is noteworthy that there was a higher proportion of women at the highest level of leadership as compared to the next two levels down.

Not all leaders have easily accessible biographies that allow for a determination of any STEM background; when the number of available instances of STEM backgrounds is different from the number of people in the group, the total of available biographies is listed in parentheses. The deans of STEM colleges were not checked for a STEM background; most deans are drawn from the disciplines within their college.

Table 1. Gender Breakdown of Leaders at top STEM Schools in the US

Position	No. of women	No. of men	% of women	No. of women with STEM background	No. of men with STEM background
Chancellor/President	7	13	35	5	8
Provost/VPAA/VCAA[1]	4	12	25	1	11
Dean of STEM college[2]	18	49	27	—	—

[1] Vice-President for Academic Affairs/Vice-Chancellor for Academic Affairs

[2] STEM background was not checked for STEM Deans

As a contrast to the STEM schools, the top liberal arts schools in the US [4] were also examined for the background of their uppermost leaders, as were the women's colleges. (Table 2). Only the President/Chancellor level was examined because these institutions tended to be smaller, and many do not have a Provost- or Dean-level position. Likewise, the women's colleges in the US were examined only for the top leadership position.

Table 2. Gender Breakdown of Presidents/Chancellors at Top Liberal Arts Schools and Women's Colleges in the US

Institution Type	No. of women	No. of men	% of women	No. of women with STEM background	No. of men with STEM background
Top liberal arts schools	9	17	35	2	3 (of 16)
Women's colleges	33	2	94	2 (of 29)	N/A[1]

[1] No biographies were easily found for the 2 men.

Not surprisingly, the liberal arts schools and women's colleges have a stronger representation of women at their highest leadership position.

Many of the top leaders at all of these institutions had a STEM background; among Chancellors/Presidents, a higher percentage of the women had a STEM degree. In the US, 30% of women's PhDs are in STEM and 56% of men's PhDs are STEM [5]. From this small sample, it looks like a STEM degree may be more important or helpful for women moving into peak leadership roles. In a study of female university presidents, Madsen notes that "All of these presidents either majored or stated that they would have majored…in math or science." [6] (p. 94) This is another place where studying the intersection of leadership, gender, and STEM is very important, both so we can offer these women further tools to perform their jobs and so we can help others replicate their successes.

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3.2. Departmental leadership

The position of department chair or department head (used interchangeably here) provided the largest and richest data set. This paper examines two sets of departments: randomly chosen from across the US [7], and from lists of the top departments in the world [8]. Lists of institutions are available in the appendix. This study only looked at four STEM fields: math, chemistry, biology, and physics for simplicity's sake, as engineering departments are often split up into separate subfields. The only previous study with any data on STEM department chair demographics, from 2004 [9], found 2.5% of women as chairs of engineering departments. Technology as its own discipline was not studied because it is rarely its own department. Table 3 lists the number of women and men as department chair in a sampling of science and mathematics fields.

Table 3. Gender Breakdown of Department Chairs in Four STEM Fields in a Random Sampling of Departments and in Top Departments

	Random Departments			Top Departments		
Discipline	**No. of women**	**No. of men**	**% of women**	**No. of women**	**No. of men**	**% of women**
Mathematics	7	21	25	2	18	10
Chemistry	8	20	29	3	15	11
Biology	8	22	27	14	44	24
Physics	3	27	10	2	16	11

It was disappointing to see that the higher prestige departments had fewer women for math and chemistry. Biology's numbers stayed consistent, as did physics. No field had more than 30% women in the chair position. Table 4 compares these percentages with the percentage of women earning PhDs in the field in the US in 2014 and 2004 [10]. The data from 2014 was chosen as it provided the most recent available numbers for women in the requisite fields. Since department chairs are typically associate professors or full professors, 2004 data was included as well since many PhD graduates from that year would now be eligible to be chair.

Table 4. Percentage of women as department chair in random departments, top departments, as graduates in 2014 and 2004 (US)

Discipline	**% of women as dept. chair in random departments**	**% of women as dept. chair in top departments**	**% of women earning PhDs in US (2014)**	**% of women earning PhDs in US (2004)**
Mathematics	25	10	29	28
Chemistry	29	11	39	32
Biology	27	24	53	46
Physics	10	11	19	16

When comparing the representation of women as chair to the awarded PhDs, we see that the percentage of women as chair is significantly lower than the percentage earning PhDs, either in recent years or in the previous decade. From a study in 2004, female PhDs showed a marked inclination to go into academia (68%) rather than industry (5%) [11]. Later data for 2014 [12] has somewhat more women (22-26%) employed in academia than men (12-13%). This suggests that women are present in the departments, and eligible for these positions, but are not represented equitably in the department leadership.

4. Discussion

This study determined the representation of women in a sampling of different STEM and academic leadership positions. The proportion of women in leadership positions within each given field (department chair) is significantly less than the proportion of women earning PhDs in those same fields. Women are very under-represented as a whole in higher education leadership such as dean, provost, president/chancellor, holding between 1/4 and 1/3 of those positions. Among the people in these positions, the number who have STEM backgrounds varies widely by school as we might expect to see given the makeup of their differing faculties. At liberal arts and women's colleges, leaders with STEM backgrounds were rare. At schools with a strong STEM reputation, most leaders did have a background in those areas.

Until now we have had no knowledge of what the representation of women in STEM leadership roles is like since this data has not been previously examined. By taking this first step in finding out how many women are STEM leaders, we can move on to further study, for example examining the experiences of these women through surveys or other means. A clear next step would be a more intentional sampling of leadership and departments.

Another interesting question is to consider if women in STEM fields are more or less likely to aspire to leadership positions. We know that stereotype threat can lower women's aspirations to leadership [13], and STEM is strong in stereotypes supporting men. So it is possible that women in STEM have lower ambitions to leadership because of the field itself.

Learning about the barriers and the assistance women in STEM leadership have encountered will help in supporting women who are starting on the path to higher-level leadership positions or looking to move upwards into higher leadership positions. These are important goals as moving towards equitable representation of women in leadership means moving towards more equitable STEM culture as a whole.

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References

1. Twitter. Available online: http://twitter.com; #metoo (accessed 28 August 2018).
2. National Academies of Sciences, Engineering, and Medicine. 2018. Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/24994.
3. Top 21 STEM Colleges of 2016. Available online: https://www.forbes.com/sites/cartercoudriet/2016/07/07/top-stem-colleges-of-2016/#1be43fe35ba8 (accessed 23 October 2017).
4. Top 25 Liberal Arts Colleges 2016. Available online: https://www.forbes.com/sites/timlevin/2016/07/07/top-liberal-arts-colleges-2016/#762f987143b4 (accessed 23 October 2017).
5. Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017. Available online: https://www.nsf.gov/statistics/2017/nsf17310/data.cfm (accessed 1 September 2018).
6. Madsen, S. R. *On becoming a woman leader*. Jossey-Bass: San Francisco, CA. 2008.
7. A2Z List of Schools, Colleges, Universities, and Institutes offering Biology majors in the US. Available online: http://www.a2zcolleges.com/Majors/Biology.html (accessed 15 February 2017).
   Chemistry & Biochemistry Departments-United States. Available online: http://guides.library.ucsb.edu/chemuniv (accessed 15 February 2017).
   USA Mathematics Departments. Available online: http://www.numbertheory.org/usa.html (accessed 15 February 2017).
   Physics Departments in United States of America. Available online: http://de.physnet.net/PhysNet/us.html (accessed 8 September 2017).Title of Site. Available online: URL (accessed on Day Month Year).
8. Academic Ranking of World Universities in Physics 2015. Available online: http://www.shanghairanking.com/SubjectPhysics2015.html (accessed 8 December 2017). Academic Ranking of World Universities in Mathematics 2015. Available online:

Peer-reviewed version available at Educ. Sci. 2019, 10, 1; doi:10.3390/educsci10010001

http://www.shanghairanking.com/SubjectMathematics2015.html (accessed 8 December 2017). Academic Ranking of World Universities in Chemistry 2015. Available online: http://www.shanghairanking.com/SubjectChemistry2015.html (accessed 8 December 2017). Best Global Universities for Biology and Biochemistry. Available online: https://www.usnews.com/education/best-global-universities/biology-biochemistry?page=3 (accessed 8 December 2017). QS World University Rankings by Subject 2015 - Biological Sciences. Available online:https://www.topuniversities.com/university-rankings/university-subject-rankings/2015/biological-sciences (accessed 8 December 2017).

9. Niemier, D. A., and Gonzalez, A. Breaking into the guildmasters' club: What we know about women science and engineering department chairs at AAU universities. NWSA Journal **2004**, 16, 157-171.
10. Women, Minorities, and Persons with Disabilities in S&E. Available online: https://www.nsf.gov/statistics/women/ (accessed 22 August 2018).
11. National Science Foundation, Division of Science Resources Statistics, Women, Minorities, and Persons with Disabilities in Science and Engineering: 2007, NSF 07-315 (Arlington, VA; February 2007). Available from http://www.nsf.gov/statistics/wmpd.
12. Women, Minorities, and Persons with Disabilities in Science and Engineering. Available online: https://www.nsf.gov/statistics/2017/nsf17310/digest/occupation/employment-sector.cfm (accessed 22 August 2018).
13. Davies, P.G., Steele, C.M., and Spencer, S.J. Clearing the Air: Identity Safety Moderates the Effects of Stereotype Threat on Women's Leadership Aspirations. Journal of Personality and Social Psychology, 2005, Vol. 88, No. 2, 276–287.

Appendix A1. Top STEM Schools

Massachusetts Institute of Technology
United States Naval Academy
Cornell University
Rice University
United States Air Force Academy
California Institute of Technology
Harvey Mudd College
Carnegie Mellon University
Johns Hopkins University
Georgia Institute of Technology
Cooper Union
Case Western Reserve University
United States Coast Guard Academy
Rensselaer Polytechnic Institute
Colorado School of Mines
Worcester Polytechnic Institute
California Polytechnic State University, San Luis Obispo
University of Portland
Rose-Hulman Institute of Technology
North Carolina State University, Raleigh

Appendix A2. Top Liberal Arts Schools

Williams College
Pomona College
Wesleyan University
Swarthmore College
Amherst College

United States Military Academy
Bowdoin College
Haverford College
United States Naval Academy
Davidson College
Carleton College
Washington and Lee University
Claremont McKenna College
Wellesley College
Vassar College
Middlebury College
United States Air Force Academy
Barnard College
Colby College
Colgate University
Oberlin College
Kenyon College
Bucknell University
Hamilton College
College of the Holy Cross

Appendix A3. Women's Colleges

Agnes Scott College
Alverno College
Barnard College
Bay Path University
Bennett College for Women
Bryn Mawr College
Cedar Crest College
College of Saint Mary csm.edu
Columbia College
Converse College
Cottey College
Hollins University
Judson College
Mary Baldwin College
Meredith College
Midway University
Mills College
Moore College of Art and Design
Mount Holyoke College
Mount Mary University
Mount Saint Mary's University, Los Angeles
Notre Dame of Maryland University
Russell Sage College of The Sage Colleges
St. Catherine University
Saint Mary's College
Salem College
Scripps College
Simmons College
Smith College

Spelman College
Stephens College
Sweet Briar College
Trinity Washington University
University of Saint Joseph
Ursuline College
Wellesley College
Wesleyan College
The Women's College of the University of Denver

Appendix A4. Mathematics Departments

Randomly Chosen Departments	Top Departments
Appalachian State	Princeton University
Auburn U, Montgomery	Stanford University
bates College	Harvard University
Central Michigan U	University of California, Berkeley
Clark U	Pierre and Marie Curie University - Paris 6
Colgate U	King Abdulaziz University
Columbia U, Applied Math	University of Oxford
Edinboro U of Pennsylvania	University of California, Los Angeles
Emporia State University	University of Cambridge
George Mason U, Virginia	University of Paris-Sud (Paris 11)
Georgia Southern U	University of Minnesota, Twin Cities
Harvard U	Massachusetts Institute of Technology (MIT)
Mesa State College	University of Warwick
Missouri Western State College	Swiss Federal Institute of Technology Zurich
New Jersey Institute of Tech	Texas A&M University
Northeastern U	University of Michigan-Ann Arbor
Ohio U	Columbia University
Oklahoma State U	University of Washington
Princeton U	University of Wisconsin - Madison
San Francisco State U	Duke University
SUNY at Newpaltz	The University of Texas at Austin
Tufts U	
UC David	
U of Chicago	
UNC Asheville	
U of Oregon	
U Tenn Knoxville	
UW-LaCrosse	

Appendix A5. Chemistry Departments

Randomly Chosen Departments	Top Departments
U Alaska Fairbanks	University of California, Berkeley
Arizona State U	Harvard University
University of Arizona	Stanford University
Lyon College (ARK)	California Institute of Technology

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Humboldt State U (CA)	Northwestern University
Berry College (GA)	Massachusetts Institute of Technology (MIT)
U Hawaii Manoa	University of Cambridge
Chaminade U of Honolulu (HI)	Swiss Federal Institute of Technology Zurich
College of Idaho	Kyoto University
Dominican University (Illinois)	University of Pennsylvania
Indiana University Kokomo	University of California, Los Angeles
Northern Kentucky U	Yale University
Centre College (KY)	University of California, Santa Barbara
Northwestern State U of LA	Technical University Munich
Univ of Southern Maine	Cornell University
College of St Scholastica (MN)	Columbia University
Metropolitan State U (MN)	University of Oxford
Missouri State University	University of California, San Diego
University of Montana	University of Strasbourg
Carroll College (MT)	Purdue University - West Lafayette
UNLV	
Brooklyn College CUNY	
Mayville State U (NoDak)	
Central State U (Ohio)	
Benedict College (SC)	
Black Hills State U (SoDak)	
Brigham Young U (UT)	
U of WA Tacoma	
Walla Walla U (WA)	
Bethany College (WV)	

Appendix A6. Biology Departments

Randomly Chosen Departments	**Top Departments**
Arizona State U at West Campus	Harvard University
Arkansas Tech University	Cambridge
Southern Arkansas U	Oxford
Philander Smith College	MIT
College of the Desert (CA)	Stanford
Yale U (CT)	Caltech
Univ of Delaware	UC Berkeley
Lewis-Clark State College (ID)	National University of Singapore
Bates College (ME)	Yale
Clark University (MA)	Swiss Federal Institute of Technology
College of the Holy Cross (MA)	UCLA
Ferris State (MI)	Cornell
Augsburg College (MN)	UCSF
MSU Billings	UCSD
U Nevada Reno	Imperial College London
College of St. Elizabeth (NJ)	Kyoto University
Barton College (NC)	University College London
Dickinson State U (ND)	University of Toronto

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Valley City State U (ND)	Princeton
Cedarville U (OH)	Columbia
Oklahoma Wesleyan U	University of Tokyo
Oregon State U	Johns Hopkins
George Fox U (OR)	University of Edinburgh
Carson-Newman U (TN)	University of Washington
Hardin-Simmons U (TX)	Duke
Dallas Baptist U (TX)	Copenhagen
Liberty U (VA)	University of Pennsylvania
Columbia Basin College (WA)	University of Chicago
Fairmont State (WV)	
Alverno College (WI)	

Appendix A7. Physics Departments

Randomly Chosen Departments	**Top Departments**
Alabama A&M University	University of California, Berkeley
Arkansas State University Jonesboro Dept of Chem and Phys	Princeton University
UC-Berkeley Dept of Astronomy	Harvard University
UC-Berkeley Neumark Group	Massachusetts Institute of Technology (MIT)
University of La Verne	California Institute of Technology
UCLA Dept of Physics and Astronomy	Stanford University
American University Dept of CS, Audio Tech, and Physics	The University of Tokyo
U Florida Gainesville Dept of Physics	University of Chicago
Armstrong Atlantic State U Dept of Chem, Physics, and Eng Studies	University of Cambridge
SIUE Dept of Physics	Cornell University
Pittsburg State U Kansas Dep of Physics	University of California, Santa Barbara
MIT Dept of Physics	University of Colorado at Boulder
Mount Holyoke College Dept of Physics	The University of Manchester
Montana State U Dept of Physics	Johns Hopkins University
UNLV Dept of Physics	The Imperial College of Science, Technology and Medicine
Princeton Dept of Phys	Columbia University
U of New Mexico Albuquerque Dept of Phys and Astro	Nagoya University
SUNY Oneonota Dept Phys Astro	University of Michigan-Ann Arbor
Appalachian State U Dept of Phys	Swiss Federal Institute of Technology Zurich
Guilford College Physics Department	The University of Edinburgh
Cleveland State U Ohio Dept of Phys	University of Munich
U of Oregon Eugene Dept of Phys	University of Arizona
Bryn Mawr Phys Dept	University of Paris-Sud (Paris 11)
Shippensburg U Dept of Phys	University of Maryland, College Park
Slippery Rock U Dept of Phys	University of California, Los Angeles
Vanderbilt U Dept of Phys and Astro	University of Washington
UT Austin Dept of Phys	Durham University
UT San Antonio	Kyoto University

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James Madison U Dept of Phys	Pierre and Marie Curie University - Paris 6
UW Madison Phys Dept	University of Illinois at Urbana-Champaign